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MEDICAL PHYSICS INTERNATIONAL
The Journal of the International Organization for Medical Physics

Aims and Coverage:

Medical Physics International (MPI) is the official IOMP journal. It provides a platform for medical physicists to share their experience, ideas and new information generated from their work of scientific, educational and professional nature. The e-journal is available free of charge to IOMP members. MPI- History Edition is dedicated to History of Medical Physics.

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EDITORIAL FROM NEW CO-EDITORS-IN-CHIEF

Francis Hasford[1], Sameer Tipnis[2]

[1] Radiological and Medical Sciences Research Institute, Ghana Atomic Energy Commission, Accra, Ghana.
[2] Department of Radiology and Radiological Sciences, Medical University of South Carolina, Charleston, USA.

Dear colleagues and friends,

We are delighted to address you as the co-Editors-in-Chief (EiCs) of the Medical Physics International (MPI) journal. It is with great pleasure and enthusiasm that we have embraced the responsibility of leading this esteemed journal towards new heights.

We extend sincere gratitude to the IOMP ExCom, led by President John Damilakis and the MPI editorial board members for the support we have received since assuming duty in January 2023. A big heartfelt appreciation to our predecessors and founding co-EiCs, Slavik Tabakov and Perry Sprawls, for their dedicated service and for laying a strong foundation for the journal's success.

The MPI journal has established a focus on e-learning, educational methods and resources, reviews of innovations and the development of the medical physics profession and organizations around the world. The journal publishes non-peer-reviewed open resource research reports, technical papers, conference abstracts, etc. This trend will be continued under our tenure as co-EiCs by upholding MPI's reputation for publishing high-quality, original, and innovative research that contributes to the advancement of knowledge, and practical ideas that can be implemented and used in everyday clinical practice by colleagues all over the world. We envision MPI to be at the forefront of scholarly publishing, fostering impactful research and knowledge dissemination.

Our first major assignment as co-editors of MPI is publication of this July 2023 edition. This edition features two books of abstracts from conferences of two Regional Federations:

- First Regional Conference of the Federation of African Medical Physics Organizations (FAMPO) held in Marrakech, Morocco; November 10 – 12, 2022.
- Middle East Federation of Organizations of Medical Physics (MEFOMP) 2023 Medical Conference held in Muscat, Oman, May 19 – 22, 2023.

This publication presents full articles and abstracts on educational topics, professional issues, scientific research and technology innovation.

The December edition of the journal will publish abstracts from the International Conference on Medical Physics (ICMP 2023) in Mumbai, India, 06 – 09 December 2023.

We firmly believe that collaboration, transparency, and innovation are the cornerstones of successful scholarly publishing. With the collective efforts of the editorial board, authors, and readers, we are confident that we can achieve new milestones and propel MPI as the leading journal in the field of medical physics.

We invite all medical physics researchers, scholars, and experts to contribute their valuable research to MPI and be part of our exciting journey. Together, let us advance knowledge, shape the future, and make a meaningful impact on society. Thank you for your support, and we look forward to working with everyone to advance our profession.

Visit www.mpijournal.org/index.aspx for latest MPI publications and enjoy reading the exciting articles.

Francis Hasford

Sameer Tipnis

MESSAGE FROM IOMP PRESIDENT

John Damilakis[1]

[1] University of Crete, School of Medicine, Crete, Greece

Dear colleagues,

First, I would like to extend a warm welcome to the new Editors of the MPI journal, Dr Francis Hasford and Dr. Sameer Tipnis. I am confident that under their guidance, the journal will thrive, facilitating the exchange of knowledge in the field of medical physics.

MPI plays a major role in keeping the medical physics community informed about the latest developments and breakthroughs. This dissemination of knowledge stimulates collaboration, encourages innovation, and supports evidence-based practices. Through its open access policy and international reach, the journal facilitates collaboration and networking opportunities, fostering an inclusive and vibrant medical physics community.

As we embark on a new chapter in the journal's journey, it is essential to emphasize the significant role it plays in advancing knowledge and promoting excellence in medical physics. MPI provides a platform for medical physicists sharing educational and professional insights in our field. This journal equips medical physicists with the knowledge and tools needed to provide high-quality education, mentorship, and training to the next generation of professionals. Furthermore, the journal offers a space to discuss professional matters. By fostering these discussions, the MPI contributes to the development of a cohesive professional community, dedicated to advancing patient-centered care and promoting the highest standards of professionalism.

As I warmly welcome the new Editors of MPI, I acknowledge the crucial role this publication plays in our quest for excellence in medical physics. By providing a platform for education and professional matters, the journal not only advances knowledge and innovation but also nurtures a community of passionate individuals dedicated to enhancing patient care and safety.

John Damilakis

(IOMP President, 2022-2025)

THE OBJECTIVES AND VALUES OF THE IOMP JOURNAL *MEDICAL PHYSICS INTERNATIONAL* AFTER 30 ISSUES

Slavik Tabakov[1,2,4] and Perry Sprawls[3,4]

[1] King's College London, UK, [2] Past President IOMP, [3]Sprawls Educational Foundation, USA, [4]MPI Founding Co-Editor in Chief

The IOMP Journal *Medical Physics International* (MPI) was created in 2012 and from its beginning has an excellent auditorium of readers. MPI was intentionally made as an open access online Journal – a free e-Journal, to support the global development of medical physics, especially in Low and Middle Income (LMI) countries. This directly supports the main objective of the International Organization for Medical Physics (IOMP). For the first 10 years MPI is read by thousands of medical physicists, students, and other professionals each month.

MPI was created and developed to address some of the topics less often discussed in the other Journals. Especially relating to professional development, education methodology and resources, practical applied physics, and the preservation and of our history and heritage. Initially the Journal made agreements with the other established Medical Physics Journals, that MPI will not focus on their specific research-orientated fields, but on the above topics.

At the same time there was a need for educational papers, based on the latest research in a form suitable for classroom presentations and discussion. Thus, MPI became a dissemination tool for all our colleagues in LMI countries and their students.

This dissemination strategy moved into the area of practical implementation of new methods and equipment. Test objects, quality control specifics, optimization criteria and various other subjects from the clinical practice were published, often as invited papers from eminent specialists.

The dissemination of research was also addressed - for teaching, presenting excellent educational materials (e.g., the foundations of DSA, the small field dosimetry, the Ultrasound imaging development, etc.). The educational topics grew into publishing whole lectures in support of classroom teaching (e.g., Lectures on Human Vision, Hospital Networks, CT Dose optimization, etc). MPI published many papers presenting educational models and resources, which were applied by educators in many countries (e.g., educational models in clinical medical physics, the VERTTM concepts, educational databases, the use of the e-Encyclopedia of medical physics, IAEA and ICTP courses, etc.).

Another educational field was publishing reviews of suitable for education books – from the IOMP-CRC Book series, and also from various other publishers. Other educational resources – both online and classical were also highlighted.

A very important part of the publications was associated with professional development in various countries. Papers from almost all IOMP National Member Organizations (NMO) were published. The MPI regular issues in the period 2018-2021 presented focused information of 65 countries from the IOMP Regional Organizations (RO): MPI 2019 (vol7) No.1 - Latin America (ALFIM); MPI 2019 (vol7), No.2 – Africa (FAMPO): MPI 2020 (vol.8), No.1 South-East Asia (SEAFOMP); MPI 2020 (vol.8) No.2 – Asia-Oceania (AFOMP); MPI 2021 (vol.9) No.1 – Middle East (MEFOMP); MPI 2021 (vol.9) No.2 – Europe (EFOMP).

All these professional publications, plus the RO Reports in the regular publications in the IOMP Newsletter Medical Physics World, formed an invaluable record of the global medical physics staffing and status, thus providing large Organisations as IAEA and WHO with information about the needs of the global workforce in medical physics for the harmonious support of healthcare.

From the beginning MPI published over 2000 pages with papers on the topics of: Education; Professional issues; Collaborating organisations; Technology innovations; How To; Tutorials; History; Book reviews; Abstracts of PhDs; Members' Awards, Editorials, Addresses and others.

Additionally, the professional publications were further enriched by publishing of the Abstracts and materials of all International Medical Physics Conferences after 2013, plus other materials from international conferences of the RO. These abstracts were previously scattered at various publications and websites. From 2013 these were collected in one place at the MPI Journal (as Annexes to the specific Journal and with separate Editors), thus forming an excellent record of the research and other development in the profession. Over 2000 pages with Abstracts were also published in the MPI.

The vision of the MPI Founding Co-Editors in Chief Slavik Tabakov and Perry Sprawls about the values of the Journal were presented also in each Editorial and a number of papers – both from them and from the invited eminent authors. Gradually over the time the MPI Journal was seen as a flag of the medical physics development and growth in LMI countries, as well as a substantial part of the backbone of this process. We thank all authors who contributed to this.

The specially made MPI Journal website was developed by the MPI Technical Editor Magdalena Stoeva, who was fully supporting the Journal from its beginning to this day. Each MPI issue and each paper has its own web address on the MPI website (www.mpijournal.org), which is optimised to work on various platforms.

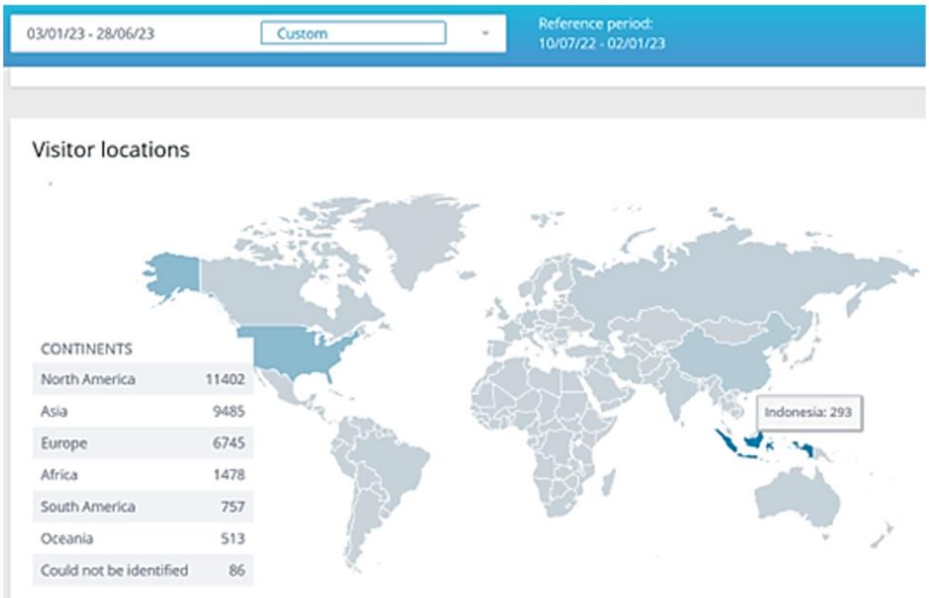
During the second Editorial term of MPI (2018-2022) a whole new independent sub-part of the Journal was created, dedicated to preserving the history of the profession – MPI-History Edition (MPI-HE, also known as Special Issues on History of Medical Physics). Its Founding EiC Slavik Tabakov and Perry Sprawls were joined soon by Geoffrey Ibbott in commissioning and producing history-related materials, which by now are over 1000 pages.

The success of the MPI Journal and its large auditory attracted interest from several professional publishers, offering potential future impact factor of the Journal. The leads of the MPI did not accept this, as the Journal was made not as a business activity, but as a free resource to all medical physicists, especially from LMI countries. Any business association of the MPI will make it a paid Journal and thus it will not be able to reach our colleagues from many countries. Thus, such business association will decrease its impact on the medical physics global development, despite the suggested impact metrics, which is usually associated primarily with research activities and related citations. For example, a number of MPI papers have 1000+ downloads each – a figure rarely reached by many research papers. Over 30 MPI papers (i.e., about 10%) have over 5000 downloads each. These are the real figures speaking about the impact of this professional/education-orientated Journal. In this line of thoughts MPI does not take the copyright of the papers – it stays with the authors.

We have presented many times official server statistics about the use of the MPI Journal and its global audience of readers. We believe that it will stay the same by keeping the Journal as a free resource (see Fig.1: stats Jan-Jun 2023). The quality of the papers is supported by internal reviewing process, which although not a typical peer-review, keeps steady influx of valuable papers and other materials (abstracts have their own Conference-related assessment).

The Editors-in-Chief and all Editorial board (based on IOMP ExCom and eminent professionals from the RO) work voluntarily for the objectives of the Journal, as are all of the IOMP ExCom members' activities.

These objectives and vision of the MPI Journal made it one of the most read Journals in Medical Physics. From its first issue in 2013 (celebrating the 50th Anniversary of the IOMP) until now – the 60th IOMP Anniversary - the regular bi-annual MPI issues are 20 and the MPI-History Editions are 9, with over 5000 published pages. This current regular MPI issue (vol.11, No.1, July 2023) will be the 30th publication of the Journal. It will be produced by the new Co-Editors in Chief Francis Hasford and Sameer Tipnis, who were elected by IOMP ExCom and Publication Com in January 2023, to replace S Tabakov and P Sprawls, who's successful second Editorial term was completed at the end of 2022. The new EiC are specialists with established record as educators and supporters of medical physics professional development in LMI countries. We are confident that they shall continue steadily the way forward of the MPI Journal and wholeheartedly wish them success.



country	visits
USA	10,405
China	2,975
Russia	1,161
Germany	1,074
UK	1,067
Singapore	913
India	906
Canada	728
Iran	667
France	663
Brazil	504
Nigeria	475
Israel	454
Australia	453
Philippines	451
Japan	449
Hong Kong	434
South Korea	314
Netherlands	308
Indonesia	293
Malaysia	277
South Africa	277
Czech Rep.	266
Italy	238
Ireland	206
Spain	165
Saudi Arabia	157
Finland	147
Sweden	144
Thailand	132

Fig.1

ANNEX: Here below are listed the most downloaded MPI papers and full Issues, and also the MPI-History Editions. All these are presented with their unique web addresses.

We cordially thank all authors and colleagues who contributed papers to the Journal over the past 10 years, and also to all Contributing Editors of the focusses MPI issues.

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COLLABORATING ORGANIZATIONS

GLOBAL REPRESENTATIVES' INITIATIVE OF THE AMERICAN ASSOCIATION OF PHYSICISTS IN MEDICINE

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Abstract— **New initiatives in the international relations of the American Association of Physicists in Medicine include determining the most imminent needs of low- and middle-income countries. A global needs survey was designed by members of the newly formed Global Needs Assessment Committee, Global Representatives Subcommittee and Equipment Donation Committee. To better understand the current needs and optimal ways of addressing them, we created a network of global representatives that serve as consultants on our committees. In addition, our members participated in several regional conferences with direct interaction with attendees from low- and middle-income countries. Based on the determined needs, we are suggesting new ways to address training of our colleagues overseas, providing them with better equipment and facilitating interactions with industry.**

Keywords— **American Association of Physicists in Medicine, International Programs.**

I. INTRODUCTION

The burden of noncommunicable diseases (NCD) is steadily increasing in low- and middle-income (LMIC) countries across the world [1-3]. For example, it has been projected that the majority of cancer deaths will occur in LMIC's by 2030 [4, 5]. Medical physicists play a critical role in the management of NCD's [6], both diagnostically and therapeutically. A number of international organizations such as the International Organization of Medical Physics (IOMP) and the International Atomic Energy Agency (IAEA) have been very active in the global application of medical physics for decades.

The American Association of Physicists in Medicine (AAPM) was formed in 1958 [7] and is the principal organization of medical physicists in the United States [8]. Despite its nominal association with the United States, the AAPM is actually an international organization with nearly 20% of its membership body residing outside the US in nearly one hundred different countries [9]. The AAPM has collaborated with a number of global stakeholders in the radiological sciences in the production of various medical physics guidance documents, such as the European Society for Therapeutic Radiology and Oncology (ESTRO) [10], the European Federation of Organizations for Medical Physics (EFOMP) [11], and the International Atomic Energy Agency (IAEA) [12]. The AAPM has been invested in global medical physics nearly since its inception. In 1963, the IOMP was formed [13], and the AAPM was one of its original charter members. An International Affairs Committee of the AAPM was formed in 1970 to promote cooperation with international organizations, facilitate the donation of both equipment and educational material to LMIC's [14]. Since 2006, the International Education Activities Committee has been coordinating the AAPM's international educational activities [15].

In 2020, the AAPM established an International Council (IC) with the aim of more effectively coordinating its international efforts. The justification for the establishment of this council were threefold. Firstly, international partnerships strengthen the AAPM and its membership. Additionally, international collaborations strengthen the education, science, and practice of medical physics domestically. Finally, international collaborations can contribute to improving quality and safety in healthcare on a global scale [9]. Within the AAPM IC, there are six committees: the Global Clinical Education and Training Committee (GCETC), the Global Data and Information Exchange Committee (GDIEC), the Global Liaisons Committee (GLC), the Global Medical Physics Education and Training Committee (GMPETC), the Global Research and Scientific Innovation Committee (GRSIC), and the Global Needs Assessment Committee (GNAC).

The GNAC has multiple charges. It seeks to develop, implement, and maintain processes for performing comprehensive quantitative assessments of medical physics needs and resources within a region or regions when such data are not available from other sources. Using the developed processes, it seeks to perform routine assessment of medical physics needs and resources in each region. It seeks to collaborate with the GDIEC to develop and maintain a database of contact information for leaders and other representatives of key stakeholder organizations, especially international, national, and regional medical physics organizations in each region. It seeks to collaborate with the GMPETC to advance education and training of medical physicists. Lastly, it seeks to collaborate with the GCETC to advance resource-stratified education and training in the clinical practice of medical physics.

Under the GNAC, two formal subcommittees have been established: the Equipment Donation Program Subcommittee and the Global Representatives Subcommittee (GRSC). The GRSC is attempting to establish a global network of regional medical physics representation in all areas of the world. The purpose of the network is to keep in touch with our colleagues and sister societies for awareness of their progress, determining their possible needs, establishing professional collaboration, assisting in the dissemination of education materials, arranging teaching courses, donating equipment, creating task groups and other possible ways of collaboration.

II. WAYS OF COLLABORATION

Global Representatives Network and its role in the communication process.

Communication is an indispensable aspect of human interaction that allows individuals to convey thoughts, ideas, and emotions. It serves as the foundation for building relationships, sharing knowledge, and fostering understanding between people. Through various channels and methods, communication processes facilitate the exchange of information and contribute to social, cultural, and personal development. In an interconnected world and, specifically, the field of Medical Physics, effective communication has become crucial for the exchange of ideas, collaboration, and problem-solving on a global scale.

The GRSC has established a global network of regional representatives in all areas of the world with the goal of developing and maintaining a database of contact information for leaders and other representatives of key stakeholder organizations from different regions of the world.

The first step was to identify the countries and regions. Using data from The World Bank [16], 135 countries were identified in the category of low- and middle-income countries. The LMICs were grouped into six regions, following the World Health Organization (WHO) definitions: (1) African Region, (2) Region of the Americas, (3) European Region, (4) Eastern Mediterranean Region, (5) Western Pacific Region, and (6) South-East Asia Region. Each region was aligned with the correspondent Regional Organization provided by the IOMP. To facilitate the communication channels, each region was then divided into sub-regions. For example, the Region of the Americas was divided into the Caribbean, Central America, North America, and South America; the Western Pacific Region was divided into Pacific Islands, Mainland Asia, and South China Sea.

The second step consisted of identifying global liaisons. The members of the GRSC were assigned one or more regions. Each member identified contacts in the medical physics organizations in the assigned region and created the connections. The contacts from each region were invited to join the GRSC as international consultants. At that point, the Global Representatives Network (GRN) was established and started the discussion of needs.

The creation and maintenance of the GRN has positively impacted the communication process between the AAPM and LMICs. The GRN plays a pivotal role in enhancing understanding among global representatives. By bringing together individuals from diverse backgrounds, the network has created opportunities for cross-cultural communication and exchange of perspectives. Through dialogue and interaction, representatives have gained valuable insights into different worldviews and needs from the LMICs. This enhanced understanding has fostered empathy, tolerance, and appreciation for the richness of human diversity. Consequently, we have been able to navigate complex cultural landscapes with sensitivity, promoting effective communication and avoiding misunderstandings that can hinder cooperation.

One of the most significant roles of the GRN lies in addressing global challenges through effective communication. Our network has served as a space for representatives from LMICs to discuss and deliberate on pressing issues, including equipment, educational and research needs. By fostering open and inclusive dialogue, the GRN enabled representatives to raise awareness about global challenges, mobilize public support, and advocate for policy changes at local, national, and international levels.

The GRN functions as a valuable platform for information sharing among global representatives. In a rapidly evolving world, staying informed is crucial for effective decision-making and problem-solving. By disseminating information across the network, representatives have been able to bridge information gaps, and address some of the needs.

The Global Representatives Network plays a vital role in the communication process, acting as a facilitator for understanding and cooperation on a global scale. Through its emphasis on cross-cultural communication, the network enhances understanding among representatives from diverse backgrounds, fostering empathy and tolerance. By promoting cooperation, the GRN enables stakeholders to collaborate effectively, leveraging their collective resources to address global needs. We are planning to further develop our Global Representatives Network to facilitate better communication between AAPM and sister societies.

Global Needs Assessments: Surveys and Structured Interviews.

The charges of the GNAC include developing, implementing, and maintaining processes for performing comprehensive quantitative assessments of medical physics needs and resources within the global regions. Global needs assessments will serve as a catalyst for future work of the AAPM IC, provide a snapshot of the current status of global needs, establish baseline metrics, serve as a guide for identifying key deliverables by the IC committees, and afford assessment of the progress of the work of the IC using the baseline metrics. Some of the methods of needs assessment that the GNAC will utilize are surveys and structured interviews.

The GNAC has initially identified a strategy of performing three different needs assessments. The first is a survey to be completed by institutional and departmental leaders in radiation oncology and radiology departments. The purpose is to provide a broad view of institutional activities, available infrastructure, and needs. Second, a survey will be completed by medical physicists working in LMICs. The purpose of the second survey is to gather information about the frontlines of medical physics practice, education, and research. Third, a needs assessment of industry partners will be conducted through structured interviews. The purpose of the third needs assessment is to obtain information about the unique challenges of providing and maintaining equipment and services in low-resource settings.

To date, the GNAC has completed the survey of institutional and departmental leaders and is in the process of submitting the results as a manuscript for publication. The IRB-approved survey was developed with input from all IC committees and in collaboration with a survey design and analysis consultant. The survey was deployed using a web-based platform and distributed through multiple channels including email, the AAPM website, social media postings, global contact lists, and regional conference presentations. The forty-six-question survey consisted of six sections: Introduction, Infrastructure, Education, Research, and General. Survey responses were received from all six global regions with the most responses from the African Region and the least responses from the Western Pacific Region. The survey was analyzed to identify trends, specific needs, and potential for collaboration. Furthermore, the survey data were analyzed with respect to the six global regions, practice specialty, and practice-specific needs. Recurring themes in the results were needs for training, equipment, and qualified personnel. We look forward to sharing detailed results in our impending publication.

The survey of medical physicists is in the final stages of development and will consist of six sections of the same categories as the initial survey. Lessons learned from the initial survey will be incorporated to streamline and improve the analysis process. The structured interview process is in the development stage and will provide valuable insight into the specific challenges of this our industry partners when working in low-resource settings.

The GNAC will conduct needs assessments through surveys and structured interviews. The first global survey has been developed, conducted, and analyzed. The results are being finalized and will be submitted to an open-access international journal so that the results will be freely available to everyone. The second survey and the structured interview process are in the final stages of development. The results of all needs assessments will provide valuable information for the international work of the AAPM and other organizations.

AAPM/IOMP Equipment Donation Program.

The International Equipment Donation Program is a joint program between the IOMP and the AAPM. The Equipment Donation Program Subcommittee (EDPSC) exists within the AAPM as a subcommittee of the GNAC and within the IOMP as a subcommittee of the Professional Relations Committee (PRC). Prior to the creation of the AAPM International Council, the EDPSC reported to the AAPM International Affairs Committee.

The program has been in existence for many years and the scope of the program has evolved over time. The current scope includes the donation of functional, sustainable, and site-appropriate medical physics quality assurance (QA) equipment. Recent donations include calibrated ionization chambers and electrometers, image quality phantoms for various imaging modalities, CTDI phantoms, triaxial cables, connectors, and linear accelerator mechanical QA devices.

Members of the EDPSC include medical physicists that specialize in both imaging and therapy and have a range of experience from graduate students to late career professionals. Many of the members have international connections and speak multiple languages. All members are enthusiastic about international work and devote time and effort to the donation of much needed medical physics equipment to low resource settings.

International equipment donation is a challenging endeavor. The World Health Organization (WHO) estimates that 80% of health-care equipment in some countries is donated or funded by international donors or foreign governments [16]. However, in some global areas, up to 70% of equipment is not in use due to issues related to equipment acquisition, user training, and technical support. The AAPM/IOMP EDPSC works diligently to ensure that donations are successful. The program follows WHO guidelines to ensure donations meet the needs of recipients, that end-users receive training, and that the equipment is maintained over time.

The program fully embraces the concept that we can do more together than we can do alone. The EDPSC seeks collaboration with other groups with the aim of reducing duplication of effort and bending silos that exist within the international arena. To date, the EDPSC has collaborated with the AAPM Global Clinical Education and Training Committee (GCETC), Radiating Hope, and Medical Physicists for World Benefit (MPWB) and hopes to collaborate with additional groups in the future.

The Equipment Donation Program also seeks to work with medical physicists in all global regions. The EDP has completed projects in the African Region, the Region of the Americas, and the Eastern Mediterranean Region. Current ongoing projects are located in the African Region, the Region of the Americas, and the European Region.

Additional information about the program can be found at *https://www.aapm.org/international/EquipmentDonation.asp*. If you would like to request equipment from the program, please go to the website and complete Form B. If you have equipment that you would like to donate to the program, please complete Form A. The website also includes a list of recommended equipment for donation.

In conclusion, the AAPM/IOMP Equipment Donation Program is a joint program between the AAPM and IOMP. The scope of the program includes medical physics QA equipment. The EDPSC follows WHO guidelines to ensure that donations are successful. The program pursues collaboration with other groups and organizations and seeks to complete projects in all global regions. Please see the program's website for additional information and details about requesting and donating equipment.

Conference Participation as a Way of Promoting Collaboration with LMIC.

Recognizing the importance of maintaining clear communication channels with medical physicists worldwide, the GNAC assigned the GRSC to establish a global network of regional representatives in all areas of the world. One way of promoting global partnerships with LMICs is through participation in international conferences. Conferences facilitate networking and collaboration opportunities for medical physicists around the world. Through their sessions, discussions, and social events, conferences offer a platform for participants to share their work with a global audience, receive feedback, exchange ideas, identify potential collaborators, and develop joint initiatives. Collaboration is playing an increasingly important role in advancing global health, where addressing the world's most complex problems requires the expertise and resources from interdisciplinary and multi-institutional efforts. This is becoming more attainable as we can now learn about each other's work through online publications or recorded presentations, as well as work together through virtual meeting platforms. Such opportunities and visibility may be more difficult for medical physicists in LMICs to establish. However, these challenges can be mitigated with ongoing participation from all regions of the world.

Several of the IC's committees are focused in disseminating training and expertise in areas of clinical practice, medical physics education, and innovative research. Knowledge sharing is a key benefit of conference participation, as attendees exchange and gain insights into emerging trends, stay updated with evolving regulatory standards and guidelines, and learn about available resources or funding opportunities to help support their work. Medical physicists may also observe a diverse range of practices and challenges from different healthcare systems worldwide, enriching their perspectives and incorporating best practices from around the globe. Furthermore, conferences expose participants to a diverse range of backgrounds, fostering cultural understanding and encouraging inclusive collaboration to address global challenges.

Global outreach and collaborations were established through presentations by GNAC members at various medical physics conferences, including those hosted by regional organizations of the IOMP. Speakers presented on the need for global outreach, the mission of the AAPM's IC, and the efforts of the AAPM's GNAC. Members also presented the development of the global needs assessment survey and invited participants to assist with disseminating the survey to increase response rates and future collaborations.

With the COVID-19 pandemic, the 19th South-East Asian Congress of Medical Physics (SEACOMP) was adapted from a face-to-face meeting to a hybrid meeting in October 2021, where local members and IT staff were onsite in Thailand to organize the online congress, and the remaining 231 attendees from 16 countries participated virtually. Three GNAC members presented sessions virtually. While the virtual format and time zone limited involvement and communication with attendees, the GNAC received many survey responses from the southeast Asian region, reflecting the value of networking and presenting the survey at the congress. In March 2022, another GNAC member also presented on the committee's efforts in a virtual meeting organized by the Pan American Health Organization (PAHO) aimed at discussing gaps in radiation therapy in Caribbean countries. The member established new connections, learned about regional needs, was invited to speak at a future meeting, and received commitment for future collaborations.

Conferences have since returned to in-person formats, and GNAC members were invited to deliver their presentations onsite. In June 2022, two GNAC members attended the 4th Meeting of the Latin American Medical Physics Association (ALFIM) in Brazil. Their fluency in regional languages and physical presence enabled significant networking and collaboration opportunities, establishing key contacts from various Latin American countries. In addition, both members were invited to present their scientific and clinical expertise in upcoming national conferences. In November 2022, three GNAC members presented at the 1st Regional Conference of the Federation of African Medical Physics Organizations (FAMPO) in Morocco. Despite being spread across the world, the conferences covered similar topics, including the importance of recognizing medical physics as a healthcare profession, lack of pathways for providing standardized certification and accreditation, updates about medical physics education and training in different regions, new quality assurance requirements, and challenges faced by women in medical physics.

In July 2022, the GNAC invited and sponsored for the President of FAMPO, Christopher Trauernicht, to attend the AAPM's 64th Annual Meeting held in Washington DC and speak on the medical physics needs in Africa, along with six other GNAC members who presented on addressing global medical physics needs.

A GNAC representative also attended the Greater Horns of Africa Oncology Summit (GHOS) that took place in Dar es Salaam, Tanzania in September 2022. This conference had participants from all over the world including, Turkey, Nepal, Jordan, USA and Canada. African countries represented at the conference included Ethiopia, Ghana, Kenya, Tanzania, Rwanda, Zambia, South Africa and Uganda. Even though this was just a medical Physics conference it brought together various specialties such as medical oncology, radiation oncology and medical Physics. The GNAC representative presented on AAPM initiatives and had the face-to-face interactions with other physicists.

Our committee members attended conferences in both virtual and face-to-face formats. It is important to note conferences can be expensive and inequitable, with LMIC attendance limited by systemic barriers including high travel costs and visa restrictions. The COVID-19 pandemic has accelerated transitions to online or hybrid conference formats, which offers benefits such as reducing expenses, improving accessibility, and facilitating dissemination of digitally archived sessions. However, virtual meetings may lack opportunities to network socially due to digital meeting fatigue, a loss of casual “hallway” conversations, and challenging time zones. These challenges may be mitigated by applying technology to meet these challenges, relocating conferences to visa-friendly countries, providing travel scholarships, and developing mentorship programs to enable LMIC researchers to participate in global conferences.

By bringing together diverse expertise and facilitating international partnerships, conferences can pave the way for transformative collaborations. The GNAC’s presence at various conferences strengthened global networks, emphasizing the significance of conference participation in driving innovation and addressing complex challenges on a global scale.

Regional Perspectives of the global medical Physics Collaboration

The global shortage of qualified medical is especially noticeable in low- and middle-income countries[17]. In a recent paper by Tsapaki et al.[17], the African continent reported to have only 697 medical physicists for a total population of approximately1.3 billion, with countries like Cameroon reporting only 2 medical physicists. This type of shortage of medical physicists creates isolation for the clinical physicists and lack of proper expertise for the patient care. In many cases, the solo physicist does not have a benchmark or oversight on the work quality or standard of care. Such situations can be improved by creation of regional associations having a critical mass of qualified physicists. Some associations are covering large geographical regions and with multiple countries. Such regional associations will be more versed with the local problems and issues and be in a better position to advocate for better roles and responsibilities of clinical physicists. This concept is supported by the IOMP [18, 19]. As of 2022, the IOMP acknowledges 6 regional organizations, namely: European Federation of Organizations for Medical Physics (EFOMP), Asian-Oceania Federation of Organizations for Medical Physics (AFOMP), Latin American Medical Physics Association (ALFIM), Southeast Asian Federation for Medical Physics (SEAFOMP), Federation of African Medical Physics Organizations (FAMPO), and Middle East Federation of Organizations for Medical Physics (MEFOMP) [19]. The GNAC is using connections to these regional associations as a way to establish the needs of the global medical physics community.

Regional associations in low- and middle-income countries can play a vital role in increasing access to various medical physics technologies, training, and expertise. One of the examples was the creation of a West African medical physics education program serving multiple countries. However, regional solutions to limited resources confront regulatory, institutional, and economical barriers. In addition, regional solutions must overcome language barriers as well. While English is the main communication language globally, not all physicists can understand it. So, the regional associations can be instrumental in creating local content for standard of care in a language that can understood by most of its membership.

III. CONCLUSIONS

Significant effort of newly created committees of the AAPM International Council is only the beginning of the process of establishing long-term relations between American medical physicists and their colleagues overseas. It is extremely important that these relations resemble a two-way street, where the communication efforts were coming from both sides and the physicists from low- and middle-income countries could directly express their needs and keep direct communications not only with the committees but also with individual physicists in the US and Canada. We will be continuously monitoring the process and working towards seamless integration of the physicists overseas into the global structure of medical physics.

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EDUCATIONAL TOPICS

IOMP ACCREDITATION OF MEDICAL PHYSICS EDUCATION PROGRAM, ACCREDITATION OF RESIDENCY AND ACCREDITATION OF CONTINUOUS PROFESSIONAL DEVELOPMENT PROGRAMMES

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Abstract— **Application of ionizing radiation in healthcare in diagnosis and treatment has increased multifield in fast few decades. Ionizing radiation needs to be used appropriately and carefully because of its inherent risks and therefore sufficiently trained and qualified medical physicists are required in various specialties of healthcare employing ionizing radiation for diagnosis and/or treatment. In recent years the demand for clinically qualified medical physics (CQMP) has increased and many institutions/universities have started the medical physics education programmes to meet the rising demand. However, the curriculum of medical physics education and training need to be harmonized so as to produce competent CQMP. There must be an assessment system to evaluate minimum acceptable competency and homogeneity To access the minimum standards of the education and provide credibility of the program the medical physics education programs needs to be accredited. Further accreditation serves as a vital process in assessing and assuring the quality of educational programs and therefore to fulfil the objectives, International Organisation of Medical Physics (IOMP) in 2016 has started accreditation of medical physics education programs, residency programmes and CPD accreditation of education and training events. The IOMP accreditation programmes have many advantages such as it validates the highest teaching standards and best preparation of medical physicists for the work environment and provides visibility and credibility of the accredited program. The details regarding IOMP accreditation are available on IOMP website at https://www.iomp.org/accreditation/.**

Keywords— **Medical Physicists, accreditation, residency program, continuous professional development.**

I. INTRODUCTION

Medical physics is a rapidly growing area needing a high degree of knowledge and professional competency due to the rise in complexity of treatment procedures, increasing access to medical technology, and the requirement of coordination between the disciplines of medicine, physics, and biomedical engineering. The unprecedented surge in medical physics competency in the last 2- 3 decades is due to the implementation of specialized physics intensive procedures such as particle therapy, image guided & intra operative radiotherapy, advanced imaging, and nuclear medicine techniques. In this scenario to handle this new technology era the quantity of qualified medical physicists needs to be in consonance with the competency needed. There is a special requirement for education and training of medical physicists which led to the opening of numerous medical physics educational programs around the world. However, the training and educational curriculum needs to be tuned with the requirement to produce the competent "Clinically Qualified Medical physicists (CQMP) not for the present but also for the future needs. Furthermore, the major outcome of the academic programme is to provide the students with a thorough grounding in medical physics, critical thinking, scientific rigor, and adequate professional ethics**,** to facilitate the integration of the graduates in a healthcare profession, where the benefit of the patient is at the centre of all activities.

As per International Labour Organization (ILO), International Atomic Energy Agency (IAEA), World Health Organisation (WHO), International Organisation of Medical physics (IOMP -Policy statement no. 1) and many other organisations recognises medical physicists working in healthcare environment as "Health Professionals" and therefore the CQMP need to undergo a structured residency program after completion of postgraduation in medical physics. **IAEA Human Health Series No. 25** document endorsed by IOMP and AAPM, envisages the roles and responsibilities of CQMP in the different specialties of medical physics (Radiation Oncology, Nuclear Medicine, Diagnostic Radiology, and Interventional Radiology) and recommends minimum requirements for their academic education and clinical training, including recommendations for their accreditation, certification and registration, along with continuing professional development.

According to IAEA *a clinically qualified medical physicist (CQMP) must have:*

- *A university degree in physics, engineering, or equivalent physical science*
- *Appropriate academic qualifications in medical physics (or equivalent) at the postgraduate level,*
- *At least two years (full time equivalent) structured clinical in-service training undertaken in a hospital.*
- *The IAEA also states that "It is emphasized that the holder of a university degree in medical physics without the required hospital training cannot be considered clinically qualified." Further this education and training should be recognized by a national accreditation body.*

Health care across the world is undergoing a period of rapid transformation because of economical, technological, and regulatory forces which brings both great challenges and great opportunities for the discipline of medical physics. To meet the growing requirement of qualified medical physicists, various institutes/universities are running medical physics education programs, however, to access the minimum standards of the education and provide credibility of the program the medical physics education programs needs to be accredited. Education Training Committee (ETC), IOMP has tried to compile the data of medical education programmes across the globe, the information is updated constantly with the feedback received. Further feedback to update the information is highly appreciated. Approximately more than 39**0** Medical Physics Undergraduates / Postgraduates and research programme are available around world. The details of the number of programs according to IOMP Regional Organization [RO] region is as follows,

- MEFOMP-21 (0.08 programs/million population)
- AFOMP ~ 119 (0.03 programs/million population)
- USA ~ 42 (0.127 programs/million population)
- ALFIM ~ 46 (0.076 programs/million population)
- EFOMP- 105 (0.141 programs/million population)
- FAMPO- 37 (0.026 programs/million population)
- CANADA- 18 (0.49 programs/million population)

The details of the institutions and the programmes RO wise is available on IOMP website at https://www.iomp.org/education-training-resources/

Now the question is whether all the medical physicists trained by various universities/institutions fulfil the expectations to be competent CQMP? Whether the medical physicists trained by different universities/institutions are competent enough to discharge the duty of unsupervised clinical medical physicists? There must be an assessment system to evaluate minimum acceptable competency and homogeneity. IAEA IBSS recommends that *"Competence of persons to be assessed by the State/ Govt. by having a formal mechanism for registration, accreditation, or certification of medical physicists in the various specialties (e.g., diagnostic radiology, radiation therapy, nuclear medicine). States/Govt. that have yet to develop such a mechanism would need to assess the education, training and competence of any individual proposed by the licensee to act as a medical physicist and to decide on the basis of either international accreditation standards or standards of a State where such an accreditation system exists, whether such an individual could undertake the functions of a medical physicist, within the required specialty."*

II. WHAT DO PATIENTS AND SOCIETY EXPECT FROM THEIR MEDICAL PHYSICIST AS HEALTH PROFESSIONAL?

- Professional Competence
- Educational qualifications/Certification
- Problem solving- finding solutions.
- Independence of decision and execution
- Practical skills, Clarity in communication, Integrity, confidentiality
- Humanity- compassion

Therefore, accreditation of the medical physics education and residency program and certification of medical physicists is required.

III. WHAT IS ACCREDITATION?

Accreditation is the process of external quality review to scrutinize colleges, universities, and educational programs for quality assurance and quality improvement. The important parameters required to be assessed for accreditation of the program are,

1. Status of the institution
2. Governance & administration
3. Vision, mission, objectives
4. Courses/programmes, curriculum & graduate outcomes
5. Approach to teaching & learning
6. Planning, programme review & quality assurance mechanism
7. Level of internationalisation

IV. ADVANTAGES OF ACCREDITATION

Accreditation serves as a vital process in assessing and assuring the quality of educational programs. It involves rigorous evaluation and verification of various aspects of an institution or program to ensure it meets predetermined standards. Accreditation in educational programs benefits students, institutions, employer, policy makers and society.

Accreditation is important because it helps determine if an institution meets or exceed minimum standards of quality and helps students determine acceptable institutions for enrolment in addition employers often require evidence that applicants have received a degree from an accredited school or program. Accreditation also fosters a culture of continuous improvement, encouraging institutions to assess their programs and make necessary enhancements to meet evolving educational needs. Additionally, accreditation can make an institution eligible for government funding and grants, attracting resources that can further enhance program quality and infrastructure.

V. STAKEHOLDERS OF ACCREDITATION OF MEDICAL PHYSICS PROGRAMS

The quality of educational programs, the safety and competence of the graduates, and the integrity of the accreditation process is important. Stakeholders in the accreditation process of medical physics education programs are:

Society – Accreditation improves educational programs and graduates from these programs provide better quality health care.

Students - They can expect their institution to meet a level of quality that is worthy of their money, time, and effort.

Educational institutions - Competitive in today's student recruitment market.

Health care employers - Can assume that graduates of accredited programs have similar skills and that they have met the requirements expected of all entry-level practitioners.

Furthermore, accreditation offers many positive features to disciplines and occupations. The presence of accreditation adds validity to the profession's claims to quality, increasing consumer confidence at all levels.

For the public, accreditation promotes the health, safety, and welfare of society by assuring competency of public health professionals. Accreditation promotes public trust in educational programs by ensuring accountability and transparency. Accreditation facilitates global recognition and comparability of educational programs.

VI. IOMP INITIATES TOWARDS ACCREDITATION OF MEDICAL PHYSICS EDUCATION AND RESIDENCY PROGRAMMES.

IOMP is established in 1962 and is dedicated to improving medical physics worldwide by disseminating systemized knowledge through education and training of medical physicists, to advance the practice of physics in medicine by fostering the education, training, and professional development of medical physicists. For harmonization of medical physics education program as per the IOMP Policy Statement No. 2 which provides general guidelines for member organizations in defining the basic requirements for education and training of medical physicists. It aims to serve as a reference for medical physics organizations, education institutions and health care providers and authorities in planning and development of their national infrastructures for education, training, and certification of medical physicists and for maintenance of standards of practice. To accomplish the goals, IOMP Accreditation Board [AB] has been set up in 2016 to ensure that accredited medical physics programs satisfy the highest standards established by IOMP in collaboration with other international organizations.

The IOMP accreditation board accredits medical physics degree/Post graduate programs, medical physics education and training institutions/centres, residency program and education and training events.

VII. ACCREDITATION STANDARDS FOLLOWED BY IOMP ACCREDITATION BOARD

Applicants must meet standards to be accredited in accordance with

1. IAEA Publication, Training Course Series No. 56 (Endorsed by the IOMP) which also incorporates the IOMP Model Curriculum: http://www-pub.iaea.org/books/IAEABooks/10591 /Postgraduate-Medical-Physics-Academic-Programmes
2. IOMP Policy Statement No. 2 'Basic requirements for education and training of medical physicists'

   https://www.iomp.org/wp-content/uploads/2019/02/iomp_policy_statement_no_2_0.pdf

The IOMP Accreditation Board ensures the Standards are met by the institute/University imparting the Medical Physics education covering all the aspects. Resources alone are not sufficient to assure quality. Evidence must be obtained that assures that the educational institution and specifically the Medical Physics education program monitor the performances of the graduate, post graduate and that they are indeed able to demonstrate successful achievement of the program goals.

For accreditation of Medical Physics education programme IOMP accreditation board scrutinises the information from following fields

1. Status of the institution
2. Governance & administration
3. Vision, mission, objectives
4. Courses/programmes, curriculum & graduate outcomes
5. Approach to teaching & learning
6. Planning, programme review & quality assurance mechanism
7. Level of internationalisation

8. Physical resources and facilities
9. Student support services
10. Industry advisory board
11. Staffing resources
12. Financial resources
13. Membership, partnership, and community engagement
14. Areas of Excellence

The very first MPE program accredited by IOMP accreditation Board [AB] was master's Medical Physics [MMP] program of ICTP- Trieste University, Trieste, Italy for 3 years from 1 November 2016 and process continued. IOMP AB has accredited and re-accredited the following MPE programs.

VIII. MASTERS IN MEDICAL PHYSICS PROGRAM ACCREDITATION BY IOMP ACCREDITATION BOARD

1. The Catholic University of Korea – Full Accreditation
2. KAIST University – Full Accreditation
3. Yonsei University – Full Accreditation
4. ICTP-Trieste University joint Master of Advanced Studies in Medical Physics- Full Accreditation
5. Fundación Médica de Río Negro y Neuquén (FMdeRNyN), and Facultad de Ciencias Médicas de la Universidad Nacional del Comahue (UNCo), Río Negro, Argentina - The postgraduate program (3 years) in Medical Physics specialized in Radiotherapy, Nuclear Medicine, and Diagnostic/ Interventional Radiology- Full accreditation.

IX. MASTERS IN MEDICAL PHYSICS PROGRAM RE-ACCREDITATION BY IOMP ACCREDITATION BOARD

1. ICTP & Trieste University joint Master of Advanced Studies in Medical Physics, Trieste, Italy. Re-accredited for 5 years (1 August 2022 – 31 July 2027)
2. The Catholic University of Korea, Seoul Republic of Korea – Re-accredited for 5 years (1 January 2023 – 31 December 2027)
3. KAIST University, Daejeon, Republic of Korea – Re-accredited for 5 years (1 January 2023 – 31 December 2027)
4. Yonsei University, Wonju, Republic of Korea – Re-accredited for 5 years (1 January 2023 – 31 December 2027)

The details about the IOMP accreditation procedure, accreditation manual, the application forms and accredited program are available at https://www.iomp.org/accreditation/

X. IOMP ACCREDITATION OF CONTINUING PROFESSIONAL DEVELOPMENT [CPD] EVENTS

As per IOMP policy statement 1, Medical Physicists working in healthcare environment are health professionals and need to be certified as Clinically Qualified Medical Physicists [CQMP] according to IAEA HHS 25 guidelines endorsed by IOMP. To maintain and enhance the professional competence, and the ability to work independently, practising medical physicists should undertake a continuing professional development (CPD) programme which should include attendance at national and/or international conferences and courses on topics related to their field of specialization. They should also regularly consult relevant scientific journals and literature. To maintain the certification/licence as CQMP, medical physicists need to acquire certain CPD points by attending/participating in educational/training programmes. CPD is one of the essential measures in maintaining professional competency, particularly for certified CQMPs. Its goal is to keep professional knowledge and skills up to date. The concept of CPD varies from country to country, but, in general, includes participation in educational and scientific activities such as conferences, symposia, courses and workshops, and education and training duties of medical physicists and other clinical professionals. The educational /training programmes awarding CPD points needs to be accredited by authorised/recognised accreditation board. Formal CPD programmes should include an evaluation mechanism, such as a credit-based system, where CQMPs are awarded CPD points for each activity they participate in. These should form part of the criteria for re-certification as CQMP. To encourage CQMP's to acquire the CPD points through Continuing Professional Development events by acquiring the CME/CPD points, IOMP has started in 2019 the accreditation of CPD events provided by educational institutions, professional and scientific associations, hospital departments, units or divisions, research organizations and other scientific organizations. IOMP does not accredit CPD events organized by the industry. The concept of CPD is related to knowledge, skill and competence acquired during lifelong learning. The outcome of CPD should lead to an improvement in professional practice.

The IOMP accredits CPD events conducted/organised by:

1. Educational institutions
2. Professional and scientific associations
3. Hospital departments, units, or divisions
4. Research organizations and other scientific organizations.

The IOMP does not accredit CPD events organized by the industry.

XI. IOMP CPD ACCREDITATION STANDARDS REQUIREMENTS:

- Target audience - A clearly defined target audience
- Learning objectives of the program - Clearly defined learning objectives and a clear statement of what a participant is expected to learn. The learning objectives must be specifically defined to indicate what knowledge, skills and competences participants are expected to obtain after attending the activity.
- Program contents and structure- A detailed statement outlining the contents and structure of the program and the expected outcome.
- Teaching methodology - A clear statement about what teaching methodology will be used (lectures, presentations, discussions, technical demonstration, hands-on training)
- Supporting information - Supporting information should be sufficient to support the learning outcome; material should be accessible and up to date at the time of the event.
- Teaching staff - The organizers of the activity should demonstrate that the teaching staffs are qualified to deliver the educational programme and meet the learning objectives.
- Evaluation and quality assurance- There should be a clear statement outlining how the organizer will conduct an evaluation of the activity.
- Commercial interest - Education providers must guarantee that non-biased education is given.
- Administrative arrangements and verification of attendance- The organizers of the activity should describe the mechanism in place to record and verify participation (attendance list, badges, etc.).
- Details of financial support from organisation/ company/ firm/ foundation etc.

List of CPD accreditation by IOMP Accreditation Board

1. CPD: Dosimetry of Small Fields in External Beam Therapy: Reference and Relative Dose Determination 2nd – 4th October 2019, SCMPCR Training Room and National Institute of Cancer Research and Hospital (NICRH), Dhaka, Bangladesh.
2. ICMP 2019 (ALFIM), Santiago, Chile, 8 – 11 September 2019.
3. CPD: Hands-on Workshop: Commissioning, Planning and Quality Control for the IMRT/VMAT Treatment Techniques. 25th – 27th April 2020, University of Colombo, Sri Lanka and National Cancer, Institute, Maharagama, Sri Lanka
4. Universität Heidelberg (Germany) Online Teaching Course: Particle Therapy, September 2020.
5. CPD: SCMPCR E-learning Program (ELP-03): Basic Principles and Advanced Clinical Applications (webinar platform) 5-26 Feb 2021.
6. MEFOMP virtual conference, 5 -7 April 2021.
7. Virtual Summer School 2021: Image Guided Radiation Therapy (IGRT) and Advanced Treatment Techniques during Sept. 20th – Nov. 14th, 2021, German Cancer Research Center (DKFZ)
8. Online Teaching Course Particle Therapy- program during 22- 26 November 2021. German cancer Research Center (DKFZ).
9. SCMPCR E-learning Program (ELP-05): Advanced Techniques in Radiotherapy1st October 2021 – 22nd October 2021, Dhaka, Bangladesh.
10. 4th Summer School in Medical Physics: Radiobiology and Biological Modelling for Radiotherapy, German Cancer Research Center (DKFZ), 5 – 30 Sept 2022
11. Course type 3: Online teaching course “Particle Therapy” online phase Oct. 17 – Nov 20, 2022, online phase Nov. 21- Nov 25, 2022, German Cancer Research Center (DKFZ).
12. SCMPCR E-learning Program (ELP-06): Clinical Medical Physics in Modern Radiotherapy Date:01 July 2022 – 22 July 2022.
13. SCMPCR Hands-on Workshop (HW-06): Modern Quality Assurance in Modern Radiotherapy during 15th – 18th February 2023.
14. MEFOMP2023 Medical Physics conference, 19–22 May 2023, Muscat, Oman.
15. Online Teaching Course “Particle Therapy”, OCT. 09 – NOV. 19, 2023, German cancer Research Center (DKFZ)

XII. IOMP ACCREDITATION OF MEDICAL PHYSICS RESIDENCY PROGRAMS

The objective of the medical physics residency program is to develop human resources as a professional medical physicist (Clinically Qualified Medical Physicists - CQMP) who is competent to participate actively in the individual clinical field independently. To accomplish this goal, adequate organization, facilities, staff, patience, and educational environments should be provided. The major outcome of the residency program should be to provide residents with clinical training in a hospital under certified/qualified medical physicists so as to acquire the required practical skills and professionalism. The medical physics residency programme should be conducted in a clinical environment, having adequate infrastructure and the facilities to support resident education and training. The staff involved in teaching and training should have adequate training and experience. Further the equipment and instruments specific to the specialty concerned should be available. The duration of clinical training should not be less than 2 years' full time equivalent for a given specialty. The training should be carried out under the direct supervision of a qualified/certified and well experienced medical physicist in the area of specialty who can be designated as clinical training supervisor of the resident. If a candidate desires to undergo clinical training in two specialties in the same institution, the duration of the clinical training should not be less than 3 years full time equivalent. The competency-based assessment approach should be adopted.

IOMP accreditation board scrutinises the information from following fields,

Specialty specific requirements for accreditation for radiation oncology physics, diagnostic and interventional radiology physics, nuclear medicine physics are given in the manual, the broad parameters are,

1. Institution and staff
2. Program director
3. Equipment and other resources
4. Clinical/Practical Training areas/topics

The details and application forms available at https://www.iomp.org/wp-content/uploads/2020/02/IOMP-Accreditation-of-MP-Residency-manual-application-form-11-February-2020-AAC.pdf

Residency Program accreditation by IOMP Accreditation Board

1. The Residency program (1 year) in Radiotherapy Physics at Fundación Médica de Río Negro y Neuquén (FMdeRNyN), and Facultad de Ciencias Médicas de la Universidad Nacional del Comahue (UNCo), Río Negro, ARGENTINA- Full accreditation
2. The Residency program (1 year) in NM&DIR Physics at Fundación Médica de Río Negro y Neuquén (FMdeRNyN), and Facultad de Ciencias Médicas de la Universidad Nacional del Comahue (UNCo), Río Negro, ARGENTINA- Initial accreditation

XIII. SOME OF IMPORTANT BENEFITS OF IOMP ACCREDITATION

- Reputation of accredited programs and courses which will result in more demand for these education and training activities.
- Provision of an international dimension to an education event that will attract participants from other countries.
- Evidence of highest teaching standards and best preparation of medical physicists for the work environment
- Publication of accredited programs and courses on the IOMP website

The IOMP accreditation Board for 2022-25

Prof. Arun Chougule, India – Chair
Prof. Golam Abu Zakaria – Vice Chair
Prof. Rodolfo Alfonso, Cuba
Dr. Huda Al Naami, Qatar
Dr. Christoph Trauernicht, S. Africa
Prof. Shinji Kawamura, Japan
Dr. S.D Sharma, India
Dr Laura Padilla, USA

IOMP issues the accreditaion certificate cetificates to accrediated programms


International Organization for Medical Physics (IOMP)

CERTIFICATE OF ACCREDITATION

Radiation Therapy Physics
Korea Advanced Institute of Science and Technology (KAIST)
Daejeon, S. Korea

The IOMP accreditation board certifies that the Radiation Therapy Physics Postgraduate Course, at Korea Advanced Institute of Science and Technology (KAIST), Daejeon, S. Korea having met its requirements is granted accreditation

Commencing 1st August 2019 until 31st July 2022

Professor Arun Chougule
Chair, Education and Training Committee &
Chair, Accreditation Board

Masters Level Program
ACCREDITED

Professor Madan Rehani
President, IOMP


International Organization for Medical Physics (IOMP)

CERTIFICATE OF RE- ACCREDITATION

Medical Physics Postgraduate Course
Department of Biomedicine & Health Sciences, College of Medicine, Catholic University, Republic of Korea

The IOMP accreditation board certifies that the Medical Physics Postgraduate Course, at Catholic University, Seoul, Republic of Korea having met its requirements is granted re- accreditation

Commencing 1st January 2023 until 31st December 2027

Professor Arun Chougule
Chair, Education and Training Committee &
Chair, Accreditation Board

Masters Level Program
ACCREDITED

Professor John Damilakis
President, IOMP


International Organization for Medical Physics (IOMP)

CERTIFICATE OF ACCREDITATION

Master of Advanced Studies in Medical Physics (MMP)

International Center for Theoretical Physics (ICTP) &

Università degli studi di Trieste

The IOMP accreditation board certifies that the MMP having met its requirements is granted accreditation

Commencing 1st November 2016 until October 31, 2019

Professor John Damilakis
Chair, Education and Training Committee

Masters Level Program
ACCREDITED

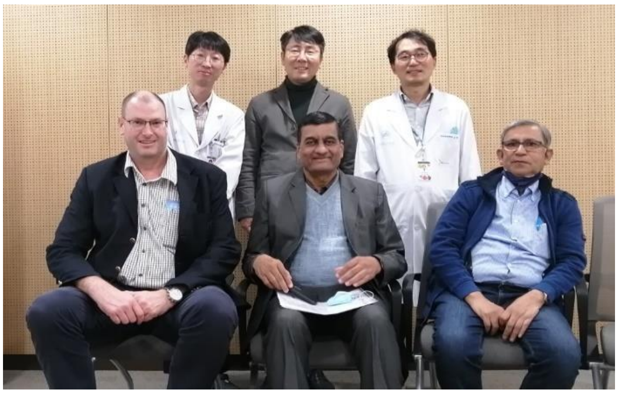
Professor Slavik Tabakov
IOMP President

Appendix: Photos taken during IOMP accreditation visit.

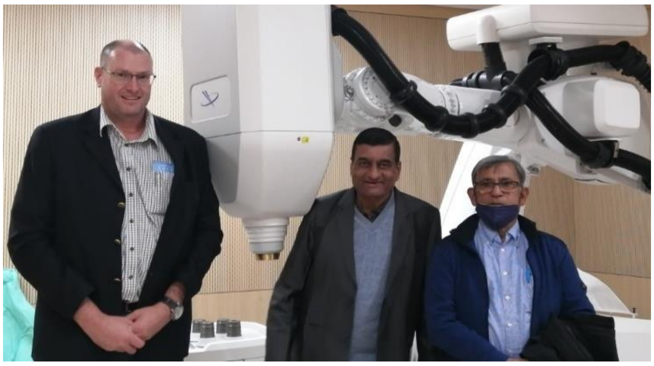
Tour of St. Mary's Hospital

KAIST faculty and students

Re-accreditation at Yonsei University



Asan Medical Center, S Korea



Programm Discussion with Prof. L Bertocchi and Prof Renato Longo, ICTP, Trieste, Italy

Interaction with First year students in Info Lab, ICTP, Trieste, Italy

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A NOVEL CURRICULAR MODEL FOR MEDICAL PHYSICS AND RADIATION PROTECTION EDUCATION – AN ALTERNATIVE POSSIBLE WAY FORWARD FOR AFRICA?

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[1] Medical Physics, University of Malta, Msida, Malta

***Abstract*— In Malta, the Medical Physics and Radiation Protection professions have, in recent past, faced an acute shortage of entrants owing to the low popularity of two-year Masters programmes (including the one in Medical Physics) and the very low number of undergraduate physics graduates. A formula needed to be found to: (a) address the paradox of having to reduce the Masters programme to a single year at a time when the knowledge-skills-competences required for modern medical physics and radiation protection practice are expanding rapidly, (b) ensure that the potential stock of entrants to the Masters would be independent of erratic student numbers in undergraduate physics. We also wanted to address what we believe are shortcomings of the present curricular model of medical physics education, particularly the low level or even non-existence of medical science, soft skills, professional issues and hospital experience. An extensive literature review of current issues impacting the medical physics and radiation protection curriculum was carried out. We also surveyed medical physics programme curricula worldwide; best practices were identified and used as further inputs to the model. Very importantly, the programme also needed to be cost-effective and attractive to the young people of today. We have opted for a four-year undergraduate inter-faculty programme that combines physics, medical physics, and radiation protection followed by a single year Masters in medical physics. This innovative curricular experiment has been a great success and has attracted many students. The inter-faculty nature of the programme (where students share lectures with both physics students from the Faculty of Science and healthcare students of the Faculty of Health Sciences) together with the element of clinical practice have been found to be the most appealing features. We have succeeded to develop a state-of-the-art programme at minimal cost.**

Keywords— **medical physics, radiation protection, curriculum development, professional issues.**

I. INTRODUCTION

The impetus for this curriculum development project started off from two very pragmatic issues: (a) Traditionally the qualifications framework for Medical Physicists consisted of an undergraduate degree in physics, followed by a Masters in medical physics. However, the number of students taking undergraduate physics has plummeted in many countries. How can one ensure sufficient applicants to the Masters in medical physics hence guaranteeing the development of the profession and the necessary human resources for the development of healthcare services? How can we ensure that the number of entrants to the Masters in medical physics be independent of what happens in physics? (b) Owing to the wide range of content that needed to be covered, Masters programmes in medical physics have in the past been of a two-year duration. However, two-year Masters programmes have lost their popularity over the last years as for economic reasons students are unwilling to forgo two years salary and prefer single year Masters programmes. In addition, though undergraduate programmes are often free, the same often does not hold for post-graduate programmes which often carry tuition fees again making uptake even less attractive. However, reducing the Masters in medical physics programme to a single year is problematic as it is found to be nigh impossible to compress the two-year content of a regular Masters programme into a single year particularly at a time when the number and complexity of medical devices and the use of physical agents in healthcare is expanding rapidly. Medical Physicists today need to not only deal with ionising radiation and all three associated specialties of medical physics (D&IR, RO and NM) but also ultrasound, MRI, advanced image processing software, artificial intelligence (including pattern recognition and machine learning), advanced mathematical techniques such as Monte Carlo and computational methods (e.g., iterative image reconstruction). In addition, given the many developments on the professional front, certain obvious lacunas that have lowered the quality and appeal of our programmes needed to be addressed - in particular the low anatomy/physiology/pathology content (how can we be taken seriously as a healthcare profession without a strong component of these in our curricula?), the quasi-total absence of hospital experience and the low attention to legislation, soft skills (communication, inter-professional skills, management) and strategic leadership skills which are so critical for our students to be able to survive in the complex environments in hospitals today. Finally, the curriculum needed to be attractive to physics students and very importantly its cost had to be minimal.

II. MATERIALS AND METHODS

We aimed for a state-of-the-art curriculum which would be valid not only in the present but also for the next future. We therefore carried out an extensive literature review to identify the issues impacting the present and envisaged future development of the medical physics profession. These issues are listed in Table 1. We also surveyed medical physics undergraduate and Masters programmes via the internet; best practices were identified and used as further inputs to the curriculum development process and the outcome curriculum model.

Table 1: Issues impacting the development of the medical physics profession and curriculum.

Area	Issues
Technological and Scientific	The rapid expansion in the number and complexity of medical devices The rise of artificial intelligence (including pattern-recognition, machine-learning) [1] Need for increased scientific / mathematical/ statistical /programming skills.
Professional	EFOMP Policy Statement on Education and Training 12.1 [2], Malaga Declaration [3] and Medical Physics 3.0 [4]: the role of the medical physicist should be expanded to *all* medical devices and *all* physical agents and include a high level of involvement in service development and patient care. Need for high scientific leadership skills. Need for a higher level of medical sciences. Need for higher level of soft skills [5]
Economic	Low university budgets The threat of commoditization [6] Inter-professional competition [6] Need for strategic leadership skills [6]
Social and Legal	Political pressure for higher standards of patient service and safety and associated legislation Political pressure for higher standards in occupational and public safety with respect to *all* physical agents (not only ionising radiation) and associated legislation

III. Results

In order to maximise the appeal of the programme to pre-university students and increase their future employment opportunities we opted for an undergraduate degree which involves *all three of physics, medical physics and radiation protection (BSc (Hons) Physics, Medical Physics and Radiation Protection)*. Hence graduands of the programme can go on to further studies or seek future employment in all three areas. It also has the advantage of ensuring strong physics and mathematics foundations whilst including sufficient medical physics and radiation protection content to permit us to reduce the duration of the Masters in medical physics programme from two years to one. The Bachelor programme is a four-year programme to ensure comprehensive robust cover of the necessary content. Since the programme is a Bachelor programme it does not carry a tuition fee.

A. Structure of the Bachelor programme

The overall structure of the programme can be found in Table 2 (number of asterisks indicates weighting). A description of the programme and full curriculum can be found here https://www.um.edu.mt/courses/overview/UBSCHPMRFT-2022-3-O and here https://www.um.edu.mt/courses/programme/UBSCHPMRFT-2022-3-O.

The programme consists of five parallel strands.

The first strand includes all the essential physics and mathematics-for-physics study units normally found in any regular Bachelor physics programme. Our students attend the same Physics classes as the regular physics students of the Faculty of Science. This ensures a solid foundation in physical science, mathematics, statistics and computational methods, and very importantly the strong problem solving and analytical skills so critical for higher level medical physics and radiation protection competences. It also ensures that our students maintain close ties to their physics roots; a link which would be very useful in their future careers in medical physics and radiation protection. It also keeps open the possibility for them to continue for higher studies in physics as opposed to medical physics or radiation protection should they wish to. The physics staff are pleased with the higher number of students taking their classes. Very importantly, since our students are joining the regular physics groups, the cost of these study units for our programme is zero.

Table 2: Structure of the undergraduate curriculum

Year	Physics Mathematics Statistics Programming	Anatomy Physiology Pathology	Medical Physics Radiation Protection	Hospital Clinical Practice	Research Ethics Legislation Professional Issues
4	**		*****	112 h	***
3	***	*	****	112 h	*
2	****	**	**	112 h	*
1	****	****	*		*

The second strand consists of an anatomy /physiology/pathology strand. A good grounding in the medical sciences is required of all healthcare professionals and Medical Physicists are no exception. X-ray physics and medical devices as well as ultrasound and MRI are of little value unless we link them with a good knowledge of anatomy so that we can liaise with Radiologists and Radiographers. Radionuclide physics and gamma sensors are meaningless unless they are linked with physiology and pharmacology so that we can work as a team with Nuclear Medicine Physicians and Nuclear Medicine Radiographers. Monte Carlo techniques are worthless if not tagged to anatomy and radiobiology-based treatment planning. Medical Physicists have in the past been criticized for not involving themselves at a deep level in the everyday challenges of clinical departments; *this needs to stop. We must accept this criticism with humility, avoid excessive professional pride and do* *something about it.* In these study units our students join shared common units taken by Radiographers, Physiotherapists and other healthcare professions. This has the major advantage that they learn to appreciate and work with other healthcare professions and other healthcare professionals in turn learn about our own profession. Again, since our students join already established study units, the cost for the programme is zero.

The third strand involves medical physics and radiation protection study units. These study units lay the foundations for and serve as an introduction to the various specialties of medical physics which are then studied at a higher level during the Masters. They also lay the foundations of occupational and public radiation protection, not only for medical uses but also for industrial and environmental protection. This has the advantage of expanding the employment opportunities of our graduates beyond the medical arena should they wish to do so. The lectures are delivered by both academic and hospital Medical Physicists ensuring strong theoretical and clinical foundations. These study units obviously carry a cost for the programme as they are specifically for medical physics and radiation protection students. Their cost is provided mostly by money that would have been allocated to the budget of the previous two-year Masters in medical physics which has been since reduced to one academic year. There is therefore minimal increase in overall costs.

The fourth strand involves clinical hospital practicals. At the moment we divide each cohort into smaller groups which rotate around the departments associated with the three main specialties of medical physics. We leave the organization of the practicals in the hands of the clinical Medical Physicists so that they may adjust the programme according to their actual clinical duties and to any opportunities arising such as the introduction of new equipment. In future, we plan to expand these practicals to other clinical areas such as physiological measurement and also to industrial locations. It is important that in parallel with the hospital practicals, students are supported by discussion sessions so that they be helped to understand that it is normal to note differences between what they experience directly in the real world of clinical practice and the future desired higher vision for medical physics and radiation protection services for the country - a vision which they themselves are being invited to help build.

The final strand involves research, legislative, ethical, soft and professional skills. Many of these study units (e.g., healthcare ethics, principles of healthcare research, healthcare management, academic English, communication) are shared units and again carry no cost. The same holds for physics research-oriented practicals as students join the regular physics students. Some areas such as professional issues are specific for medical physics students and carry a cost. In terms of research project, we have at the moment included a short 10ECTS dissertation in medical physics/radiation protection, however we would also like to add a second short 10ECTS dissertation in physics.

B. Content of the Masters programme

The content of the Masters programme can be found in Table 3. One should notice that all three specialties of medical physics are given a high weighting to ensure that students can apply for any post-Masters traineeships available and in any specialty of their choice. In addition, advanced signal and image processing and artificial intelligence (pattern recognition and machine learning) feature strongly.

Table 3: Content of the Masters programme

Study Unit	ECTS
Medical physics and radiation protection in radiation oncology	10
Medical physics and radiation protection in nuclear medicine and radioisotope cyclotron facilities	10
Medical physics and radiation protection in diagnostic and interventional radiology and dentistry – *Ionising* imaging modalities	10
Medical Physics and Radiation Protection in Diagnostic and Interventional Radiology and Dentistry - *Non-Ionising* imaging modalities	10
Advanced signal and image processing for physiological measurement and medical imaging	10
Machine learning and pattern recognition	10
Research dissertation	30

IV. DISCUSSION

We will now discuss the major issues that needed to be addressed and the way they were tackled.

A. Cost of the programme

One of the determining issues in today’s world is that of cost. If the cost of a curricular programme is high the proposal will be rejected by the university authorities. This is particularly relevant in the case of professions such as medical physics which notwithstanding their importance to society have little political clout. The cost of the programme was reduced to a minimal level in several ways. If we consider the undergraduate programme, the physics/ math/ statistics/ programming strand, the anatomy/ physiology/ pathology strand and a sizeable chunk of the research/ ethics/ legislation/ professional strand come *at zero cost as our students simply join established classes*. *The good news is that these three strands constitute a major chunk of the Bachelor programme*. The only costs are essentially the medical physics and radiation protection study units, the hospital practicals and the research projects.

During the clinical practicals, students join whatever is happening in the various departments at the time and shadow the clinical physicists. We do not insist that specific practicals are set up for the students as this would create too high a burden on our clinical colleagues and increase the cost of the programme. At the undergraduate level it is sufficient that students get a feel of the real hospital world by shadowing Medical Physicists in action. After all, in most countries in the world, Medical Physicists have their officially recognized training programme following the Masters. During these clinical practicals, the students can experience not only the many medical devices but also the various types of radiation detectors and radiation monitors hence obviating the need for us to set up and maintain our own radiation laboratory. The costs of setting up a specialized radiation laboratory and its maintenance and technician costs would be sufficiently high as to destabilize the initial and running cost budgets of the programme. Updating the equipment on an ongoing manner would also be a significant cost.

The medical physics / radiation protection research projects (undergraduate and Masters projects) are specific to us and do carry a cost. However, we have an agreement with clinical hospital directors such that our students do clinical service development-oriented projects. This is a symbiotic relationship - our students help develop the service with their projects and in turn we can use hospital equipment without cost. This arrangement has the advantage that our students work with modern equipment which is in actual service. When funds are low it is best to invest the available funding on improving the program for the students such as by inviting international experts to give lectures on state-of-the-art topics where the expertise is not locally available. Practicing Medical Physicists can be invited to these presentations hence providing CPD opportunities to the profession.

B. Summer school in human biology

During market research discussions with potential students from pre-university colleges, it was becoming clear that although such students found the Bachelors programme appealing there was an issue of major concern. This was related to the fact that pre-university physics/mathematics students do not have a background in biology a would find it difficult were they to join students from other healthcare professions during anatomy, physiology and pathology since students of these professions often had a background in pre-university biology. We solved this problem by having a pre-course summer school in human biology (I have my first daughter to thank for this idea!). Applicants for the programme are offered a free online set of lectures in human biology over the two summer months preceding the start of the course programme. Since many students work during the summer it was found impossible to find a common time for synchronous online sessions. Therefore, lectures were recorded and could be followed by the students asynchronously on any day and at any time of their choosing. Students were encouraged to submit any difficulties via email during both the summer school and during the first year of the programme. We are pleased to report that the summer school has been a success and students have not had any major difficulties in their medical sciences classes. However, students who opt not to attend the summer school find that they would need to work much harder during the first few months of the programme to make up.

C. Interfaculty problems for students

Our course programme is an inter-faculty programme in which our students have the opportunity to use the resources of both the Faculty of Science and the Faculty of Health Sciences. This has of course major advantages, but it also sometimes creates problems for the students as they have to deal with two groups of academic staff members with two entirely different ethoses. Physicists who have spent their lives in the physics milieu tend to be more theoretical and scholarly in their approach whilst academic and clinical Medical Physicists get their inspiration more from the real world of hospital practice. We have ongoing discussions with the students about this and we explain to them that one important role of the medical physicist is to help bridge this dichotomy between the theoretical world of physics and real-world practical milieu of healthcare. Another difficulty for the students is that they have to deal with two sets of administrators. We have solved this problem by having an inter-faculty board of studies with members of staff (both academic and administrative) from both faculties and with strong student representation.

D. Marketing the programmes

The major selling point of the undergraduate programme is that since it includes physics, medical physics and radiation protection, that is, both pure and applied physics – this means that the range of employment opportunities for graduands is very wide. Table 4 lists some opportunities. We have found that physics and mathematics pre-university students have an appetite for knowing about the human body and health issues - areas of knowledge which those taking the physical sciences lack – and this is highly motivating for them. Many physics students find the applications of physics in medicine interesting and challenging. *It is important to emphasize the summer school in your marketing campaign as this allays their concern regarding human biology*. The single year Masters has a lot of applicants and the issue with low numbers has been resolved. The students of the Bachelors programme having just completed a four-year programme view the single year Masters as an easily doable option and as a natural extension to their undergraduate studies.

D. Students coming to the Masters from physics.

Students who enter the programme from physics and not through our Bachelor programme do not have a background in medical physics and radiation protection. These students are again offered attendance to the summer school in human biology. They are also encouraged to voluntarily attend undergraduate units concerning medical sciences, ethics, healthcare research methods, legislation and professional issues. Such students have the option of choosing either clinically oriented research projects or more technically oriented projects should they wish to do so.

V. CONCLUSIONS

A visionary yet pragmatic approach to medical physics and radiation protection education has been presented and discussed. The curricular programme addresses all the requirements for a modern and forward-looking programme yet at a minimal cost. In Malta, we are at the moment in the fourth year of the undergraduate programme, and we will have our first graduands from the Bachelor programme. We will also have a first intake for our redesigned Masters curriculum. The undergraduate programme has been a resounding success and we have many students. Most of these have already shown a wish to continue on to the Masters programme. The existence of the programme has been critical in boosting the number of students not only for medical physics and radiation protection but also for physics itself. It has been a win-win situation.

Table 4 Employment and further study opportunities for graduands of the programme

Area	Opportunities
Physics	Further studies and research institutions in all areas of Physics All employment areas which require a Physics degree Physics teacher: secondary, pre-university, university Industry Radiation laboratories Software development and data science industry National statistics office
Medical Physics	Further studies and research in all areas of Medical Physics Clinical Medical Physicist in public/private hospitals Dental clinics Medical/biomedical research institutions Public/private hospitals Radiopharmaceutical production (e.g., cyclotron facilities) Medical device vending: company representative, marketing, consultancy, application specialist, system installation, critical examinations. Health authorities: consultant re medical devices and software, health technology assessment, international, regional and national legislation and guidelines Medical device manufacture Radionuclide / radiopharmaceutical production Medical device regulatory authorities
Radiation Protection	Further studies and research in all areas of radiation protection Industrial uses of radiation (e.g., airports, shipbuilding, industrial radiography, food industry, customs) Environmental (e.g., national radiological preparedness and emergencies, radiation monitoring of the environment, environmental contamination Officer with the national radiation regulatory authority As an expert consultant on policy and review of local implementation of legislation, drafting of national guideline and documentation. Radiation Protection Expert Nuclear energy industry
Others	Researcher: local/overseas industries/universities, International, regional and national projects, research and development in industry As an auditor / inspector to ensure hospitals, industries, research laboratories conform to legislation. Member of examination board to assess and certify radiation professionals. Employment with European/International institutions: IAEA, IEC etc

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THE HARMATTAN SCHOOL FOR MEDICAL PHYSICS: A THREE-YEAR REVIEW OF THE "CATCH THEM YOUNG" PROJECT

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Abstract— **The inaugural IPEM LMIC sponsorship award became a full-fledged partnership project between the Nigerian Association of Medical Physicists (NAMP) and the Institute of Physics and Engineering in Medicine (IPEM), and this gave birth to the annual medical physics harmattan school program for undergraduate physics students as a way to encourage more people to consider a career in medical physics and by effect increasing the number of qualified medical physics professionals in the country. The Covid-19 pandemic caused some modification especially with the lectures which were rendered virtually. In the maiden edition of 2021, a very far-reaching impact was already created as 99.4% of participants had increased knowledge of medical physics due to the harmattan school, 98.3 % were eager to participate in subsequent editions while all participants said they would recommend others to participate. After three editions, the number of participants increased by 12 %. While the harmattan school was specifically aimed at the undergraduates, more postgraduate students and even participants gainfully employed were increasingly becoming interested in the harmattan school. The female and foreign participants were also interesting features of the harmattan school which recorded significant increase. In fact, female participants in 2023 edition stood at 46 % while foreign participants rose to an unbelievable 38 %. The medical physics harmattan school proved to be an effective method of recruiting scientists into medical physics profession which is currently experiencing an acute shortage worldwide; it is also recommended for adoption in developing countries where none existed.**

Keywords— **NAMP, IPEM, Harmattan School, Medical Physics, Nigeria**

I. INTRODUCTION

Medical Physics can be simply defined as the application of physics in medicine. It is a branch of physics where theoretical and experimental methods and principles of physics are directly applied in medicine and health. This field came into more limelight when Wilhelm Roentgen in 1895 and Henry Becquerel's in 1896 discovered X-rays and radioactivity respectively. These discoveries actually accentuated the study of radiation medical physics; medical physics however has been a well-researched field of physics centuries ago. Physicists have a long time ago studied the physics of biological systems and possible medical application. Abbé Jean-Antoine Nollet (1700–1770) published his observations on the biological effects of electricity [1]. Later, Mauduyt de la Varenne (1732–1792) made critical study into the medical uses of electricity [2]. The inputs of physicists in medicine can never be overemphasized right from the beginning. Even in the heat of the French Revolution, Comte de Fourcroy (1755–1809), in 1791 launched a short-lived journal, La Médecine eclairée par les sciences physiques. In the introduction to the first issue, he lays out his own vision: "The study of medicine always starts with the study of physics. It is not possible to be a doctor without being a physicist." [3]

The first use of the term Medical Physics (or to put it more accurately, Physique médicale) was in Paris in 1778. The term was introduced by the general secretary of the Société royale de médecine, Félix Vicq d'Azir (1748–1794) [3] When Vicq d'Azir died shortly thereafter, he left a document that would, in due course, set Paris on the road to become the leading centre for medical training and research in Europe for the first half of the nineteenth century [4]. The document he left contained a plan, and this plan recommended that basic sciences, including medical physics, should be an essential part of medical training [5]. All these physicists led the way to the development of medical physics as we have it today, however we may credit the title of the founding father of medical physics to Jean-Noel Hallé, professor of medical physics and hygiene at the new École de santé (School of Health) in Paris (1754–1822) [6]. By 1814, a concise definition of medical physics in Nysten's medical dictionary was put forward.

Physics applied to the knowledge of the human body, to its preservation and to the cure of its illnesses. (Physique appliquée à la connaisance du corps humain, à son conservasion et à la guerison de ses maladie).[7]

Medical physics continues to make advances in many areas, and it will continue to expand since physics itself is all-encompassing. Medical physics courses cut across all the branches of physics, and it is safe to say that medical physics might be the only field where all the aspects of physics have an application. It is also fast becoming the most 'sort after' branch of physics. Pollard-Larkin, who earned her PhD in biomedical physics at UCLA, described her career as "the most rewarding thing I have engaged in." [8]

The Nigerian Association of Medical Physics (NAMP) was established in 1986 with a group of 4 members. To be a full member of NAMP, one must have obtained relevant bachelor's degree in Physics or engineering and postgraduate degrees in Medical Physics; MSc/MPhil/PhD from accredited universities [9]. The number of medical physicists has since grown through the years to about 250 registered members practicing in the academia, industries and hospitals. This statistic may pass for a success story at first thought, but with a population of 200 million people, a steady progressive rise in cancer burden and a need of clinically qualified MPs, the story is a far cry from hope. According to Tspaki et al's estimation, approximately 58, 950 MPs would be required by 2035 [10] with a special focus on Africa and Latin American/Caribbean regions. Nigeria, the most populous of these regions thus requires a radical approach to increase its MP workforce. While medical physics in Nigeria grapples with a myriad of problems, the lack of recognition presently being faced by existing MPs in the clinic compared with other health professionals, makes matters worse.

Summer school, as we have come to know it, is a type of education that is usually undertaken during summer in which academic and non-academic instructions and activities are taken by students. Extended periods of summer have been shown to make students relapse academically in a phenomenon known as "summer slide" upon resuming school during fall [11,12]. Summer schools thus come in to fill this academic gap, and this is perhaps one of the major benefits of summer school while at the same time not overlooking the opportunity open to students to learn some skills make friends and be energized psychologically for a new academic calendar. In most parts of the world, summer school programs are offered as part of an educational curriculum of a school or as an open independent study program for a field of interest. 'Summer' programs can either target undergraduate students, postgraduate students or professionals to expose them to areas within field of interest that they may not know much about.

In 2021, NAMP with the support of IPEM organized its first ever 'summer' school program for undergraduate physics and engineering students. This was an initiative formed to increase the number of physics students taking up careers in medical physics by stirring up their minds which will by effect hopefully increase the number of qualified medical physicists in the country. The Federation of African Medical Physics Organizations (FAMPO) reported the alarming shortage of medical physicist (1,041 medical physicists for a population of 1.2 billion!) of in the region [13]. The dearth of qualified medical physicists is even on a higher scale. This calls for an urgent consideration in finding ways to reduce this shortage before it becomes a serious emergency. In the light of the problem cited above, the medical physics summer (harmattan) school thus aimed to create more awareness of the role of physics in medicine and increase the number of qualified Medical Physicists in the country by inspiring undergraduate physics students to consider the Medical Physics profession.

II. Presentation notes

A. How it started

In 2019, IPEM through the then Vice President International, Prof Dan Clark OBE, launched an award in recognition of the challenges facing medical physicists and clinical engineers in Low- and Middle-Income Countries (LMIC). The award was aimed at supporting individuals in these countries, who showed potential as future healthcare leaders in the field of Physics and Engineering in Medicine and were able to demonstrate an enthusiasm and vision for developing professional activities in their local region. The main benefits of the award amongst others, included a 2-year sponsorship of IPEM membership, mentorship with a senior IPEM member, a certificate of recognition, 2 years support for development of professional activities and eligibility to apply for IPEM LMIC support grant. In January 2020, the first recipient of the award emerged, a member of NAMP. https://www.ipem.ac.uk/news/first-recipient-of-new-ipem-international-award-announced/

Medical physics in Nigeria needs renaissance, and the IPEM award presented an opportunity to make a worthwhile contribution. It was on this premise that the award would then be channeled towards relevant projects that would create, raise awareness and educate especially physics undergraduate students about medical physics.

B. The road to the harmattan school

A few project proposals for the development of medical physics in Nigeria were submitted to IPEM for consideration and approval. The first project that was approved was a medical physics school for creating awareness amongst undergraduate students. The aim of the school was also to expose participants to more areas of medical physics not practiced in the country, all with the intention of inspiring more physicists to consider a career in medical physics. The need for the school was stemmed from the challenge of the dearth of qualified medical physicists in the country. The proposal was approved, and it became a collaboration between IPEM and NAMP. In addition, NAMP were of the opinion that it was a very useful project for recruiting students for the postgraduate medical physics program and that it should run annually for 5 years. The school was planned to be held onsite in the 3rd quarter of 2020 in a location in the southwestern part of Nigeria. Unfortunately, the pandemic hit in the first quarter of the year. The first Covid-19 case in Nigeria was recorded on the 27th of February 2020. The country like the rest of the world, went into lockdown, and major activities were either stopped or restricted except for essential services like healthcare. This development caused the plans for the school to be suspended. Unfortunately, the severity of the pandemic continued and resulted in the continuous restriction of activities with large gatherings. The academic staff union of universities (ASUU) in Nigeria, about the same time were coincidentally on strike resulting in the shutdown of universities. Undergraduate and postgraduate students were sent home. From all indications, this meant that the school could not be held onsite as planned. It was therefore postponed to the end of the year with the hope that the restrictions of the pandemic would have been lifted and the strike by ASUU called off. While waiting for the next steps, it was observed that the most part of the world were quickly adapting to the 'new normal' of virtual meetings and e-learning. This new awakening prompted a possibility of organising the harmattan school virtually. After accessing all the variables on ground, the decision to hold the first school online in the first quarter of the following year was upheld.

C. WHY HARMATTAN SCHOOL?

The organisers recognised that although this was the first time an event such as this would be held in the country in the field, the need to standout and be unique was necessary. Most similar schools are held in the 'summer', at a time when most students are on break. Nigeria does not have a summer season and it became worrying to name a school 'summer school' when it was planned to be held in a country where there was no summer and in a season that had a unique identity in West Africa.

Nigeria has three seasons: rainy, dry and harmattan; the interface between the rainy and dry seasons. The harmattan season is characterized by hot, dry and low humid weather. Since Nigeria located in the tropical region of Africa does not experience the summer weather, the name 'harmattan school' was adopted to reflect our peculiarity. It was therefore agreed that it would be called "The harmattan school for medical physics".

D. THE PROBLEM THE SCHOOL TRIED TO SOLVE

In 2018, the global perspective of the medical physics workforce was reported, the global shortage of medical physicists in comparison with global clinical needs was studied. This study revealed the looming 'pandemic' in the medical physics workforce especially in Africa and Latin America/Caribbean [10], and of course Nigeria stands out as one requiring a drastic measure to increase its medical physics workforce. compared to other countries. Obed et al. 2016 [14] and Ige et al.2019 [15] previously reported the state of the medical physics workforce in the country. One solution proffered in all three studies was the need to create more awareness of the applications of physics in medicine and the role physicists play in medicine. The intention of the harmattan school was then to lure the participants into considering careers in medical physics with the long-term goal of improving the healthcare system of the country and producing quality professionals in the field. It became imperative to target the younger generation if we are to make significant impact in the years to come.

This huge shortage of medical physicists continues to make headlines especially in low- and middle-income countries. Lancet Oncology reported that 22,000 additional medical physicists would be needed to cover radiotherapy needs in low- and middle-income countries by 2035, [16] and this figure represents only medical physicists needed in radiation oncology alone. Particularly worrisome is the meager 54 medical physicists [15] for a 200 million population in Nigeria. It is this shortage coupled with the need to properly equip medical physicists with the requisite skill and knowledge that the harmattan school made its mandate.

E. THE MEDICAL PHYSICS HARMATTAN SCHOOL MODEL

Summer school programs are not new to Science, Technology, Engineering and Mathematics (STEM) community. They were developed and organized for several reasons: to serve as a means of bringing people together to learn a subject, for the purpose of networking, and so on. They usually take the form of teaching, laboratory work, tours of facilities or a combination of all. Summer schools help build an educational system that is both globally competitive and epitomize higher academic standard [17]. Summer schools have been shown to improve thinking skills [18], help students advance their knowledge base of a particular subject area [19] and play an important role in closing the achievement gap [20] since research supports the fact that achievement gap widens even further for students categorized as low-income [21]; and since Nigeria is recognized as a low-income country, summer school will therefore profit a lot of students.

Summer school programs are held during summer period, and NAMP decided to organize its first ever 'summer' school program at that specific season of the year. The harmattan season is a season unique to western Africa occurring between the months of November and March; the harmattan school is thus scheduled during this period. Like most **'summer school'** programs, series of lectures covering relevant areas of medical physics were delivered over a few days with one day of virtual lab work. Although initially planned to be onsite, the onset of the Covid-19 pandemic and strict restrictions placed on large gatherings, altered the plans temporarily. In addition to the constraints caused by the Covid-19 pandemic, the country's higher institution lecturers were in a face-off with the government forcing the academic staff of universities (ASUU) to halt academic activities and by implication disrupting the academic calendars of government universities. This made it extremely difficult to decide on a period that would accommodate various applicants from different parts of the country. All these problems coupled with the Covid-19 pandemic led to the choice of virtual mode for the harmattan school. These challenges later became a blessing in disguise as the number and diversity of participants increased even as the pressure to get funds through sponsorships was greatly reduced due to the 'low cost' of virtual events. In addition to the lectures and to achieve the aim of improving the health care system in the long run, Do-it-yourself (DIY) projects were included to create hands on experience. The projects were carefully selected to initiate the interest of developing a mindset of fabricating medical equipment and devices locally. The aim also was to present an atmosphere where various interests could be accommodated in the field of medical physics. Being the first time, this would be organized, a few challenges which were foreseen could arise were averted due to the virtual program. Challenges like sponsorship, interest in participation due to varying academic calendars of higher institutions in the country, cost of in-person attendance, travel security concerns for students travelling down from extreme geographical locations etc. This model was created to bring modern ideas from developed communities while allowing local facilitators interpret these ideas in a way that can be understood properly by the audience.

While there are a good number of summer programs for medical physics like the AAPM, GI-CORE, EUTEMP, etc., it is important to highlight clearly that the harmattan school does not exist to compete but aims to tailor the teachings to a local audience with the aim of raising a generation of medical physicists who have an agenda for national and regional development through research, clinical and industrial practices. This we believe is the way out of the crisis currently facing Africa and Nigeria's education and health systems development. It could also serve as a way of stemming the brain drain.

F. THE INITIAL FORMAT:

The initial format was to select qualified students from a pool of applicants. These students would then be treated to a series of lectures, seminars, projects, break out discussion/project groups under the supervision of coordinators from Nigeria. The projects were supplied by IPEM members to be co-supervised on ground by NAMP members. There were six projects altogether, one was from an AAPM member. The College of Medicine of the University of Lagos was the preferred choice of the harmattan school, and it was to be a 5-day event. While plans were underway, on the 30th of March, Nigeria like the rest of the world experienced a Covid-19 visitation and thus went into lockdown. Restrictions were placed on large gatherings and even inter-state travels. The Covid-19 debacle gave way to explosion of online learning, and this virtual mode of learning became a 'new normal' worldwide. It was at this point that the need to convert the harmattan school program to a revised (virtual) one became necessary.

The revised program would comprise a 2-day online workshop and 4 weeks projects. The workshop consists of talks and lectures from medical physicists and engineers' home and abroad in industry, hospitals and academia. The DIY projects at different campuses across the country would be under the supervision of lecturers (coordinators) in such schools with undergraduate physics student selected from various tertiary institutions in the country. The projects will run for 4 weeks; two days of online workshop and the remaining weeks for the execution of the projects. Day 1 would be for introduction, day 2 would be projects/ teams formation and explanation of projects and introduction of team to their coordinators. Selection criteria would be based on the merit of the application. Students would form groups in their schools after selecting a project by ballot or assignment. Toolkits would be sent to various participants. They would agree on a day to meet to discuss their ideas. A maximum of 120 students from various universities would make up teams of 3 in their schools/states. Nigeria has 36 states in the federation and the selection would take care of the geographical spread of the schools such that students would not need to travel too far from their schools. Each coordinating centre would structure the project such that the timetable of the participating students' school would be factored in.

III. THE NEED FOR ESCALATION OF INTEREST IN MP

Nigeria with a population of about 200 million has a medical physics strength of 54 [15]; this translates to one medical physicist to 3.7 million people. The United States has over 10871 medical physicists [22] for a population of about 330 million people. This represents a ratio of one medical physicist to about 30, 0000 people. Comparing Nigeria with the US, it is about 123 times more incapacitated in providing medical physics services to its population. Furthermore, as at the time of writing this paper, there are only 8 institution offering medical physics at post graduate level as reported by [15] despite having 220 universities accredited by the Nigerian Universities Commission [23] This number is even expected to drop should Nigeria have a medical physics education regulatory body like those in the US, UK, Canada and Australia.

It is also not surprising that medical physics unlike other aspects of physics like atmospheric physics, solid state physics and so on are not offered as options at undergraduate level; even where they are, the medical physics courses lack in content and coverage. So, most students do not have the opportunity of knowing about the application of physics in medicine. A few, though, through the Student Industrial Work Experience Scheme (SIWES) training programs, get to have clinical experience before graduation. A major problem facing medical physics profession is shortage of qualified staff as reported in many literatures [10, 24, 25, 26, 27] while scientific and professional challenges form another cluster of problem area in medical physics since it is a profession that is highly dependent on scientific ideas. In fact, in their study [28], they identified four grand challenges of medical physics in radiation oncology (the major area of medical physics): (1) improving target volume definition, (2) adoption of artificial intelligence and automation, (3) development of predictive models of biological effects for precision medicine, and (4) need for leadership. The harmattan school thus seeks to address the education and training deficiency faced by practicing medical physicists while at the same time raise appropriate awareness to physics undergraduates, and very importantly prepare medical physicists for leadership roles which has become an important aspect if we ever want medical physics to move beyond the traditional role of just providing routine medical services. Leadership and mentorship are one of the key areas we need to fully explore and develop and move the medical physics profession from the status of always "explaining" it to "teaching" it. We need to prepare quality medical physicists who will build capacities in the profession and take the campaign outward because the recognition issue bedeviling medical physics in many countries as reported [29, 30] is directly related to the vague understanding of the role of medical physicists even among health professionals in radiation medicine safely attributed to no fault of theirs.

At this preliminary stage, the medical physics harmattan school attempts to raise awareness about medical physics in Nigeria with a view to getting more students to take up the medical physics profession that seriously needs a revamp. The harmattan school awareness was done through low budget publicity using social media. Google form was used as the application mode. Flyers were made and shared on the association's official website and social media platforms – WhatsApp, Instagram, twitter and Facebook. Figure 1 shows the e-flyers used for advertising the program in the three editions.

IV. THE FACILITATORS

In addition to the objectives of the school, one of the major things we wanted to showcase was the talents from Nigeria. There is this misconception people have generally about made in Nigeria and internationally imported items, the latter perceived as being of a better quality. This mindset has caused a slow growth in the empowerment of Nigerians generally speaking. The same mindset has found its way into our educational system. Taking the growing field of medical physics, where little is known amongst students, it is generally assumed that if you want a good medical physics education you have to look outside. That may have been true at the onset of the development of medical physics in Nigeria, but a lot has happened in the last decade. We decided that the harmattan school would be a good opportunity to create the balance and show young brilliant and passionate Nigerian medical physicists who were doing well in their endeavors. We hoped that it would also help to create a mindset of "I too can be like them" mentality. This of course did not overshadow one of the objectives of the school which was to also create awareness of the various applications of medical physics especially those which were not common in the country. This is where the facilitators from IPEM came in. They created the balance of bridging the gap between where we were as a country and where we hoped and ought to be. It is also important to note here that all facilitators both from NAMP and IPEM completely volunteered and were more than happy to be part of a program that was making a difference. In 2022 however we had two volunteers from the AAPM join the list of facilitators. The facilitators and the topics they taught are as presented in Table 1.

Table 1 Timetable for the 2021, 2022 and 2023 Harmattan School

Day	Topic	Facilitator
	2021	
1	Introduction to the Harmattan school An Introduction to Physics in Healthcare An Introduction to Engineering in Healthcare	Iyobosa Uwadiae Liz Parvin Dan Clark
2	Introduction to Health Physics Radiation detection and measurement Physics of x-ray imaging Physics of nuclear medicine Physics of molecular imaging The physics of cancer treatment	Tobi Ife-Adediran Akin Omojola Maryann Ekpo Tolulope Ayodele Tosin Ijaleye Emmanuel Oyekunle
3	Application of cell mechanics in medicine An Introduction to Physiological Measurement Physics of the eye Physics of the ear Physics of the heart	Kayode Dada Dan Clark Chris Degg Chris Degg Leandro Pecchia
4	Application of Fourier transformation/ mathematical physics in medicine NMR in medicine Sound waves in medicine/ultrasound RF Interaction with the human body Artificial intelligence in medicine Radiobiology and Artificial Intelligence.	Paul Morgan Michael Dada Bede Madu Bright Aboyewa Maruf Adewole Abayomi Opadele
5	Measurements of percentage depth dose and inverse square law Calibration of MTS-N (LiF: Mg, Ti) chips with a RadPro TLDcube 400 manual reader	Dare Adewa /Temitope Orotoye Akintayo Omojola
	2022	
1	Medical Physics: the past, present and future Career prospects for Medical Physicists in Nigeria Career opportunities in Clinical Engineering	Lookman Abdallah Michael Akpochafor Dan Clark
2	Overview of Radiography and Medical Imaging Understanding Digital Communication in Medicine Patient dose monitoring and optimization in diagnostic radiology Radiotherapy Physics	Jimmy Strinnger Peter Sandwall Matt Dunn Keith Langmack
3	MR Radio-Frequency Coils: Physics Principles and Design Pulse Oximetry Explained: Using Light Waves to Analyse Haemoglobin Electricity in the Heart: The basic principles behind Electrocardiography	Ben Stormont Chenyang He Busola Oronti
	2023	
1	Why I decided to study Medical Physics Radiation around us The History of Radiation Therapy Mammography: looking inside the breast	Victor Ekpo Francisca Abdul Evans Sasu Akintayo Omojola
2	Biophysics: physics of life Machine Learning Applications Cyclotrons: an introduction to particle accelerators in nuclear medicine Electrical safety of medical devices and equipment	Abba Lawal Michael Dada Adekunle Akintokun Busola Oronti

	DIY Projects	
3 months	Project 1 (Digital Communication in Medicine and Image Analysis)	Completed
	Projects 2,3,4,5 & 6	Postponed due to the strike

Fig. 1 Harmattan School e-Posters (L-R): 2021, 2022 and 2023

V. The Applicants

A total of 455 applications were submitted to the harmattan school in 2021; 483 applications in 2022 and 542 applications in 2023. Applications were submitted via google and zoom registration forms. We expected all the applications to come from undergraduate students being the target audience, but many applications came from postgraduate students, medical physicists, and physicists in other fields. Even participants from outside the country took part in it. Table 2 summarizes the demographics.

Table 2 Demography of Applicants

Year	2021	2022	2023
No of Applications	455	483	542
Gender (Female)	29 %	26 %	46 %
Gender (Male)	71 %	74 %	54 %

Table 3 Spectrum of Applicants

Year	2021	2022	2023
No of Applications	455	483	542
Non-Nigerian Nationality	11.5 %	10%	38 %
Undergraduates	302	206	167
Graduates	78	98	85
Postgraduates	65	152	119
Working	10	27	168

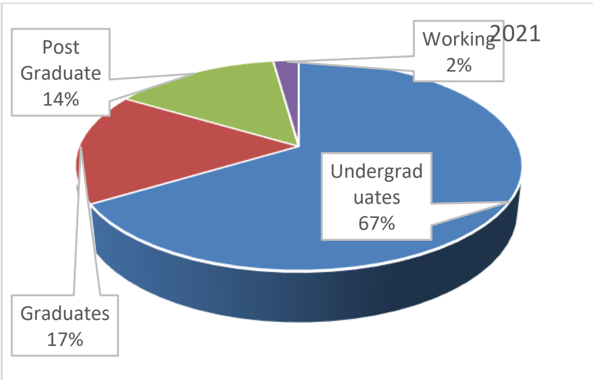

Fig. 2 Statistics of participants in 2021

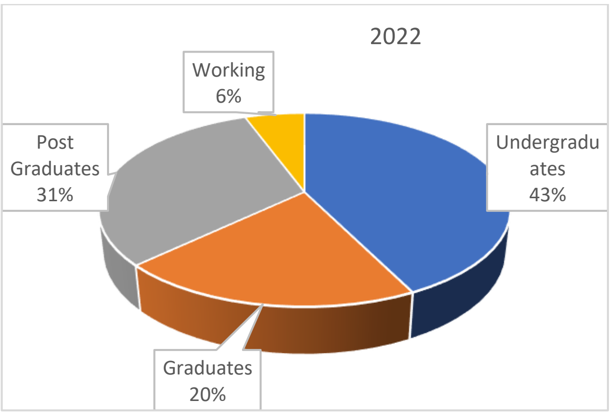

Fig. 3 Statistics of participants in 2022

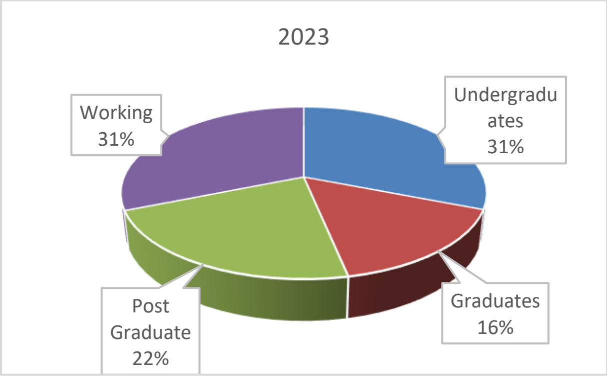

Fig. 4 Statistics of participants in 2023

In the maiden edition (2021), 80 % of participants had never heard of or participated in a similar program; 99.4% had an increased knowledge due to the harmattan school; 98.3 % asked to participate in subsequent editions; 100 % would recommend the school to colleagues and friends while 99.4 % said they would consider a career in MP. 0.4 % did not have access to a smart phone of personal computer. 84.6 % had access to a good internet connection while 15.2 % didn't. 93 % could dedicate at least 2 hrs. per day to attend the virtual school and 91.6 % showed interest in participating in the DIY projects. The others could not because they were either out of school or did not have access to a physics laboratory which was one of the criteria for participating in the projects.

VI. Analyses and Discussions

Although the school was primarily planned for undergraduate students, data collected during the school showed that students from other disciplines were equally curious about medical physics. As a matter of fact, postgraduate students and non-Nigerians participated in the school. Table 3 shows the distribution of the applicants across the spectrum.

More sponsorship would be sought to increase participation and develop an e-learning platform tailored to medical physics learning in Nigeria. 'tailored' because even though the world and field are advancing, we cannot shy away from the fact that the needs of continents, regions, race and even country still differ. The principle may be the same, but the application differs.

From the distribution (Tables 2 and 3) of the applicants and attendees of the program. The undergraduates that participated stood at 66.4% (302), 42.7% (206) and 30.8% (167) in 2021, 2022 and 2023 respectively. While the number of participants increased marginally in 2022 by 6% and hitting a double digit (12%) by 2023 with respect to 2022, the number of undergraduates however showed a downward trend. In fact, by 2023 the number of undergraduates almost halved. The reason might not be farfetched; in 2023 an 8-month strike was called off and students were much more imbued with resumption duties and subsequent examinations thereafter. This downward trend in undergraduate applications might be better seen as a positive impact of the harmattan school - Some students who were in their final years (who represent a good percentage of participants especially in 2021 edition) having enjoyed the first edition (2021) naturally joined the subsequent editions as postgraduates with a good number enrolled in postgraduate medical physics program, and as graduates undergoing the compulsory national service or working. Graduates include MSc student, PhD students and other at various levels of their careers. This points to the need for a similar program tailored for non- undergraduates so as not to lose the flavor of the harmattan school program for undergraduate students.

There might need to be other developed methods of sustaining the attraction that has been spurred by the harmattan school program. The harmattan school was an important strategy needed to lure undergraduate students into the MP profession and at the same time bridge the 'widening' knowledge gap.

Another interesting feature of the harmattan school is the participation of females. The percentage of women' participation in 2021 and 2022 were both about 30%, but in 2023 it peaked at 46% almost equaling the participation of men. This result is as interesting as it is encouraging because the percentage of women enrollment in physics and in fact in STEM programs have always been small. Even according to their study [10], the workforce of female medical physicists worldwide stood at 30%. So the significant increase in the number of female participants is an indication that more women are embracing medical physics.

An exciting upshot of the harmattan school was the participation of non-Nigerians. The school was designed for Nigerians since the original format was intended to be onsite which would involve huge finances to accommodate participants from outside Nigeria, however, the modification of the program into an online one (except some DIY projects) attracted interests from non-Nigerian participants. In the maiden edition about 11.5% foreigners participated. The percentage remained fairly unchanged to 10% in 2022 before an unprecedented 38% in 2023 signaling the growing interest in the medical physics field in other developing countries.

Table 4 summarizes the post-course survey of the 2021 harmattan school lectures; scores for each course of all participants were averaged. The lowest lecture score was 3.1, while the highest lecture score was 4.5. The overall average for all the lectures scored by the 174 respondents was 3. This represents a very good performance of the 2021 lectures.

VII. Feedback and Challenges

The first major challenge was the Covid-19 pandemic that halted the initial plans. This would then mean a waiting period of so many months. As the world moved forward even with the pandemic, the harmattan school also had to adopt to the "new normal" of doing things. The online version was thus considered and eventually adopted with some peculiar problems. Some of these challenges were identified by the participants in a post-course survey shown in figure 5

The feedback/post course survey revealed another pressing need – the harmattan school provided an opportunity for 'loopholes' in the education of medical physicist in the country created by the lack or shortage of qualified clinical and academic medical physicists. Courses that were taught during the harmattan program were not only selected to introduce students to the field of medical physics generally, they were selected to introduce current trends and courses not commonly part of the medical physics academic curriculum in the country. This not only was beneficial to undergraduate students who had no idea of physics applications in medicine but even to post graduate students and working professionals. To increase involvement, it might be necessary to create similar programs tailored to PG students and practicing medical physicists.

Furthermore, the outcome of the survey informed the decision to reduce the number of days of the virtual school due to the challenges the participants faced. The ASUU strikes in 2021 and 2022 really affected the schedule as it scrambled the academic calendars of the universities except the privately owned ones. We also hoped to go back to the original plan of hosting the school onsite, but we couldn't do as planned. Three major reasons were the lack of funds, the irregularity in the academic calendars and insecurity. Nigeria is a very large country, and it would be difficult to gather students from the different geopolitical zones. To solve this problem, we planned that the school can be held in regions rather than all converging in Lagos or Ibadan. This will cost more but it will ensure that no one is left out.

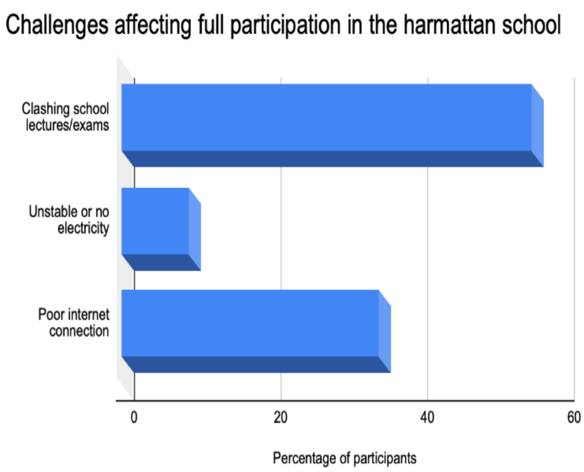

Fig. 5 Challenges affecting full participation in 2021 Harmattan School

Table 4. A post course survey in 2021 of 174 respondents

(A)QUESTIONS/RESPONSES IN PERCENTAGE	YES	NO	MAYBE
Have you participated in similar programs in the past?	20.1	79.9	-
Did you experience any challenge(s) during the program?	52.3	43.1	4.6
Did you know about medical physics before the program?	79.9	13.8	6.3
Did the school increase your knowledge of medical physics?	99.4	0.6	0
Would you like to participate in the harmattan school next year if given the opportunity?	98.3	0.6	1.1
Were you satisfied with the organization and technical aspects of the harmattan school?	94.3	5.7	-
Would you recommend the school to colleagues and friends?	100	-	-
(B) OVERALL SATISFACTION WITH THE LECTURES (22 Lectures)	Lowest Score	Highest Score	Average Score
The results are based on a scale of 1-5, where 1 represents the least score and 5 represents the highest score. The scores (lowest, average and highest) in the following columns have taken into account all the 22 lectures for the 174 respondents.	3.1	4.5	3.6

VIII. Conclusion

A. MATTERS ARISING

Nigeria like most other developing countries, is experiencing rapid brain drain in the sciences and medical profession. One way of preventing or slowing this down is by developing the system in a way that It becomes equally attractive or at least almost comparable. The harmattan school proved to be an effective way of equipping medical physicists with the requisite knowledge and skills, and thus become a major way to make up for some of the shortfalls during the ost graduate medical physics program. This will make medical physics more attractive to practice in Nigeria and stem the tide of brain drain.

The medical physics harmattan school never envisaged participants from outside Nigeria; it was a welcome surprise. This revelation can be leveraged upon to encourage other countries where medical physics summer school never existed, especially in LMIC countries to adopt the harmattan school model as a method to increase medical physics manpower, reduce the dearth of qualified medical physics which will ultimately lead to more proficiency.

B. EMBRACING THE OBVIOUS

Thanks to the COVID19 pandemic, the virtual/e-learning platform evolved quickly as a preferred teaching method for most of the developed world. It however still posed a challenge for a nation that had not previously embraced it due to several challenges highlighted in this paper. This learning method cannot replace the traditional face to face teaching experience, but it can be modified to create a blended method. They are challenges that need to be overcome if we are to develop the field of medical physics in the country to a reasonable comparable standard that could be serve as a landing strip (springboard) to solving local problems.

C. THE NEED FOR MORE COLLABORATION

The success, popularity and interest in the harmattan school program was partly spurred by the collaboration between NAMP and IPEM. The union was necessary to glean from both the experiences of the facilitators from both associations. The students needed to see their own and know that medical physics existed and was actively practiced in the country. A balance also needed to be created to fill in the technological gap that existed between the two regions represented.

The harmattan school program was a success and has been shown to be a potentially effective model or method of recruiting scientists into the Medical Physics profession. The collaboration between NAMP and IPEM contributed greatly to the success and effectiveness of the school and more collaborations between other medical physics organizations and related agencies are highly recommended to not only spice up the program but mitigate the knowledge and technology gap in the developing world.

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STANDARDIZATION AND HARMONIZATION OF MEDICAL PHYSICS EDUCATION AND TRAINING: SURVEY OF STATUS

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Abstract— **The rapid scientific and technological advancements have increased the complexity of physics intensive specialized diagnostic and therapeutic procedures in various fields of medicine and necessitated highly proficient and competent medical physics manpower to ensure the best radiation protection while preserving the necessary diagnostic information or therapeutic outcome from the procedure. This surge in demand has led to the escalation of requirement for education and training of medical physicists and hence opening of numerous educational programs around the world. It is imperative that these programs are standardized and in harmonization with each other. To evaluate the educational and training status of medical physics programs of the member states, a structured questionnaire was shared among the national member organizations (NMO) of International Organization of Medical Physics (IOMP), and the responses received from 31 NMOs were appraised to assess the standardization and harmonization of educational programs across member states. It is observed from this survey that the variations in the number of advanced treatment facilities and the availability of clinically qualified medical physicists (CQMP) for various specialties are hugely diverse among the participated countries. For harmonization of medical physics education and training across the globe, IAEA, IOMP, AFOMP, EFOMP and many regional and international professional organizations have expended huge efforts and resources, still much to be done looking into the growing need of CQMP across the world.**

Keywords— **medical physics, education and training, standardization, harmonization, survey.**

I. INTRODUCTION

Medical uses of ionizing radiation include a wide variety of diagnostic and therapeutic procedures performed in radiology (including dentistry), nuclear medicine and radiation therapy, as well as image-guided interventional procedures in medical specialties such as cardiology, vascular surgery, urology, gastroenterology, neurosurgery etc. [1]. Medical Physicists play an important and vital role in ensuring the best radiation protection while preserving the necessary diagnostic information or therapeutic outcome from the procedure.

The International Labour Organization (ILO) has recognized medical physicists as health professionals and the medical physicists working in a clinical environment should have the required competency to optimally perform the duties and responsibilities of each of the roles [2]. This necessitates the medical physics students to undergo a structured training program and residency under an experienced medical physicist in a recognized institution. Furthermore, the complexity of diagnostic and therapeutic procedures is increasing with advancements in technology demanding a high degree of knowledge and professional competency of medical physicists. The requirement interdisciplinary coordination between medicine, biology, physics, and biomedical engineering also calls for an upgrade in the involved individual's professional competencies and expertise. Implementation of specialized physics intensive procedures such as particle therapy, image-guided & intra-operative radiotherapy, advanced imaging and nuclear medicine techniques led to an unprecedented surge in the requirement of medical physics competency in healthcare. In order to facilitate the highly challenging requirements of these advanced scientific and technological methodologies the quantity of clinically qualified medical physicists (CQMP) needs to be in consonance with the competency needed and hence an escalation in requirement for education and training of medical physicists which led to opening of numerous educational programs around the world [3].

II. MATERIALS AND METHODS

It is imperative that these programs are standardized and in harmonization with each other. To evaluate the educational and training status of medical physics programs of the member states, a structured questionnaire was shared among the national member organizations (NMO) of IOMP, and the responses received from 31 NMOs were appraised to assess the standardization and harmonization of educational programs across the member states.

IOMP, with the aim of harmonization of medical physics education programs provides general guidelines for member organizations in defining the basic requirements for education and training of medical physicists as per IOMP Policy Statement No. 2 [4]. It aims to serve as a reference for medical physics organizations, education institutions and healthcare providers and authorities in planning and development of their national infrastructures for education, training, and certification of medical physicists and for maintenance of standards of practice.

Further, International Atomic Energy Agency (IAEA) is proactively working and helping its member countries in fostering the status of medical physics in radiation medicine through multiple initiatives of technical and cooperation projects and publication of important documents like IAEA

Human Health Series No. 25-Roles and Responsibilities, and Education and Training Requirements for Clinically Qualified Medical Physicists, published by IAEA in 2013 [5] which is endorsed by IOMP and American Association of Physicists in Medicine (AAPM). The document defines appropriately and unequivocally the roles and responsibilities of CQMP in the different specialties of medical physics and recommends minimum requirements for their academic education and clinical training, including recommendations for their accreditation, certification, and registration, along with continuing professional development (CPD). A CQMP is one who has successfully completed an appropriate academic postgraduate medical physics degree and has successfully undergone an appropriate clinical residency training program in a chosen specialty or subfield of medical physics.

In the present survey, the education and training committee (ETC), IOMP circulated a structured questionnaire consisting of 34 questions to assess status of education, training, certification, accreditation, health professional recognition, clinical training, radiation safety and professional scope.

III. Results and Discussion

Medical physics professional organizations from 31 member states responded to the questionnaire.

Table 1 Details of medical physics education program
Y- Year, B- Bachelors, M- Masters, PM- Post Masters, D- Doctoral, HY- Half Yearly

Country	Duration (Y)	Level of Education B/M/PM/D	Exam HY/Y
Belgium	>2 Y	M/PM	HY
Brazil	2 Y	Residency	Y
Bulgaria	>2 Y	B/M/PM/D	HY
Canada	>2 Y	B	HY
Czech-Republic	2 Y	M	HY
Denmark	>2 Y	B	Y
Finland	>2 Y	M	Y
France	>2 Y	M	Y
Georgia	>2 Y	--	--
Germany	>2 Y	PM	individualized
Ghana	2 Y	B	HY
Hong Kong	1 Y	M	HY
Hungary	>2 Y	PM	HY
India	>2 Y	M/PM/D	HY
Iraq	>2 Y	M	HY&Y
Ireland	2 Y	M	HY
Japan	2 Y	M	Y
Malaysia	1 Y	M	HY
Nepal	2 Y	M	N/A
Paraguay	>2 Y	B	HY
Qatar			
Romania	3+2 Y	B/M	HY
Russia	2Y	M	HY
South Africa	>2 Y	M	HY
Spain	>2 Y	M	Y
Sweden	>2 Y	M	Course wise
Switzerland	>2 Y	M	Y
Taiwan	2 Y	M/D	HY
United Kingdom	>2 Y	M	-
Vietnam	2 Y	PM	HY

Table 2: Details of medical physics education program

Country	Radiation protection part of syllabus	No of programs	Max no of students per year
Belgium	No	6	40
Brazil	No	15	44
Bulgaria	Yes	4	32
Canada	No	13	>100
Czech Republic	No	2	10
Denmark	No	5	8
Finland	Yes	5	20
France	No	7	45
Georgia	No	0	0
Germany	Yes	23	400
Ghana	No	1	10
Hong Kong	Yes	1	15
Hungary	Yes	3	13
India	Yes	22	> 200
Iraq	Yes	15	382
Ireland	No	2	25
Japan	Yes	---	
Malaysia	No	2	30
Nepal		0	0
Paraguay	No	1	5
Republic of Moldova	No	0	0
Romania	Yes	6	290
Russia	No	>10	300
South Africa	Yes	7	15
Spain	Yes	40	43
Sweden	Yes	4	48
Switzerland	Yes	1	15
Taiwan	Yes	2	20
United Kingdom	No	8	150
Vietnam	No	4	40

Further, it was observed that 77% of the responded states have a structured medical physics education program and 90% of the courses are of 2 or more than 2 years of duration. The eligibility level education to pursue the medical physics education program is graduation or above in 93% of responders.

All the programs are graduate level or above. One interesting observation is that only 47% have radiation safety certification course as part of the medical physics education program. The maximum number of medical physics education programs are in Spain (40) and maximum student intake in a year is in Germany (400). The number of courses varies from none to 40 and student's uptake also varies from 2 to 400 per year among the countries participated in the survey emphasizing the need for harmonization and standardization to meet the need for CQMP in respective countries. In Iraq, there are 6 BSc programs in medical physics with up to 300 students, 7 MSc programs with up to 80 students and 2 PhD programs with one student each totaling up to 382 students in a year. Further 66% of these medical physics education programs are accredited by government agencies or government authorized/ approved accreditation bodies.

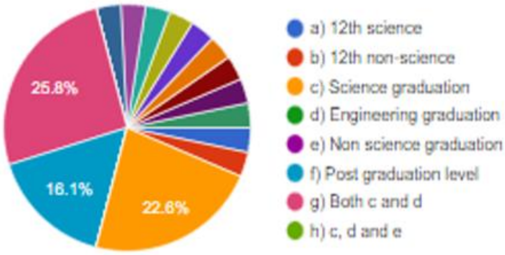

Fig. 1 Eligibility level for pursuing medical physics

As per IAEA to be a CQMP a minimum 2 years residency program [for Africa and Latin America – 1 year residency] in addition to the Master's in medical physics is essential. A residency or a hospital based clinical training is mandatory for 65% of the states participating in the survey and the duration of residency program varies between less than a year to more than 2 years. Only in 34% of the cases, medical physicists are recognized as health professionals by the respective governments. As medical physicists are health professionals, HSS25 of IAEA recommends registration of medical physicists by national agency.

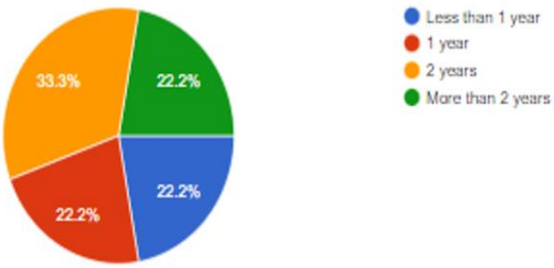

Fig. 2 Duration of Medical Physics Residency/ Clinical Training

Kron et al. [6] reported that though there is an increasing trend in the number of medical physicists in radiation oncology between 2008- 2014, with increase in the number of high-tech treatment modalities and complexity of treatment more experienced medical physicists are required to ensure quality research in medical physics. Similarly, Chougule A [7] observed that in spite of the remarkable growth in medical physics education in AFOMP region over 20 years the growing population and cancer burden demands for higher number of medical physicists in the region to fill the gap. Chougule A, from a survey of the status of medical physics education and training in 20 countries of the Asia-Oceania region also concluded that the existing capacity of medical physics education in AFOMP region needs to scale up to bridge the gap of required numbers of medical physicists in the region [8]. An IOMP survey of 93 countries results show that global increase of CQMP does not meet clinical needs of the world and to meet the double the requirement of CQMP, more medical physics education and training programs are needed [9].

It is observed from this survey that the variations in the number of advanced treatment facilities and the available CQMPs for various specialties are hugely diverse among the participated countries. While Ghana, Qatar and the Republic of Moldova have less than 3 linear accelerators, Germany, India, and Japan have more than 500 linear accelerators. Availability of KV X-ray therapy also varies from none (Finland, Ghana, Republic of Moldova, and Paraguay) to a few in many to more than 40 in Switzerland. As for particle therapy, many do not have the facility, while most have very few and countries like Japan have 20 particle therapy equipments/facilities. Availability of brachytherapy units mostly everyone has only a few while countries like Brazil, France, Germany, Japan and Russia have more than 100 and India have more than 300 brachytherapy machines. Most countries have none or very few tele-cobalt machines and Sweden use it only for calibration and few have only Gamma Knife machines at the same time India have more than 200 and Russia 180 tele-cobalt machines.

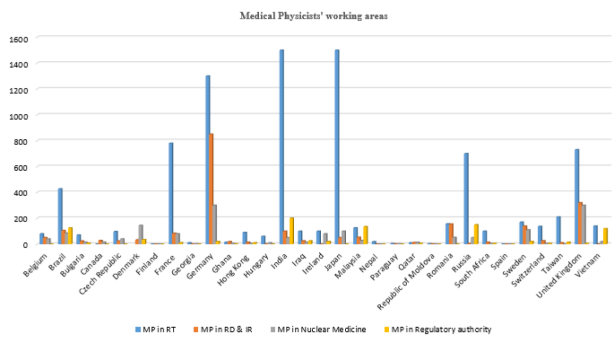

Fig. 3 Distribution of medical physicists in different specialties

Looking at the number of CQMP available for different specialties, other than Ghana every other country has a higher number of CQMP in radiotherapy in comparison to diagnostic and interventional radiology and nuclear medicine. In Ghana, the number of CQMP in radiology is higher though the difference is not significant as the total number of CQMPs is very small. The number of medical physicists working in regulatory authority/ body is also very few in most of the countries while Belgium, India, Malaysia, and Russia have a higher representation of more than 100-200 medical physicists in regulatory authority/body. The number of medical physicists/ million population recommended by European Federation of Organization for Medical Physics (EFOMP) [10], the incidence of cancer [11] and the analysis by Chougule A on the requirement of CQMP to fulfill the estimated gap and the deficit in the number of CQMP per million population for the countries in Asia Oceania [12] are also in line with the observations of present survey.

In order to strengthen the radiation safety culture, the IAEA and WHO gave a recommendation in consensus that recognition of medical physics as an independent health profession with specific radiation protection responsibilities is a key step [13]. Further WHO promotes the role of the medical physicist in ensuring radiation safety and quality in medical exposures and supporting the implementation of the Basic Safety Standards (BSS) by stressing the increase in the role of medical physicists in diagnostic radiology, radiation therapy and nuclear medicine [14, 15, 16]. Considering the total requirement of CQMP in radiation oncology, interventional radiology, nuclear medicine, and regulatory requirements at least three-fold increment is necessary in the number of CQMP [12].

In order to achieve harmonization of medical physics curriculum, infrastructure, faculty and other necessary requirements, IOMP initiated an accreditation board in 2016 for evaluating the educational programs and this accredits medical physics degree programs, residency programs, medical physics education and training institutions/ centers and education and training events. The details regarding accreditation is available on IOMP website [https://www.iomp.org/accreditation/] Further for wider acceptance and credibility of the national medical physics certification boards (NMPCB) of the country, International Medical Physics Certification Board (IMPCB) has started accreditation of the NMPCBs [17]. IMPCB also certificates individual medical physicists from countries where no NMPCB exists through written, oral and practical examinations [18]. IOMP accreditation of the medical physics education program and IMPCB accreditation of NMPCB and individual medical physicists are useful for accreditation of educational program and certification of CQMP [19].

IV. Conclusions

For harmonization of medical physics education and training across the globe, IAEA, IOMP, AFOMP, EFOMP and many regional and national medical physics professional organizations have expended huge efforts and resources, still much to be done looking into the growing need of CQMP across the world.

Acknowledgement

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PROFESSIONAL ISSUES

AN INITIAL SWOT AUDIT OF THE MEDICAL PHYSICS PROFESSION IN MALTA: THE PERSPECTIVE OF MEDICAL PHYSICISTS

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Abstract— In Malta, medical physics is a relatively new profession and thus far there has not yet been a formal situational analysis to determine how the profession is progressing. A SWOT audit of the profession in Malta was therefore deemed necessary so that a strategic plan may be developed. The specific objectives of the study were: (a) to develop a vision statement for the medical physics profession in Malta, (b) to analyse the current state of the profession in Malta by carrying out a SWOT thematic analysis with respect to the desired vision statement as perceived by the local Medical Physics professionals, and (c) to develop an initial set of strategic objectives for the profession in Malta. Data for the vision statement was collected via document analysis whilst SWOT data were collected using a structured online anonymous questionnaire distributed to all the medical physics professionals. The study has provided a comprehensive analysis of the profession, its strengths and weaknesses, ways in which the profession can grow by making good use of the available opportunities, and also highlighting the external threats facing the profession. A list of strategic objectives was developed. It is the hope of the authors that this study will encourage other medical physics national organisations in other countries to carry out similar studies.

Keywords— **Medical physics profession, medical physicists, SWOT analysis, vision statement.**

Nomenclature

MP	Medical Physics
MPE	Medical Physics Expert
MPP	Medical Physics Professional (Medical Physicist or Medical Physics Expert)
RPC	Commission for Protection against Ionising and Non-Ionising Radiation (Malta)
CPCM	Council of Professions Complementary to Medicine

I. INTRODUCTION

Medical Physics (MP) is a relatively new profession in Malta. Although discussions on its development and recognition began in 2007, it was not until 2012 that the Ministry of Health acknowledged the relevance of MP. A grant from the European Social Fund was awarded to help fund the first cohorts as a result of a strong partnership between the Ministry of Health and the University of Malta's MP department [1]. MP was classified as a regulated profession by the Maltese government in 2014 [2]. At present, Malta has 20 clinically qualified medical physics professionals (MPPs) who work within Diagnostic and Interventional Radiology (D&IR), Radiation Therapy (RT) and Nuclear Medicine (NM) [1] [2]. The Malta Association of Medical Physics (MAMP) is the officially recognised professional organization for MPPs in Malta and holds meetings and seminars to encourage members to participate in the Association's and EFOMP's activities. The M.Sc. in Medical Physics and B.Sc. in Physics, Medical Physics and Radiation Protection were established in Malta to ensure a steady number of potential entrants to the profession. Today MPPs in Malta contribute significantly to healthcare, particularly in the use and safety of ionising and non-ionising radiation. MPPs work in hospitals or as consultants to hospitals, the administrative sector and academia [3].

Since there had not yet ever been a formal situational analysis of the profession it was decided to carry out a SWOT audit so that the state of the profession may be assessed. This would help make possible the increased development of the MP profession in Malta. SWOT-based strategic planning is used widely in healthcare, including for MP [4-9].

The objectives of the study were to: (a) develop a vision statement for the profession, (b) conduct a SWOT analysis of the present state of the MP profession in Malta with respect to the vision statement as perceived by the MPPs, and (c) develop a research-based list of strategic objectives for the profession and for the identification of potential actions to be taken. The research study provided the MPPs involved with the opportunity to reflect on a desired enhanced future vision for the profession in Malta.

II. MATERIALS AND METHODS

We live in a globalised world and Malta is part of Europe. Therefore, the creation of the vision statement for the MP profession in Malta was carried out via a document analysis of relevant European and international legislation and documentation [3], [10-19]. To develop the vision statement a search for the following terms was carried out within the documentation: vision, future, competences, key activities. A vision statement was then formulated which reflected the desired future mission for MPPs. In practice, the resulting vision statement was very close to one which was being concurrently developed by EFOMP. The SWOT themes were identified via an anonymous quantitative survey among MPPs in Malta. The survey questionnaire consisted mostly of possible SWOT thematic statements derived from the vision statement to each of which was attached a standard level of agreement/disagreement Likert scale. A mean level of agreement/disagreement score was achieved by assigning values $+2.0$ = 'Strongly Agree', $+1.0$ = 'Agree', 0.0 = 'Not Sure', -1.0 = 'Disagree', -2.0 = 'Strongly Disagree' to the

Likert scale. A value between $+0.5$ and $+2.0$ indicated agreement with the statement with a value above $+1.0$ indicating strong agreement. Corresponding negative values indicated disagreement and strong disagreement whilst a value in the range $-0.5 < Mean < +0.5$ indicated a more neutral, indecisive, or ambiguous stance.

Some additional thematic statements suggested by the participants themselves (indicated by *), were included in the results. Some questions (indicated by **), probed the current scope of the role at several stages of the medical device cycle and had the following response alternatives (participants could choose more than one alternative):

a. ionising radiation based medical devices,
b. non-ionising radiation based medical devices,
c. all medical devices,
d. no medical devices.

Some other questions required a simple yes/no answer (indicated by ***).

The quantitative data from the questionnaire were analysed using descriptive statistics. The survey was held online via a Google form and kept anonymous so that all MPPs in Malta could participate at a time of their convenience. The response rate was 40% ($n = 8$). A copy of the questionnaire is available via the first author.

III. RESULTS AND DISCUSSION

This section first provides the proposed vision statement for the MP profession in Malta. The SWOT data obtained from the survey is then presented and discussed. The section ends by suggesting a list of strategic objectives for achieving the proposed vision.

3.1 Vision statement

Given the present work done by the EFOMP Professional Matters committee on the future envisaged role of MPPs, it was decided to adopt the version of the vision statement suggested by the committee at the time when the questionnaire was being finalised [20]. The proposed vision statement is as follows:

"The Medical Physics profession will be recognised by all healthcare stakeholders as contributing to maintaining and improving the quality, safety and cost-effectiveness of healthcare services through patient-oriented activities requiring expert action, involvement or advice regarding the specification, selection, acceptance testing, commissioning, quality assurance, decommissioning and optimized clinical use of present and future medical devices and regarding patient risks from all associated physical agents including protection from such physical agents, installation design and surveillance, and the prevention of unintended or accidental exposures to physical agents; all activities will be based on current best evidence or own scientific research when the available evidence is not sufficient. The scope includes risks to volunteers in biomedical research and carers and comforters."

"In addition, Medical Physics Professionals should also take on at the expert level the added function of the protection of workers and the general public from physical agents (such as Radiation Protection Expert, Magnetic Resonance Safety Expert and Laser Safety Expert)."
(Caruana, C. J., personal communication, 22 March 2022)

3.2 STRENGTHS (S) of the MP profession

The main strengths of the profession identified via the survey were:

S1. Most MPPs are certified by the Commission for the Protection against Ionising and Non-Ionising Radiation (RPC) as Medical Physics Experts (MPEs) and Radiation Protection Experts (RPEs) (***)
Having a high percentage of MPPs certified as MPEs (100%) and RPEs (75%) is a strength of the profession.

S2. MPPs recognised by stakeholders as a contributor to healthcare ($+0.75$)
MPPs agree with this statement which is a strength with respect to the vision statement. However, the score indicates that more attention must be given to promotion of the profession and increase its visibility among stakeholders.

S3. High knowledge and skills in specialty areas ($+1.50$)
MPPs strongly agree that they are well informed of the procedures and techniques in their corresponding specialty area. This can be considered as a core competence with respect to the vision statement.

S4. MPPs provide education to students (*)
According to the responsibilities of a MPP as specified by IAEA and the European Commission, MPPs should contribute to the education of MP and other healthcare students and staff. The great majority of MPPs contribute actively to the education of students and are recognised as experts in MP by the University of Malta [10], [17].

S5. MPPs have sufficient scientific expertise regarding medical devices used in their specialty area and their clinical use ($+1.25$)
MPPs strongly agree with this statement. MP is the only profession in healthcare with a strong understanding of the technology and means of optimisation of protocols.

S6. MPPs have deep techno-scientific expertise for safeguarding patients, workers, and the public from ionising radiation and other physical agents employed in their field ($+1.25$)
MPPs in Malta consider that they are highly capable of handling such agents which is a strength with respect to the vision statement. Physical agents provide considerable medical benefits, and their usage is steadily rising. However,

there is a risk component as well, and when employed by individuals who lack appropriate understanding they constitute a source of unnecessary patient, occupational and public risk.

S7. MPPs have strong analytical, problem-solving, and trouble-shooting skills (+1.25)
MP services require strong problem-solving skills. MPPs in Malta all possess a first degree with a strong physics and mathematics component that guarantees that only those possessing high analytical skills enter the profession.

S8. MPPs have strong mathematical, statistical, and data analysis skills (+1.13)
MPPs lead over all other healthcare professions in terms of quantitative data analysis, statistics, and mathematics. Quantitative imaging, artificial intelligence (AI), and machine learning are seeing a surge in both diagnostic and therapeutic applications, opening yet another higher tier dimension. The Master's in medical physics programme at the University of Malta includes a strong machine learning and pattern recognition component as well as advanced signal and image processing skills for physiological measurement and medical imaging.

S9. Strong legal foundation for the profession (+0.75)
The Maltese Parliament transposed EU directive 2013/59/EURATOM as the Basic Safety Standard Subsidiary Legislation (SL) 585.01, stating MPEs are qualified to provide specialist advice on radiation physics related matters [11, 12]. The MP profession is also a legally established health care profession regulated via the Council of Professions Complementary to Medicine (CPCM) [2]. Having the profession legally recognised by the local authorities is a critical strength with respect to the vision statement.

S10. MPPs have strong scientific research skills (+1.25)
MPPs have unmatched quantitative scientific research abilities that have been perfected through many years of undergraduate and postgraduate training. MPPs are strong in concepts of accuracy, reliability, and estimations of uncertainty. Since MPPs often introduce new technologies in healthcare and since often manufacturer provided protocols are not sufficiently optimised to the local population or to every clinical indication, they need to have research skills to drive the optimised use of the technology forward. This is in consonance with the part of the vision statement stating that "*all activities will be based on current best evidence or own scientific research when the available evidence is not sufficient*", this is a critical strength.

S11. MPPs have strong ICT skills (+1.00)
MPPs in Malta possess high ICT skill levels, including programming and this is a strength with respect to the vision statement. MAMP organises a highly sought course on data analysis in Python specifically for MPPs annually and attended by many physicists from around the world [21, 22].

S12. MP services in Malta compare well with other EU countries (+0.50)
The MPPs agree, though not strongly, that services offered locally are comparable to those in other EU countries.

S13. High level qualification and curriculum framework leading to the certification of a MPP (***)
The majority of the MPPs agree with this statement (62.5%). However, those that did not necessarily agree (32.5%) have mentioned that the curriculum could be improved by having part of the clinical training carried out at hospitals in other EU countries to widen the expertise and vision to other specialties of MP not presently available.

S14. Young team that is able to adapt and with a motivational drive for improvement (*)
The MPPs identified the determination, competitive attitude and drive for improvement within the profession as being one of its critical strengths. MPPs constitute a young team with progressive ideas. One of the respondents identified that Malta as a small country made it easier for the profession to adapt to new changes: "Since we are a small country, we can be highly cohesive and adaptable. For example, in larger countries things are often a bit fragmented because of the many variations in local procedures within the same country, and professionals would be hesitant to comment or commit without approval from all."

S15. MPPs take part in regional/international networking (+0.50)
Regional and international networking will improve the perception of the profession and strengthen its professional and political position. However, the mean Likert score indicates that this strength needs to be developed further.

S16. Introduction of the Bachelor's degree in Physics, Medical Physics and Radiation allows for the profession to grow (+0.75)
The introduction of the Bachelor programme has boosted the number of young people entering the profession. With more members, the MP profession in Malta will be able to be more involved in the clinical use of present and future medical devices and physical agents which is a strength with respect to the vision.

3.3 WEAKNESSES (W) of the MP profession

The main weaknesses of the profession identified via the survey were:

W1. No MPPs certified as a Magnetic Resonance Safety Expert (MRSE) or Laser Safety Expert (LSE) (***)
With regard to the vision statement this can be seen as a weakness since none of the MPPs in Malta are recognised as a MR Safety Expert nor as a Laser Safety Expert. This is indeed a pity as courses for certification in these areas are easily available internationally. No such recognitions are

legally required in Malta, which is a lacuna that needs to be addressed. However, MPPs should acquire the necessary qualifications so that they will be ready when the opportunity presents itself.

W2. Shortage of material resources (0.0)
The results were neutral, which means that a significant number of MPPs may be deprived of the resources necessary for them to deliver effective and safe service. This can be considered as a weakness of the profession as it makes it more difficult to achieve the objectives stated in the vision statement.

W3. MPPs are mainly involved in the specification and procurement of ionising and non-ionising radiation based medical devices rather than all medical devices (**)
The MP profession in Malta is young, and its position at the moment is weak concerning the vision statement that emphasizes the involvement of MPPs in the specification and procurement of *all* medical devices. The profession needs to broaden its scope of practice beyond radiation-based devices, as suggested by the vision statement. The involvement of MPPs in the procurement and specification of non-ionising radiation devices is higher for D&IR (100%) compared to RT (66.7%) and NM (50%). D&IR MPPs are giving increased attention to the quality control of ultrasound (US) and magnetic resonance imaging (MRI), which may explain this difference. However, the introduction of MR-LINAC at the main oncology centre in Malta would likely encourage RT MPPs to become more involved in non-ionising radiation devices. Two RT MPPs believe that MPPs are involved in procuring all medical devices – this is probably because they help procure various ancillary medical devices such as applicators, moulds, and patient restraint devices. It has however been advised that to move this issue forward the University of Malta will be introducing Physiological Measurement in its revised M.Sc. Medical Physics curriculum for October 2023 (Caruana, C.J., personal communication, 5 September 2022).

W4. MPPs in Malta are involved in the acceptance testing of ionising and non-ionising radiation based medical devices, but this is not entrenched in law and not to all medical devices (**)
Overall, the perception is that MPPs in Malta are involved in the acceptance testing of ionising and non-ionising radiation based medical devices but very little outside these two categories. Hence with respect to the vision statement which states that MPPs should endeavour to involve themselves in the acceptance testing of *all* medical devices, the position of the profession is still weak. The profession should strive to extend acceptance testing to all medical devices to make sure that device performance adheres to the desired specifications [23]. It should be noted however that currently there are no non-ionising radiation based medical devices in NM, whilst the MR-LINAC in RT should be introduced at the last quarter of 2023.

*W5. MPPs in Malta are involved in commissioning, but this is not entrenched in law, and not to all medical devices (***)
Again, the perception is that MPPs in Malta are involved in the commissioning of ionising and non-ionising radiation based medical devices only. Hence with respect to the vision statement, the MPPs should endeavour to involve themselves in the commissioning of *all* medical devices. All the participants in the study indicated that MPPs in each respective specialty area perceive that MPPs in Malta are involved in the commissioning of ionising radiation based medical devices. On the other hand, there are larger percentages of MPPs from RT and D&IR (66.7% and 100% respectively) than MPPs from NM (50%) who perceive that MPPs are involved in the commissioning of non-ionising radiation based medical devices. This can be explained by the fact that there are no non-ionising devices yet in NM, unlike D&IR.

W6. MPPs in Malta are mostly involved in the quality assurance (QA) of ionising and non-ionising radiation based medical devices and not all medical devices (**)
With respect to the vision statement, which states that MPPs should endeavour to involve themselves in the QA of *all* medical devices, the position of the profession is still weak. 87.5% are involved in the QA of ionising radiation based medical devices, whilst 62.5% and 12.5% perceive that MPPs in Malta are involved in the QA of non-ionising radiation based medical devices and all medical devices respectively.

W7. MPPs in Malta are little involved in the decommissioning process of medical devices (**)
Only 50% of MPPs in Malta are involved in the decommissioning process with regards to ionising radiation based medical devices, with 37.5% not performing this duty on any medical device. It could be that MPPs are not performing this duty due to other pressing work. Therefore, the involvement of MPPs in the decommissioning process of all medical devices, as stated in the vision statement, is weak. MPs should strive to be part of the decommissioning process of all medical devices. However, it should also be mentioned that very few machines were decommissioned over the past years. Traditionally medical radiological devices in Malta have a life span of more than 10 years.

W8. MPPs are mostly involved in optimising the clinical use of ionising and non-ionising radiation based medical devices only (**)
Concerning the vision statement that states MPPs should be involved in optimising the clinical use of *all* medical devices, the position of the profession is still weak. With 87.5%, 62.5%, and 12.5% indicating that MPPs are involved in optimising the clinical use of ionising based medical devices, non-ionising based medical devices, and all medical devices respectively.

W9. MPPs are able to provide advice regarding patient risks and protection from ionising and non-ionising radiation but not from all physical agents (**)
100% of MPPs provide advice in cases of ionising radiation and 50% provide advice in cases of non-ionising radiation. None of the participants provide advice regarding patient risks and protection from all physical agents. This shows that the general notion of physical agents is not well established but just ionising and non-ionising radiation devices and in the case of the latter this is limited to only US and MRI – but not lasers, ultraviolet, infra-red, visible.

W10. MPPs are involved in the installation and surveillance of radiation devices but not all medical devices (**)
All the participants stated that they are involved in the installation and surveillance of ionising radiation based medical devices, 62.5% are involved in the installation and surveillance of non-ionising based medical devices, and none are involved for all medical devices.

W11. Lack of a universally acknowledged easy to promote mission statement for the profession (+0.38)
One of the issues that the profession is facing is the lack of a mission statement that is unambiguous, universally recognised, and easily marketable. The implementation of a mission statement shows the importance of the MPPs role to the healthcare management and society at large. This cannot be achieved without a well-publicised mission statement.

W12. Narrow range of specialties (−0.38)
The use of ionising radiation in D&IR, RT, and NM remains the primary clinical MPP role in Malta. The focus of the profession should be broadened to include all physical agents and all medical devices as indicated by the vision statement.

W13. Insufficient robust leadership and strategic skills (−0.13)
Strategic leadership is important as it is critical to the achievement of the desired vision. Perhaps there needs to be a debate on the development of strategic leadership for the profession in Malta. Members of the profession should attend leadership conferences/webinars/courses.

W14. Low marketing skills (+0.25)
The mean Likert score suggests that MPPs struggle with such skills. This is a weakness in the profession's ability to make itself more recognised by stakeholders as a critical profession with respect to the quality, safety, and cost-effectiveness of healthcare services. However, one respondent noted that efforts are being made to address this issue by actively engaging with other healthcare professions.

W15. Some MPPs are reluctant to be part of the wider healthcare picture (0.0)
The respondents are unsure whether their peers are reluctant to be part of the wider healthcare picture. Some MPPs may prioritise physics but inter-professional teamwork and cooperation are also important.

W16. Some MPPs have insufficient communication and pedagogical skills (−0.25)
MPPs should develop their communication skills, as this would help the profession market its services and its vision to other professions and management.

W17. Low level of research including research on professional and educational issues (+0.75)
Research has barely taken off in Malta due to either other work/personal commitments or else lack of motivation. This is considered as a weakness with respect to the vision statement.

W18. Low number of MPPs (+0.63)
The MPPs stated that their work duties can at times be overwhelming and it can be challenging to enrol in new training courses to further increase their knowledge and skills in the profession. By employing more MPPs this weakness can be minimised. One of the respondents stated: "We are essentially a start-up operating within a larger government organisation. There is foundational work to be completed and more staff to be recruited before we can reach a steady working state to be able to take on higher level duties."

3.4 OPPORTUNITIES (O) for the MP profession

The main opportunities available to the profession identified via the survey were:

O1. Increase in number of hospital medical devices (+1.13)
MPPs should take advantage of the ever-increasing range and sophistication of medical devices. MPPs have more competence in this field than other healthcare professions, and that there is an opportunity for MPPs to lead in the use of advances in AI, theranostics, lasers, biomedical optics, and nanotechnology. A MPP stated: "If we are proactive, we can be at the forefront for adoption of these technologies."

O2. Link up with patient organisations and act as patient advocates regarding safety standards in healthcare (+0.25)
MPPs are not sure whether they can work towards this. This could be due to their overwhelming range of duties and low numbers; the time may simply not be available.

O3. Link up with occupational health and safety organisations and environmental groups and project themselves as occupational/public advocates with regard to safety from physical agents (+0.13)
This is a great opportunity for MPPs that are interested in expanding their role given the ever-increasing emphasis on occupational safety and environmental issues in society at large. It is also an opportunity for greater public outreach by the profession.

O4. Exerting pressure on legislators to recognise that patient safety is not limited to ionising radiation (+1.25)
Legislation regarding physical agents other than ionizing radiation would further increase the opportunities for the profession. For instance, the EU has implemented laws for staff safety related to electromagnetic radiation, but there is no strong legislation for patient protection as there is for ionising radiation. This is an opportunity for MPPs to raise awareness of these challenges among the broader public, pushing the field into the public eye and increasing its visibility.

O5. Raise profile with health economists (+1.00)
Health economics, which is the practise of utilising limited resources in the best way, is very important as healthcare costs are on the rise as are patient expectations. This is an opportunity for MPPs to be involved in clinical trials and health technology assessment. One respondent noted: "Involvement in clinical patient pathways to ensure that introduction and use of new medical devices is really justified."

O6. Self-testing and wearable devices can be turned into a business opportunity (+0.50)
Medical devices are being designed for home use that can collect health data. According to the vision statement this could be an opportunity for the MPPs to provide quality control services and proper guidance on the selection and use of such devices.

O7. Research grants from the Government of Malta (0.0)
The responses were neutral. This could be since very few to none are actively involved in research as dedicated time is simply not available.

O8. Involvement in IPEM/EFOMP/IAEA courses and conferences (+0.38/+1.13/+1.50)
The majority of MPPs take part in such courses. The courses offered by these organisations present a valuable opportunity for the continual professional development of MPPs in Malta.

3.5 THREATS (T) to the MP profession

The main threats to the profession identified via the survey were:

T1. Low number of MPPs (+1.0)
A lack of MPPs is a threat as it would not allow the profession to achieve what is being proposed by the vision statement. In the last few years, the number of physics and engineering graduates have decreased dramatically. However, this threat has been averted with the introduction of the Bachelors in Physics, Medical Physics and Radiation Protection at the University of Malta which has led to a dramatic increase in the number of students taking up MP studies. One expects this solution to bear fruit in October 2023, when the first cohort following the new Bachelors will be in a position to start their Master's in medical physics which will lead to new candidates seeking clinical certification as MPPs.

T2. Austerity economics (+0.75)
Austerity measures could result in a low yearly intake of MPPs, causing a threat to the profession's growth as workload increases but staffing levels do not. However, the political leadership of the profession is taking proactive steps to counter the threat of commoditisation.

T3. Role poaching from other professions (+0.50)
Role-poaching can be harmful to the profession and inter-professional relations. A MPP even stated that some MPPs themselves could be contributing to this when they do not strive to deliver high level competences: "MPPs only performing routine constancy testing may give the impression that their job can be done by other healthcare professionals or technicians."

T4. The profession is facing unfair competition from other professions (+0.38)
According to some MPPs, technicians or other healthcare professionals have been performing some work that is typically done by MPPs. Involving other professions for daily and weekly QC is a positive development and such professions should be encouraged to do basic checks before using the device with patients. However, it is important that more complex and quantitative tests be done by MPPs and that the daily/weekly tests are overseen by MPPs.

3.6 The way forward: Strategic Objectives

The following strategic objectives were proposed based on the SWOT analysis.

3.6.1 Strengthening of Internal Strengths

1. MPPs should enrol in regional/international approved courses to upgrade their core competences and learn new skills.
2. MPPs should be involved in the education of all healthcare professionals and research on all medical devices and physical agents, not just ionising and non-ionising radiation-based ones.
3. MPPs should exchange experiences between specialty areas to increase the level of cohesion of the profession, with annual written reports on updates and achievements presented at the annual national MP conference, organised by MAMP.
4. The MP profession should expand its role to other specialty areas, such as physiological measurement.

3.6.2 Reducing Internal Weaknesses

1. MPPs should prioritise the core competences outlined in the mission statement and eliminate weaknesses. They should ensure that repeatable tasks like daily constancy testing are delegated to other professions and focus on higher order competences like advanced quantitative QC, optimisation and upcoming technologies. This will

make it more challenging for MPPs to be replaced and ensures the growth of the profession.
2. Attend courses for magnetic resonance safety expert and laser safety expert. Several organisations offer these courses even remotely.
3. MPPs need to improve their strategic planning, advertising, and public relations skills to succeed in the modern world. They should become active participants in the larger society and acquire skills from other fields like management, strategic planning, business, and economics. MAMP should organise specific courses on these subjects and provide materials to assist MPPs in pitching their expertise to stakeholders.
4. The MP profession should adopt the vision statement and focus all its strategic planning in this direction.

3.6.3 Grasping Available Opportunities

1. MPP members should leverage their relationships with external organisations to request that education and training in the technical competences necessary for effective and safe use of medical devices be made compulsory through adequate legislation.
2. Attend courses organised by country, regional, or international organisations including those involving new technologies such as machine learning and nanotechnology.
3. Apply for funds such that there is a push in research activities in each specialty area.
4. Link with the RPC such that the profession would have a stronger presence and MPPs can exchange views with the members of the RPC on a regular basis.
5. MAMP should encourage its members to participate in courses offered by the European Network for Training and Education of Medical Physics Experts (EUTEMPE) consortium and EFOMPs European School for Medical Physics Experts (ESMPE), which cover areas such as AI, leadership, radiation protection, and advanced MRI. Participating in these courses can elevate the competences of MPPs in Malta to exceptional levels [24]. The European Nuclear Education Network (ENEN+) consortium presently provides funds for attendance at these courses [25].

3.6.4 Countering External Threats

1. There should be better communication between the CPCM and the Association with regards to the registration of MPPs in Malta. The benchmarking document for medical physics issued by the CPCM should also be amended such that it would strictly follow EU guidelines.
2. Take proactive measures to combat any attempt in introducing the idea that MPPs can be replaced by other members of other professions, which is very hazardous for the MP profession and to patients.
3. Regulations in Malta should be amended such that acceptance testing and commissioning is done by an MPE.
4. Exert pressure on the regulator to ascertain that the MPE is more involved in the work done in the public and private sector.

IV. CONCLUSIONS

The MPPs in Malta provided their perspective on the strengths, weaknesses, opportunities, and threats for their profession. The MPPs highlighted their strong competences in each specialty area, arising from their backgrounds in physics and engineering, which allow them to gain an in-depth understanding of medical devices and their ability to protect patients and the public from ionising radiation and other physical agents. However, they also identified weaknesses in the profession's low level of involvement with non-radiological medical devices, which is a significant drawback in achieving the profession's vision statement.

The questionnaire identified several opportunities for the MPPs to develop the profession further, including attending courses provided by international organisations to improve their competences and further enhance the profession's profile. However, they also acknowledged the threats posed by the lack of new MPPs entering the profession, which may hinder their ability to achieve EU standards. Other threats mentioned were role poaching from other healthcare professionals and austerity economics.

The survey provided a comprehensive overview of the present state of the MP profession in Malta, outlining both its strengths and weaknesses, as well as the opportunities available to it and the threats that it faces. While there are several areas for improvement, the MPPs strong competences and scientific expertise ensure that they are well-positioned to continue providing high-quality care and protection to patients, workers, and the public.

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INVITED PAPERS

LOCAL DRL IN NUCLEAR MEDICINE DEPARTMENT OF CANCEROLOGY INSTITUTE OF LIBREVILLE

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ABSTRACT

The present study aimed to evaluate the Diagnostic Reference Level (DRL) of the only nuclear medicine department of Libreville in Gabon. The studies were carried out with a SPECT/CT equipment and adult patients, the focus was on Tc-99m Bone scan examinations. Actual administered activities were calculated by the difference between the measured activity and residual activity after injection, the decay time was also considered for actual activities. Then, the median, mean and third quartile of actual administered activities distribution have been calculated. Results: The values found are comparable with those reported in other countries. Conclusion: This study presents the establishment process and the results of the first national DRLs for nuclear medicine procedures in Gabon to optimize radiation exposure.

Keywords: Radiation Protection, Nuclear medicine, Diagnostic reference levels, bone scintigraphy

I. INTRODUCTION

Over the past century, medical imaging has evolved to an indispensable part of diagnostic procedures. However, some of the most common imaging methods make use of ionizing radiation and thus, inherently imply radiation exposure to patients [1 below]. Diagnostic Reference Levels (DRLs) have been introduced by the International Commission on Radiological Protection ICRP publications [2,3] for assisting the optimization of radiological investigation.

In 2012, a nuclear medicine global initiative was established that aims to promote human health by advancing the fields of nuclear medicine and molecular imaging, to encourage global collaboration in education, and to harmonize procedure guidelines and other policies that ultimately lead to improvements in quality and safety in the fields throughout the world [on page 63]. One of the recommendations of this initiative was that countries with no current guidelines on administered nuclear medicine activities in children should either develop their own or officially adopt currently existing ones.

Nuclear medicine and hybrid imaging procedures may also increase radiation exposure to the general public because of the characteristics of the administered radiopharmaceuticals compared with diagnostic radiology procedures. This potential increased exposure has raised many concerns about potential radiation risks [5]. There is substantial need to establish DRLs in nuclear medicine imaging studies to reduce unjustified medical radiation exposure and social concerns, as well as to optimize radiation protection. DRL are standard levels of easily measurable quantities, such as the dose length product in computer tomography (CT) or administrated activity in nuclear medicine (NUC), for common procedures. DRL for NUC can be set at the third quartile as for radiography or CT but also at the median or mean of each examination type.

II. MATERIALS AND METHODS

This study was conducted at the Institute of Cancerology of Akanda, formerly known as the Institute of Cancerology of Libreville. The data were collected from the nuclear medicine department of the institute over several months, the NUC department is the only one in Gabon, so this study has covered all the national nuclear medicine activities of the country.

Data recording and collection has been done with those different parameters:

- Patient and examination information: patient identification, procedure type, equipment, date, time, age, gender and weight.

- Nuclear medicine: radionuclide, radiopharmaceutical, administered activity, pre-administration measured activity, post-administration measured activity and activity per weigh.

The studies were carried out with a SPECT/CT equipment (Philips) and the data for 30 adult patients (more than 30 years old) is presented in this paper. The focus was on Tc-99m-methyl diphosphonate Bone scan examinations. All datasets of patient weight lower than 45 kg were excluded and less than 20% of the group weighed over 90kg.

The collected data of patients was analysed, and the required details were extracted. The departmental protocol for bone scintigraphy included preparing the radiopharmaceutical (^{99m}Tc), measuring it with a dose calibrator in the radiopharmacy hot lab, administering it intravenously to referred patients. The administered activity administered, and other anthropometric parameters were recorded for each patient.

Actual administered activities were calculated by the difference between the measured activity and residual activity after injection, the decay time was also considered for actual activities.

The data collected in this study were saved and analyzed using Microsoft Office Excel. It was mainly used to compute administered activity of each patient, the mean values, median values and plot graphs.

The actual administered activities (Aadm) for each patient have been calculated using the following formula:

$$\mathrm{Aadm} = \mathrm{Ameas} * e^{\ln(2)*\frac{\mathrm{admT}-\mathrm{measT}}{\lambda}} - \mathrm{Ares} * e^{\ln(2)*\frac{\mathrm{resT}-\mathrm{admT}}{\lambda}} \quad (1)$$

With:
Measured activity: Ameas (MBq)
Measured time: measT
Administered time: admT
Residual activity: Ares (MBq)
Residual activity time: resT
Actual administered activity: Aadm (MBq)
λ: half-life of the ^{99m}Tc. (Day)

Then, the 75th percentile, median and mean of actual administered activities were calculated to get local reference levels.

III. RESULTS

Patients data, measured activities and residual activities for the 30 patients have been collected and registered in an Excel spreadsheet. With the compiled data, the actual administered activity has been calculated for each patient using the formula (1). **Table 2** shows a sample of patients and their collected parameters.

Thereafter, the median and mean of administered activities have also been calculated and are respectively 700.76 MBq and 686.74 MBq and the DRL value that has been calculated with the 3rd quartile is 721.03 MBq.

The DRL in Gabon was compared with DRLs recently internationally reported [6,7,8,9] (**Table 3)**. The Gabon DRL value is lower than the DRL values from Sudan [6], Kuwait [7], Nigeria [8] and Australia but higher than the U.K. [9] value; It is also in the range of European union values [10].

The mean administered activity has also been compared to other countries **(Table 4**). The Gabonese mean value was lower than the Sudanese, Nigerian and Brazilian mean value but higher than the French mean value [11].

It was also important to see if there is a correlation between administered activities to the patient and his weight (**Figure 1)**. The graph has showed that for these datasets, the administered activity did not take into account the weight of the patient. Infact, a patient with a weight of 52Kg has received an activity of 815Mbq while another one weighing 78Kg has received an activity of 721MBq.

IV. DISCUSSION

DRLs are considered an effective optimization tool for improving radiation protection in medical imaging [12] and are not in any way dose limits or constraints, nor do they serve regulatory purposes. However, they aim to identify whether some common procedures present unusually high values, alerting the department to act accordingly by, for instance, reviewing procedures, protocols, or equipment.

This study has established preliminary DRLs for bone scintigraphy for the only hospital that offers nuclear medicine services currently. The values have been found within the international range of 500 – 1110 MBq whether for the DRL value or mean administered activity value. The DRL value is 721.03MBq and the mean administered activity is 686.74MBq

Nevertheless, the present study has some limitations. The patient weight has not been considered for the administered activity, while the ICRP recommend a consideration should be given to adjusting administered activities based on agreed factors linked to weight [13]. So, procedures should be optimized to include the patient weight factor to determine the administered activity, thus the next DRL should be better improved with this new added component.

Also, the administered activity alone is analyzed without evaluation of the image quality. Although, it may be difficult to assess the image quality objectively as it involves not only administered activity but also the use of different hardware and readers' preferences.

More, the equipment used in the institution is a SPECT/CT so for the next study, the DRL of the CT component of SPECT/CT should be considered for hybrid imaging examinations.

Also, the administered activity in children is not analyzed in this study while children are more sensitive to ionizing radiation.

Table 2: Actual administrated activities

Patients	Age	Weight (kg)	A_{meas} (MBq)	Meas time	Admin time	Ares (MBq)	Res time	A_{adm} (MBq)
1	78	73.6	775	08:20	08:28	22.51	08:33	**740.43**
2	54	51.5	876	08:44	08:53	29.62	08:55	**831.22**
3	31	46.1	832	08:12	09:17	14	09:20	**720.05**
4	77	50.1	727.5	08:17	09:00	17.4	09:15	**651.78**
5	59	78	856	08:14	09:00	61.13	09:08	**721.37**
6	34	87.7	926.1	08:18	09:08	48.83	09:11	**791.99**
7	55	52.3	868.7	08:16	08:35	21.44	09:00	**815.00**
8	36	45	724	08:06	08:30	39.66	08:42	**650.72**
9	40	98.1	759.3	08:08	08:35	18.1	08:42	**702.49**
10	39	64.3	852.3	08:10	08:45	48.95	08:53	**747.05**

Table 3 : DRL (MBq) in Gabon compared with other countries.

Radioisotope study	Gabon	European Union	Kuwait	Sudan	Nigeria	Australia	U.K.
^{99m}Tc-MDP Bone scan	721.03	500–1,110	944	777	895.4	920	600

Table 4: Mean administered activity (MBq) in Gabon Compared with Other Countries

Radioisotope study	Gabon	France	Sudan	Nigeria	Brazil
99mTc-MDP Bone scan	686.74	670	709.7	833.98	1,036

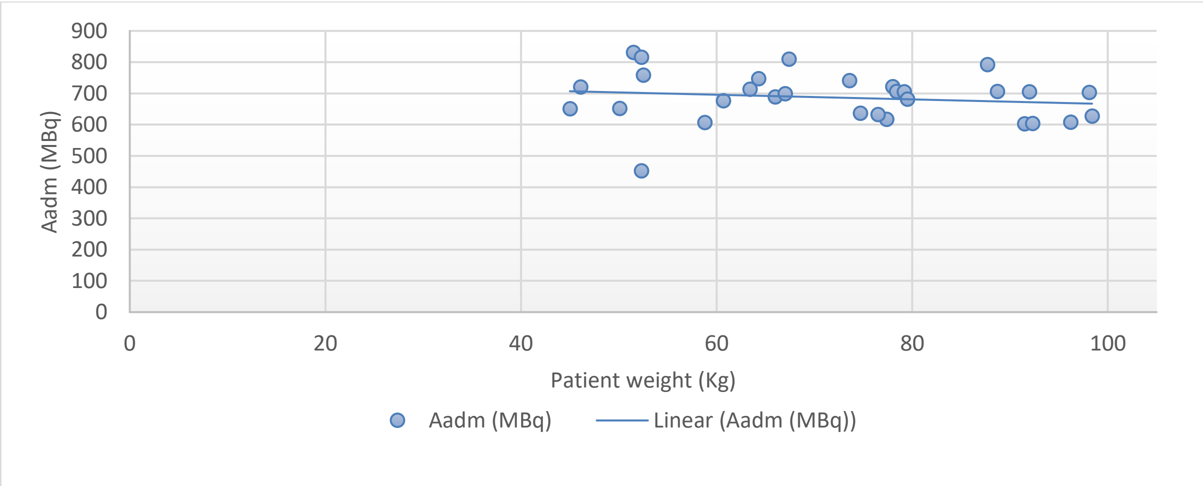

Figure 1: Correlation administered activity and patient weight.

V. CONCLUSION

This work presents data on administered activities used in clinical practice for diagnostic nuclear medicine procedures in Gabon to provide the DRL at a national level. The administered activities found are comparable with those reported in other countries. However, meeting DRLs does not automatically mean that good practice is being performed. The patient weight factor is not included in this review and must be added for the update of the DRL as well as DRLs of other procedures. Additionally, local reference levels should continuously be reassessed to optimize protocols, to ensure best practices and to reduce radiation exposure to patients and workers.

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USE OF THE BAYESIAN STATISTICS AND THE PRODUCT OF PROBABILITIES IN THE IONIZING RADIATION FIELD

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Abstract— **Nowadays, the probability of the intersection (PI) of two or more stochastic events or processes is calculated as the product of probabilities (PPs). The Bayes' theorem (BT) is widely used in the ionizing radiation field. We will show the PI is not only obtained as the PPs; but the minimum of their probabilities; and demonstrate that terms P(B|A) and P(A|B) in the BT are not new probabilistic metrics, but the own respective probabilities of B and A events. Mathematical derivations based on strong probabilistic foundations, and with their respective illustrations were our methodology. There are demonstrations of: 1) The two ways for determining the PI; and 2) Incoherencies of the BT. The tumor control probability (TCP) and normal tissue non-complication probability (NTCP0) of the radiation oncology treatments to patients with more than one target, calculated respectively as the product of TCP, and NTCP0 of each treatment, are excellent-practical examples in the determination of the PI using PPs. Given previously explained conditions of the BT terms; the use of this theorem should be re-considered. The current determination of the PI using the PPs is not valid for stochastic variables belonging to a stochastic event or process**.

Keywords— **Bayesian statistics; simulation; TCP; NTCP0; product of probabilities.**

I. INTRODUCTION

I.1 The derivation of the Bayes' theorem (BT)

Bayesian statistics (BS) is named after Thomas Bayes in 1793 formulated a specific case of Bayes' theorem in a published paper. "Bayes' theorem is a way to figure out conditional probability. Conditional probability is the probability of an event happening, given that it has some relationship to one or more other events." [1]. The BS is widely used in the ionizing radiation field as shown in [2-4]. The Figure 1 shows procedures described in the derivation of the BT.

In the Figure 1, N is the number of people of a population with two stochastic events A and B in These events are characterized with their respective probabilities P(A) and P(B), and

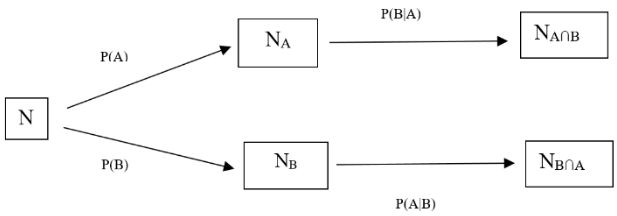

Figure 1. Graphical representation of the probabilistic procedures used in the derivation of the BT of the Eq. (7), and product of probabilities of the Eq. (5) and Eq. (6).

$$N_A = N * P(A) \quad (1)$$
$$N_{A\cap B} = N_A * P(B|A) \quad (2)$$

where N_A is the mean number of people (MNP) with a true A event; while $NA_{\cap B}$ is the MNP with true event A and B, and P(B|A) is the probability of B given A.

$$N_B = N * P(B) \quad (3)$$
$$N_{B\cap A} = N_B * P(A|B) \quad (4)$$

where N_B is the MNP with a true B event; while $N_{B\cap A}$ is the MNP with true both events B and A, where, P(A|B) is the probability of A given B.

Given P(A∩B) is probabilistically defined as $P(A \cap B) = N_{A\cap B}/N$, and using the elements of the Eq. (1) and Eq. (2), then

$$P(A \cap B) = P(A) * P(B|A) \quad (5)$$

The P(B∩A)= P(A∩B), and derived using a similar way is

$$P(B \cap A) = P(B) * \mathrm{P(A|B)} \quad (6)$$

.

Combining the Eq. (5) and Eq. (6), the BT is obtained as the following equation.

$$\mathrm{P(A|B)} = \frac{\mathrm{P(B|A)*P(A)}}{P(B)} \quad (7)$$

I.2 The product of probabilities (PPs) rule

"This rule states that the probability of simultaneous occurrence of two or more independent events (let's call A and B) is the product of the probabilities of occurrence of each of these events individually" [6], and mathematically expressed as

$$P(A \cap B) = P(A) * P(B) \quad (8)$$

$$P(B \cap A) = P(B) * \mathrm{P(A)} \quad (9)$$

In the radiation oncology therapy, the formulation of the normal tissue complication probability (NTCP) for multiple organs at risk (tNTCP) in [7] used the PPs as

$$tNTCP = 1 - \prod_i (1 - NTCP_i) \quad (10)$$

where $NTCP_i$ is the NTCP for i^{th} organ at risk.

Using the PPs and probabilistic definition, the uncomplicated TCP (UTCP), nowadays, the most acceptable UTCP formulation is the following:

$$UTCP = P(TC \cap NTC0) = TCP * NTCP0 \quad (11)$$

TCP is calculated as the ratio number of patients with a tumor control (TC) and total of a homogenous patient population treated with a specified radiation treatment; and NTCP0 as ratio number of patients without normal tissue complication (NTC0) and total of a homogenous patient population treated with a specified radiation treatment.

II. RESULT AND DISCUSSION

II.1 The Bayes' theorem

Taking into account the Eq. (5) and Eq. (8), as well as Eq. (6) and Eq. (9), then

$$P(A) * P(B|A) = P(A) * P(B) \quad (12)$$

$$P(B) * \mathrm{P(A|B)} = \mathrm{P(B)} * \mathrm{P(A)} \quad (13)$$

The two previous equations show that actually P(B|A) is P(B), and P(A|B) is P(A).

II. 2 Product of probabilities (PPs)

The radiation oncology treatment is a stochastic process (SP) that involves the tumor control (TC), normal tissue non-complication (NTC0) and normal tissue complications, which are independent stochastic variables (SVs), and associated respectively to probabilistic metrics TCP, NTCP0 and $NTCP_i$ (i=1..nc, nc: Number of complications). NTCP0 has been recently introduced in the radiotherapy, as described in [8-10].

When the radiation treatment is given to patients with more than one target, these are treated with more than one treatment. Each separated or successive treatment has its own SVs. For these reasons, TCP and NTCP0 for multiple targets are calculated as

$$TCP = \prod TCP_i \quad (14)$$

$$NTCP0 = \prod NTCP0_i \quad (15)$$

where TCP_i and $NTCP0_i$ are respectively TCP and NTCP0 of the treatment for the i^{th} target. The previous equations can be obtained using the same procedure of the Eq. (5). The Eq. (14) has been previous developed already in [7] by other researchers.

The normal tissue complications associated to $NTCP_i$ or their probabilistic complements ($1-NTCP_i$) are SVs and simultaneously generated after a radiation treatment; i.e., these processes are not successive, for this reason the PPs of the previous Eq. (10) is incoherent.

In [8] and [10] we have developed a new formulation of the NTCP for multiple organs at risks or End-points, which we have called as the total NTCP (TNTCP=1-NTCP0), and expressed as

$$TNTCP = \sum_i NTCP_i \quad (16)$$

where *i=1..nc, nc:* Number of complications

II. 2 The new P(A∩B) formulation

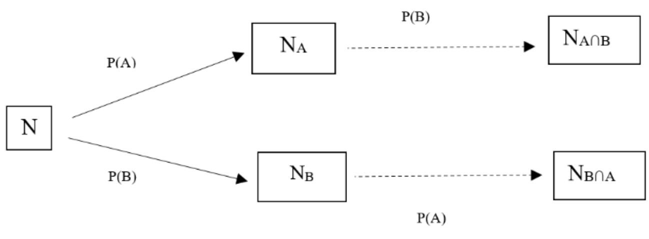

Figure 2. Graphical representation of the incorrect procedures used in the P(A∩B) and P(B∩A) formulations using the Eq. (17) and Eq. (18). Although these equations are probabilistically well-formulated; the dash arrows represent there are not any stochastic process associated.

As shown in the Figure 2 with a dash arow, although the following expressions

$$N_{A\cap B} = N_A * P(B) \quad (17)$$

$$N_{B\cap A} = N_B * P(A) \quad (18)$$

are probabilistically well-formulated; these should be used only for successive SPs, like successive radiation treatments to patients with two targets; and it is incorrect its use when are not associated to SPs. A statistic justification should exist for determining mean values using PPs.

As whatever probabilistic metric, for obtaining P(A∩B) using computational simulations, one should generate one random number (RN) in each simulation; where RN <= P(A∩B) is the condition of success. If a SP has two SVs A and B; given this SP inherently involves a specific P(A) and P(B); in the simulations the generated RN should be compared with P(A) and P(B), in particular with min(P(A),P(B)), which expresses the condition of success for P(A∩B).

The Figure 3 illustrates the procedure used in the derivation of the Eq. (19).

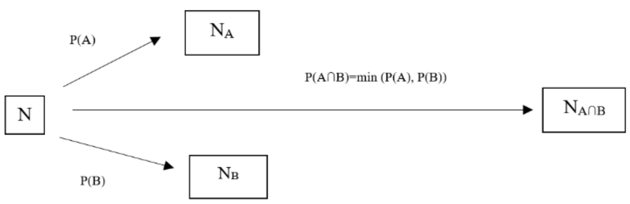

Figure 3. Representation of the two stochastic and independent events or variables A and B with their respective probabilities P(A) and P(B), and our proposal of the joint probability or PI P(A∩B) = min(P(A),P(B)).

$$P(A \cap B) = min(P(A), P(B)) \quad (19)$$

The probabilistic foundation of the Eq. (19) is represented in the Figure 4; and its values are determined for the region of intersection, which is the minimum of the probabilities P(A) and P(B).

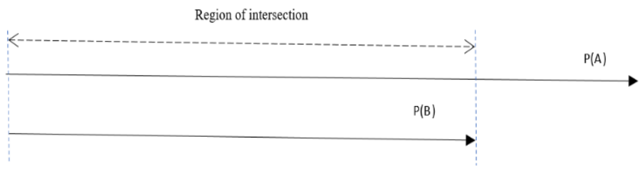

Figure 4. Representation of probabilistic foundation of the PI calculation done by the Eq. (19)

BT example of [1]: You might be interested in finding out a patient's probability of having liver disease if they are an alcoholic. "Being an alcoholic" is the test (kind of like a litmus test) for liver disease.

- A could mean the event "Patient has liver disease." Past data tells you that 10% of patients entering your clinic have liver disease. P(A) = 0.10.
- B could mean the litmus test that "Patient is an alcoholic." Five percent of the clinic's patients are alcoholics. P(B) = 0.05.
- You might also know that among those patients diagnosed with liver disease, are alcoholics. This is your B|A: the probability that a patient is alcoholic, given that they have liver disease, is 7%.
- BT tells you: P(A|B) = (0.07 * 0.1)/0.05 = 0.14. In other words, if the patient is an alcoholic, their chances of having liver disease is 0.14 (14%). This is a large increase from the 10% suggested by past data. But it's still unlikely that any particular patient has liver disease.

The P(B|A) value used in this example (0.07 or 7%) has been assumed.

For determining the probability of patients diagnosed with liver disease, alcoholics too, it should be calculated using the Eq. (19), then its value in this particular case is 5%.

II.3 Application of the P(A∩B)=min(P(A),P(B)) in the radiation oncology therapy.

UTCP is calculated as the ratio of the number of patients with a TC with NTC0 and the total of a homogenous patient population treated with a specified radiation treatment. Although UTCP is related to TCP and NTCP0; like each one of them, UTCP is a probabilistic metric, and this is not a derivation from TCP and NTCP0. Based on the Eq (19) this metric is calculated as

$$UTCP = min(TCP, NTCP0) \quad (20)$$

III) CONCLUSION

For two stochastic variables A and B of a stochastic process, P(A∩B)=min(P(A),P(B)), in other cases P(A∩B)=P(A)*P(B).

As shown in the Eq. (12) and Eq. (13), the P(B|A) and P(A|B) used in the derivation of the BT are not new probabilistic metrics, but they are own respective P(B) and P(A). For this reason, the use of the BT should be re-considered.

The UTCP of the radiation oncology treatments with a known TCP and NTCP0, and calculated as UTCP=min(TCP,NTCP0) is an excellent-practical example in the determination of the PI without using the PPs; but the minimum of the involved probabilities.

The results of UTCP=min(TCP,NTCP0) shows that is more probable the number of patients without normal tissue complications after they being cured with a treatment characterized with a TCP; than of results of

UTCP=TCP*NTCP0 because of min(TCP,NTCP0) >= TCP*NTCP0.

A. Author Contributions Statement

T. Frometa-Castillo wrote the main text; A. Pyakuryal and G. Narayanasamy prepared all figures; and Pyakuryal, Ganesh and Mesbahi reviewed the manuscript.

Data availability statement: No data

'Conflict of interest' statement: None

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MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE FOR MEDICAL PHYSICISTS: THE IMPORTANCE OF CONTINUOUS SELF-LEARNING

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Abstract— **Artificial intelligence (AI) and machine learning (ML) have emerged as game-changers in the realm of medical physics, offering unprecedented advancements in diagnostic and treatment methodologies. It is essential for medical physicists to keep up to date with the latest developments in AI/ML to stay relevant and provide the best patient care. In the present work, we emphasize the importance of continuous self-learning for medical physicists in order to harness the potential of AI/ML. As these technologies permeate various aspects of medical physics, including image analysis, radiotherapy planning, and personalized medicine, staying abreast of the latest trends and techniques is crucial. Medical physicists who actively engage in self-learning can develop a deeper understanding of AI/ML algorithms, which facilitates their integration into clinical workflows, ultimately leading to improved patient outcomes. By engaging in self-learning, medical physicists can cultivate a culture of adaptability and lifelong learning, essential for thriving in an ever-evolving technological landscape. In conclusion, it is vital for medical physicists to adopt a self-learning approach to stay updated with the rapidly advancing AI/ML technologies. This will not only enhance their professional competence but also contribute to the overall growth and development of the medical physics field, ultimately benefiting patients through more accurate diagnostics and effective treatment strategies.**

Keywords— **artificial intelligence, machine learning, lifelong learning, medical physics**

I. INTRODUCTION

Artificial intelligence (AI) and machine learning (ML) have been making significant strides in various sectors, and healthcare is no exception. In recent years, the intersection of AI/ML and medical physics has created new opportunities to enhance diagnostic and therapeutic procedures, leading to improved patient care. The rapid evolution of these technologies necessitates that medical physicists adopt a self-learning approach to stay current with the latest developments and integrate them effectively into clinical practice. This paper aims to provide an overview of the impact of AI/ML on medical physics, as of 2023, and emphasize the importance of continuous self-learning for medical physicists.

Medical physics, as a discipline, focuses on the application of physics principles to medicine, particularly in the diagnosis and treatment of diseases using radiation. Traditionally, medical physicists have played a crucial role in the safe and effective use of radiation in diagnostic imaging and radiotherapy. However, with the advent of AI/ML technologies, their role is expanding to encompass the integration of these cutting-edge tools in various such aspects of medical physics [1-7].

The introduction of AI/ML in medical physics has led to the development of novel techniques that can enhance diagnostic accuracy [8], optimize treatment planning [9], and enable personalized medicine [10-14]. As these technologies continue to evolve at a rapid pace, medical physicists must invest in self-learning to acquire the skills and knowledge necessary to effectively implement AI/ML-based solutions. This commitment to continuous learning will not only ensure the professional growth of medical physicists but also contribute to the advancement of the field as a whole.

In this paper, we will discuss the various applications of AI/ML in medical physics, the challenges and opportunities associated with their integration, and the strategies that medical physicists can employ for effective self-learning. Our aim is to underscore the importance of embracing a culture of adaptability and lifelong learning to fully harness the potential of AI/ML, ultimately leading to better patient outcomes and enhanced healthcare delivery.

The integration of artificial intelligence (AI) in healthcare has gained significant momentum in recent years, with numerous AI-driven solutions being developed and tested to enhance patient care. Regulatory bodies, such as the US Food and Drug Administration (FDA), have acknowledged the potential of AI in transforming healthcare and have been increasingly approving AI-based medical devices and software.

As of October 2022 [15], the FDA had approved over 178 AI-based products, with the actual number of approvals since then likely to be much higher. Although a comprehensive account of all FDA-approved AI products until the present date is beyond the scope of this work, we can examine the trends and highlight some notable approvals to provide a broader understanding of the impact AI has had on healthcare, and particularly in the field of diagnostic radiology and imaging.

II. M.EDICAL IMAGING AND ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) has emerged as a significant driving force in medical imaging, demonstrating the potential to revolutionize the way clinicians interpret and analyze magnetic resonance imaging (MRI) and computed tomography (CT) scans.

In the context of MRI, AI-powered techniques have been developed to address various challenges, such as improving image quality by leveraging raw k-space data [16] or by acting as a AI-based filter in the final image [17] (or somewhere in between [18], and automating the segmentation and quantification of anatomical structures [19]. AI-driven solutions like de-noising and super-resolution algorithms have been instrumental in enhancing the quality of MRI images, enabling more accurate diagnoses.

One notable AI-driven development in MRI is the advent of synthetic MRI [20-22], which uses ML algorithms to generate multiple contrast-weighted images from a single acquisition.

CT imaging has also greatly benefited from the incorporation of AI-based solutions. AI algorithms have been employed to optimize image reconstruction, reduce radiation dose, and automate the detection and characterization of various pathologies. AI-driven iterative reconstruction techniques [23] have demonstrated the potential to improve image quality while reducing radiation dose, a crucial factor in minimizing the risks associated with repeated CT scans.

AI-powered solutions have been particularly beneficial in detecting and characterizing lung nodules in CT scans, enabling early diagnosis of lung cancer [24]. Moreover, AI has been applied to differentiate between benign and malignant lesions in both MRI and CT images, assisting radiologists and clinicians in making more informed decisions regarding patient management and treatment [25, 26].

The integration of AI in medical imaging has also facilitated the implementation of radiomics [27], a field that extracts quantitative features from medical images and uses ML algorithms to predict patient prognosis, treatment response, and disease progression. Radiomics has demonstrated potential in personalizing patient care, paving the way towards precision medicine [28-30].

Finally, recent works have demonstrated that AI-based solutions can help with contrast-enhanced images acquired at only a $1/10^{th}$ of the full dose, by synthesizing the predicted full-dose image [31-32].

Overall, AI-based solutions in medical imaging have the potential to transform diagnostic processes and enhance patient care. By improving image quality, reducing acquisition times, and automating the detection and characterization of various pathologies, AI-driven technologies are empowering radiologists, medical physicists, and clinicians to make more accurate and timely decisions, ultimately improving patient outcomes. As AI continues to evolve, its impact on medical imaging is expected to grow even more, fostering innovation and driving advancements in personalized medicine.

III. STARTING POINT AND READING MATERIALS

Over the past years, Python has seen a tremendous increase in usage from the medical physics community, although MatLab is still considered the go-to computing language for the medical physicist. While MatLab gives equivalent possibilities for AI and ML, Python is by far the most widely spread language for AI/ML, mainly due to the fact that it is an open-source language, with several important major libraries (such as TensorFlow [33], PyTorch [34] etc.) that can help the developer.

For the medical physicist who wants to begin his/her journey to artificial intelligence, we propose the following steps (assuming working knowledge of Python v.3): First, participate in the following online courses offered by Andrew NG (pioneer in the field of ML/AI) in the website www.deeplearning.ai.

A. ***AI for everyone*** *(Online Course)*
https://www.deeplearning.ai/courses/ai-for-everyone/

B. ***Mathematics for Machine Learning and Data Science Specialization*** *(Online Course)*
https://www.deeplearning.ai/courses/mathematics-for-machine-learning-and-data-science-specialization/

C. ***Machine Learning Specialization*** *(Online Course)*
https://www.deeplearning.ai/courses/machine-learning-specialization/

D. ***Deep Learning Specialization*** *(Online Course)*
https://www.deeplearning.ai/courses/deep-learning-specialization/

E. ***TensorFlow Developer Professional Certificate*** *(Online Course) https://www.deeplearning.ai/courses/tensorflow-developer-professional-certificate/*

F. ***AI for Medicine Specialization*** *(Online Course)*
https://www.deeplearning.ai/courses/ai-for-medicine-specialization/

Of course, this list is non-exhaustive, and is based on the authors' collective experience with ML/AI online courses. There are several excellent online courses offered on the website www.coursera.org, organized and delivered by various universities and research institutions.

In case the medical physicist is unfamiliar with Python, we propose some free courses with working examples offered on www.kaggle.com, and some excellent paid courses offered on udemy.com, like Anthony NG's course (The Complete Machine Learning Course with Python-https://www.udemy.com/course/machine-learning-course-with-python/).

IV. Conclusions

To sum up, artificial intelligence (AI) and machine learning (ML) have made significant strides in healthcare, particularly in medical physics and medical imaging. Medical physicists must engage in continuous self-learning to effectively implement AI/ML-based solutions and enhance patient care. As AI continues to evolve, it is crucial for healthcare professionals to embrace a culture of adaptability and lifelong learning to harness the transformative potential of AI and ensure better healthcare delivery. Finally, the medical physicist should stay tuned for the latest AI developments and trends in the field, by following closely the European and international guidelines/recommendations from the leading experts in the field (numerous publications, whitepapers, reviews, and current opinions, can be found here[1]).

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QUANTIFICATION OF RADIATION DOSE TO THE RADIOLOGIST'S EYES ASSOCIATED WITH VARIOUS INTERVENTION PROCEDURES

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Abstract— **This study aimed to measure equivalent doses to the eyes of intervention radiologists during various procedures using an organ TLD dosimeter and compare them with the threshold radiation dose to the eyes. The study was conducted at the Interventional Radiology Department of the Sanjay Gandhi Post Graduate Institute of Medical Sciences in Lucknow, Uttar Pradesh. A TLD eye dosimeter (Head badge) comprising three CaSO4: Dy Teflon TL discs (0.4 mm thickness, 5.0 mm diameter) was used to measure radiation dose to the eyes. Doses were evaluated using the standard dose evaluation algorithm employed in TLD personal monitoring services, with a PC-based Nucleonic TL Research Reader (Type TL 1009I). Additional data collected included procedure type, fluoroscopy duration, primary doctor, secondary doctor (assisting physician), and machine model. The dose received in mSv/hr by an interventional radiologist was converted to mSv/yr based on the specified working hour limits by the International Commission on Radiological Protection (ICRP).The study revealed the highest ocular radiation dose during gastroenterological procedures at 2.9 mSv/h, followed by vascular and neurological procedures at 0.69 and 0.41 mSv/h, respectively. The primary operators received higher doses compared to the secondary auxiliary physicians. On average, the radiation exposure to the eyes of doctors (205 mSv/yr) exceeded the acceptable equivalent annual dose limit for the eye, which is 20 mSv/year, as recommended by ICRP 103 (2007).The study highlights that interventional radiologists at our center are exposed to significantly higher doses to the eyes than the recommended levels, which may lead to long-term adverse side effects. Alongside strict radiation dose monitoring, implementing measures such as an increase in the frequency of rotating intervention radiology postings and providing appropriate radiation protection (Ceiling shield for Eye) could help prevent high radiation exposure to the eyes.**

Keywords— **TLD, Eye dose, Interventional radiologist.**

I. INTRODUCTION

Interventional radiology procedures play a crucial role in medical diagnosis and treatment but come with the challenge of exposing both interventional radiology staff and patients to significant doses of radiation. The extent of radiation exposure can vary depending on several factors, including the complexity and duration of the procedure, the experience of the radiologist, and the distance between the staff and the radiation source.

Of particular concern is the potential radiation exposure to the eyes, which can increase the risk of developing cataracts. Research conducted by Haskal and Worgul[2] identified cataracts in five out of 59 (8%) interventional radiology physicians screened, with an additional 22 subjects (37%) exhibiting small paracentral dotlike opacities an early sign of cataract development. Furthermore, studies, such as the one by Ainsbury et al.[3] in 2009, have suggested that the threshold for radiation-induced cataract formation might be lower than previously estimated. As a result, ensuring radiation protection and accurate dose evaluation are critical aspects of safeguarding interventional radiology staff.

Typically, the radiation dose received by interventional radiologists is measured using personal radiation monitoring devices, which assess the effective dose received by the whole body. However, there is limited research focusing on organ-specific equivalent dosages for the eyes. Thus, the objective of this study was to measure the equivalent dose to the eyes of interventional radiologists during various procedures, utilizing an organ TLD dosimeter. Subsequently, the findings were compared with the threshold radiation dosage considered safe for the eyes.

In light of the potential long-term health implications associated with radiation exposure, this study aims to contribute valuable insights that can help refine safety measures and establish best practices for protecting interventional radiology staff from the hazards of excessive radiation exposure to the eyes. By providing essential data on organ-specific equivalent dosages, we aim to underscore the significance of radiation protection and promote the well-being of those dedicated to advancing medical care through interventional radiology procedures.

II. MATERIALS AND METHODS

The research was conducted in the interventional radiology department's gastroenterology, neurology, and vascular units, which are integral parts of the medical facility. To measure the eye lens dose, an eye lens dosimeter (head badge) was used, which was worn on the forehead between the eyes. The dosimeter comprised three CaSO4: Dy Teflon TL discs, each with a thickness of 0.4 mm and a diameter of 5.0 mm (as depicted in Fig. 1). The doses were evaluated using a standard dose evaluation algorithm, which is part of the TLD (Thermoluminescent Dosimeter) personal monitoring service. The readings were analyzed on a PC-based Nucleonic TL Research Reader (Type TL 1009I), as shown in Fig. 2.

During the evaluation process, a reporting dose of 0.5 mSv was used, and any evaluated dose below this threshold was recorded as 0.00 mSv. The equivalent dose was measured in terms of the operational quantity Hp (0.07), which represents the dose absorbed in the eye lens.

A total of 164 readings were collected from seven specifically designated eye lens dosimeters (ELDs), assigned to the neurology (ELD1, ELD2), gastroenterology (ELD3, ELD4, ELD6), and vascular (ELD5, ELD7) interventional radiology units. However, it is important to note that data from ELD5 was not included in the study due to a missing disc.

For each procedure, the x-ray parameters (Kv, mA, mAs) and the total fluoroscopy time in mGy were meticulously recorded. Additionally, detailed information was gathered concerning the duration of each procedure, the specific type of procedure performed, the experience level of the interventional radiologist conducting the procedure, and the utilization of various radiation protection equipment. These protective measures included the use of table curtains, ceiling shields, floor shields, eyeglasses, thyroid collar shields, whole-body lead aprons, and other relevant safety gear.

The comprehensive data collection and analysis in this study aim to provide a thorough understanding of the eye lens doses received by interventional radiology staff during various procedures. By examining the x-ray parameters, fluoroscopy times, and protective measures utilized, we seek to identify potential factors influencing radiation exposure to the eyes. The outcomes of this research are vital in establishing guidelines and best practices to ensure the safety and well-being of interventional radiology personnel, reducing the risk of cataract development and other adverse effects associated with excessive eye lens radiation exposure.

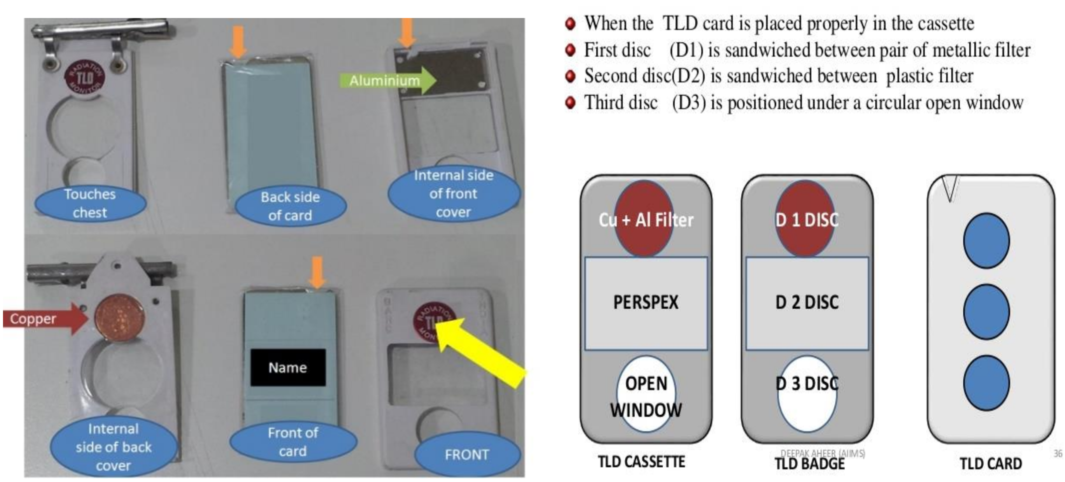

Figure 1: Cross section of TLD Badge description

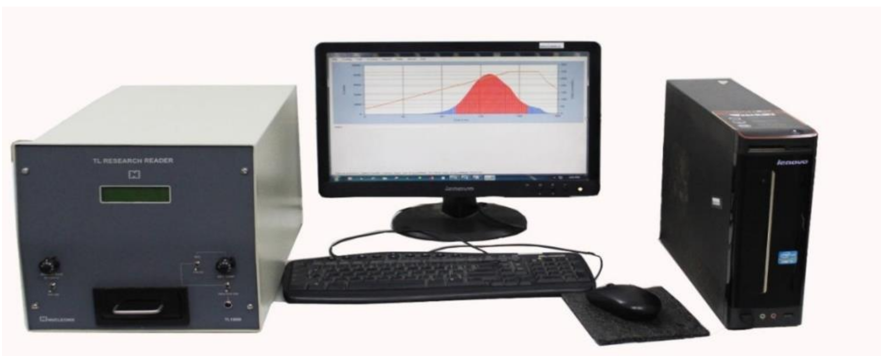

Figure-2: TLD Chest Badge Reader

III. RESULTS

In our study, we employed Thermoluminescent Dosimeters (TLDs) to assess the integrated dose, also referred to as the cumulative dose, received by medical personnel during various interventional radiology procedures. The integrated dose represents the total radiation dose accumulated over a specific exposure period. However, for our analysis and reporting in the results section, we focused on the dose rate, which denotes the rate at which radiation is received per unit of time, measured in millisieverts per hour (mSv/hr). To calculate the dose rate from the integrated dose readings, we divided the total integrated dose by the corresponding exposure hours for each doctor involved in the procedures. This division provided us with the average dose rate per hour for each specific procedure, allowing us to comprehend the intensity of radiation exposure during various moments throughout the medical interventions.

For example, in the case of the Gastro procedure, TLD measurements provided the integrated dose for both the primary and secondary doctors. By dividing these integrated doses by the respective exposure hours for each doctor, we obtained the dose rate values:

Integrated dose (TLD reading): 34.60 mSv
Exposure time: 11.94 hours
Dose rate (mSv/hr) for the primary doctor: 34.60 mSv / 11.94 hours ≈ 2.89 mSv/hr
Dose rate (mSv/hr) for the secondary doctor: 11.03 mSv / 15.78 hours ≈ 0.70 mSv/hr
Total dose rate (mSv/hr) for Gastro doctors: 2.89 mSv/hr + 0.70 mSv/hr = 3.59 mSv/hr

Similarly, we followed the same process for the Neuro and Vascular procedures, resulting in dose rate values of 0.56 mSv/hr and 0.54 mSv/hr, respectively.

Neuro Procedure:
Integrated dose (TLD reading): 6.80 mSv
Exposure time: 16.72 hours
Dose rate (mSv/hr) for the primary doctor: 6.80 mSv / 16.72 hours ≈ 0.41 mSv/hr
Dose rate (mSv/hr) for the secondary doctor: 3 mSv / 20.48 hours ≈ 0.15 mSv/hr
Total dose rate (mSv/hr) for Neuro doctors: 0.41 mSv/hr + 0.15 mSv/hr = 0.56 mSv/hr

Vascular Procedure:
Integrated dose (TLD reading) for the primary doctor: Data not received (due to no disc in the ring)
Integrated dose (TLD reading) for the secondary doctor: 4.5 mSv
Exposure time for the secondary doctor: 8.32 hours
Dose rate (mSv/hr) for the secondary doctor: 4.5 mSv / 8.32 hours ≈ 0.54 mSv/hr
Total dose rate (mSv/hr) for Vascular doctor: 0.54 mSv/hr

The results from the vascular unit may not be fully representative due to the mechanical defect in one of the ELDs.

Regarding the eye lens dose, the average radiation dose to the eyes of the doctors was measured at 0.79 mSv/hr, which is equivalent to 205 mSv/yr (the dose received in mSv/hr was converted to mSv/yr according to the ICRP specified working hours limit for the year). This calculated dose is 10 times higher than the equivalent annual dose limit of 20 mSv/yr for the eyes, as recommended by the ICRP 103 (2007) guidelines.

To elucidate the cumulative dose in a year to the eye, the following calculation was performed:
Total Eye (mSV/hr) calculated in DSA procedure for Gastrology, Neurology & Vascular departments was 0.79 mSv/hr as per TLD reading. It was converted to 205 mSv/yr.

The calculation process:
52 weeks / year * 5 Working hours * 1 Hour (fluoroscopy time <X-ray pressed by Doctors>) = 260 Hours.

260 Hours X 0.79 mSv/hr = 205 mSv/yr

It is essential to note that approximately per week, one doctor can be exposed to X-rays for about 60 minutes during fluoroscopy time (X-ray pressed by the Doctor), even though each procedure may take 3 to 4 hours, fluoroscopy time typically lasts for 15-20 minutes only.

Our study reveals concerning findings regarding the high radiation dose rates experienced by interventional radiologists during various procedures, especially in the eyes. These results underscore the critical importance of implementing strict radiation protection protocols and safety measures to safeguard the well-being of medical personnel exposed to ionizing radiation regularly. By addressing and mitigating the risk of excessive radiation exposure, we can better protect the health and safety of interventional radiology staff, reducing the potential long-term adverse effects associated with such exposure.

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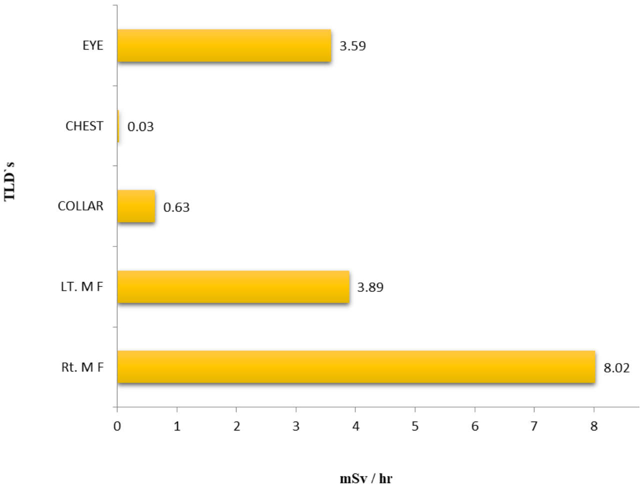

Figure 3: Distribution with regards to radiation exposure (mSv/hr) to the eye (ELD-eye lens dosimetry), chest (whole body), collar, left hand middle finger and right-hand middle finger (ERB-extremities ring badge) to the doctors in Gastrology unit while working on DSA radiology

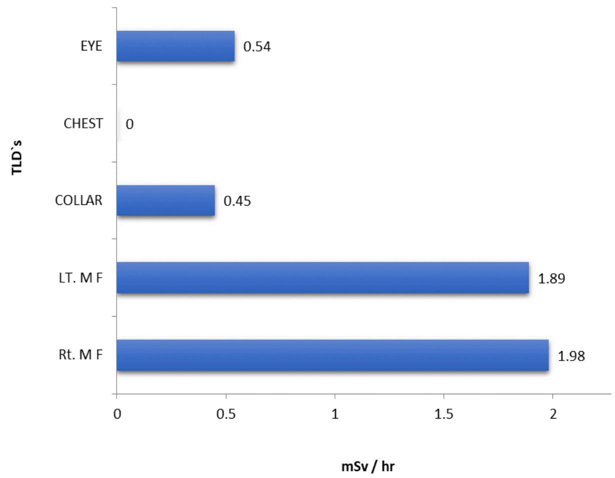

Figure 4: Distribution with regards to radiation exposure (mSv/hr) to the eye (ELD-eye lens dosimetry), chest (whole body), collar, left hand middle finger and right hand middle finger (ERB-extremities ring badge) to the doctors in vascular unit while working in DSA radiology

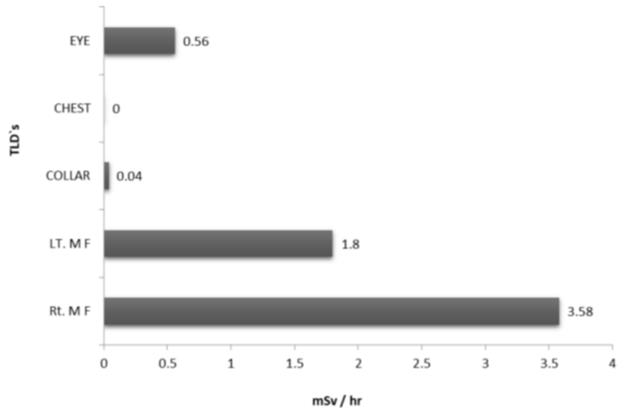

Figure 5: Distribution with regards to radiation exposure (mSv/hr) to the eye (ELD-eye lens dosimetry), chest (whole body), collar, left hand middle finger and right-hand middle finger (ERB-extremities ring badge) to the doctors in neurology unit while working in DSA radiology

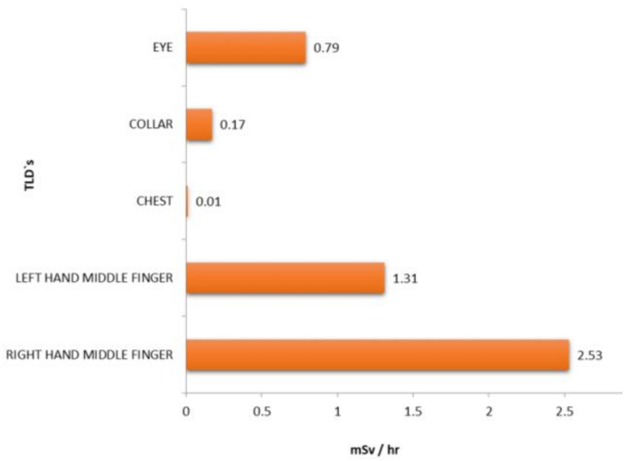

Fig-6:- Distribution with regards to radiation exposure (mSv/hr) to the Eye, Collar, Chest and Finger to the doctors working in Neuro, Gastro & Vascular units, in the DSA Radiology department

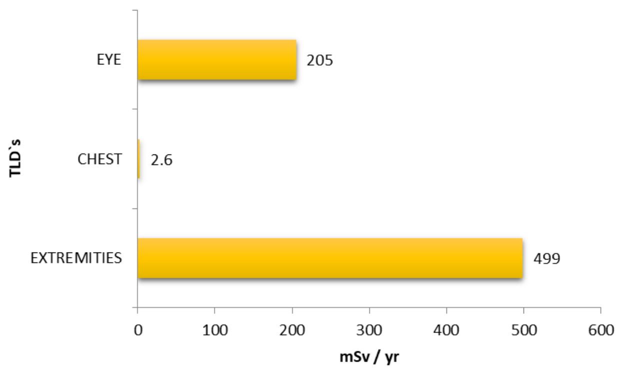

Figure 7: Conversion graph with regards to radiation exposure mSv per hour to mSv per year to the Eye, Chest (WB) and Extremities to the doctors working in Neuro, Gastro & Vascular units, in the DSA Radiology department

IV. DISCUSSION

The findings from our study raise significant concerns regarding the high radiation doses received by interventional radiologists to their eyes, potentially leading to an increased risk of cataract development. The lack of specific local studies addressing this issue further emphasizes the urgency of investigating and objectively measuring the impact of radiation dose on the eyes of medical personnel working in interventional radiology.

The annual reference equivalent dose limit for ocular lenses set at 20 mSv/year, as per ICRP 203 (2007) guidelines, serves as a crucial benchmark for radiation safety. However, in routine practice, the radiation dose to the eyes is not routinely measured, making it vital to incorporate additional Eye TLDs (head badges) alongside conventional TLDs for accurate and precise evaluation of the cumulative radiation dose to the radiologists' eyes.

Our study revealed notable variations in the cumulative radiation dose to the eyes among different interventional radiology units. Specifically, the gastroenterology procedures demonstrated the highest dose, followed by vascular and neurology procedures. This discrepancy could be attributed to the increased number and duration of procedures performed in the gastroenterology units compared to the other units. Nevertheless, we must acknowledge that the radiation dose measured in vascular procedures may have been underestimated due to the absence of data from one of the TLDs, indicating the need for further investigations to address this limitation.

The strikingly high average equivalent dose to the eyes, approximately 10 times higher than the equivalent annual dose limit recommended by IRCP 103 (2007), is a significant cause for concern. While some of the observed discrepancies may be attributed to the small sample size and unusual radiation dose in specific instances (ELD 3), it nonetheless highlights the critical importance of diligently monitoring radiation dose and ensuring strict adherence to radiation safety guidelines.

To effectively mitigate the potential adverse effects of excessive radiation exposure, proactive measures are necessary. Ensuring the availability and proper use of radiation protective gear, including lead aprons, thyroid collars, and eyeglasses, can significantly minimize radiation exposure to sensitive organs like the eyes.

Furthermore, implementing appropriate rotation in the duty roster is crucial to limit the frequency and duration of radiation exposure for individual radiologists. An organized and well-managed scheduling system can provide adequate recovery time between procedures, minimizing the cumulative impact of radiation exposure on the eyes and overall health of the medical personnel.

Continuing education and training programs play a pivotal role in raising awareness among interventional radiology staff regarding radiation safety guidelines and best practices. By staying informed and updated on the latest advancements in radiation protection, medical professionals can take proactive steps to safeguard their health while providing optimal patient care.

To comprehensively address this issue, larger-scale studies and collaborative efforts within the medical community are essential. Gathering comprehensive data from multiple institutions and countries will enable the establishment of evidence-based guidelines for radiation dose limits specific to interventional radiologists, thereby improving radiation safety protocols and practices.

Our study serves as a critical call-to-action to prioritize the monitoring and control of radiation dose in the eyes of interventional radiologists. By recognizing and addressing potential risks, and implementing stringent safety measures, we can ensure the well-being and long-term health of medical professionals working in this field. Protecting the health of interventional radiologists is not only crucial for their own sake but also paramount for providing high-quality patient care and advancing the field of interventional radiology as a whole. Additional research and concerted efforts within the medical community are necessary to fully comprehend the extent of radiation exposure and devise effective strategies to mitigate potential adverse effects on the health of interventional radiologists.

V. CONCLUSIONS

The findings of our study have shed light on a critical concern for interventional radiologists—the high radiation doses they receive to their eyes, which significantly increases the risk of developing cataracts. The implications of this revelation are profound, as cataracts can have debilitating effects on an individual's vision and overall quality of life.

Although the alarmingly high equivalent dose to the interventional radiologist's eyes, as demonstrated in our study, should be interpreted with caution due to the small sample size and the asymmetry of the data, it nonetheless serves as a wake-up call for the medical community. It underscores the urgent need for strict monitoring of radiation dose and the implementation of effective radiation safety protocols.

The health and well-being of interventional radiologists are at stake, and measures must be taken to reduce the harmful effects of excessive radiation exposure. Frequent exposure to high radiation doses can have cumulative and long-term adverse effects on the eyes, potentially leading to severe health issues for medical professionals who dedicate their careers to helping patients through interventional radiology procedures.

To address this issue, there must be a collective effort to prioritize radiation protection and safety in interventional radiology departments. This includes ensuring the availability and proper use of radiation protective gear, such as lead aprons, thyroid collars, and eyeglasses, to minimize radiation exposure to critical organs like the eyes.

Furthermore, appropriate rotation in the duty roster should be implemented to limit the frequency and duration of radiation exposure for individual radiologists. A careful and thoughtful scheduling system can help ensure that no one is exposed to excessive levels of radiation and allow for adequate recovery time between procedures.

Additionally, continuing education and training programs should be provided to interventional radiology staff to raise awareness of radiation safety guidelines and best practices. By staying informed and up-to-date on the latest advancements in radiation protection, medical personnel can take proactive steps to safeguard their health while providing the best care possible to their patients.

Furthermore, larger-scale studies and collaborative efforts within the medical community are needed to gather comprehensive data and establish evidence-based guidelines for radiation dose limits specific to interventional radiologists. This will enable the development of more tailored and effective radiation safety protocols that suit the unique demands of interventional radiology procedures.

In conclusion, the findings of our study serve as a crucial reminder of the potential risks faced by interventional radiologists due to high radiation doses to their eyes. While more extensive research is necessary to fully understand the extent of this issue, immediate action is warranted to protect the health and well-being of medical professionals who play a crucial role in patient care. By emphasizing radiation safety and implementing stringent monitoring measures, we can ensure that interventional radiologists can continue their invaluable work while safeguarding their own health. The health of medical professionals is paramount, and it is our collective responsibility to prioritize their well-being in the pursuit of advancing medical knowledge and improving patient outcomes through interventional radiology.

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IMPLEMENTATION OF IAEA/AFRA HARMONIZED QUALITY CONTROL PROTOCOL FOR DIAGNOSTIC RADIOLOGY: THE GHANA EXPERIENCE

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***Abstract*— Quality control test have been undertaken in some selected public and quasi-government diagnostic radiology Centres with the aim of improving the overall safety and effectiveness of diagnostic radiology service within those departments whiles developing the skills of trained medical physicists who have been employed in diagnostic radiology centres. The test was performed as part of implementation of the new "Harmonized Diagnostic Radiology Quality Control Manual" developed under the Technical Cooperation Regional Project RAF6/053 entitled: "Enhancing Capacity Building of Medical Physicists to Improve Safety and Effectiveness of Medical Imaging". Test were performed on twenty (20) operational conventional X-ray, seven (7) Computed Tomography (CT) systems and three (3) mammography systems. The tests were undertaken using the Radcal Multimeter and accessories. 8 out of 15 tests could not be performed under the "Radiography" due to unavailability of Screen Film (Cassette) systems at facilities visited. 10 out of 15 tests could not be performed under Computed Tomography dues to unavailability of certain phantoms and the absence of Engineers to "lock the tube in the gantry". 2 out of 9 tests were not performed under Mammography due to the systems available at the units visited. Generally, results obtained were with tolerance level for a majority of test undertaken. Newly posted Medical Physicist and Interns benefitted from the exercise. It was observed that the test for Entrance Surface Dose was not present under the "Radiography" tests. It is recommended that the Manual should be updated to include procedures to undertake quality control on Computed Radiology (CR) systems and other newer imaging modalities.**

Keywords— **Quality Control, Mammography, Computed Tomography, Dose, Radiology**

I. INTRODUCTION

Diagnostic imaging, which includes the use of mammography, fluoroscopy, conventional radiography, computed tomography, angiography and magnetic resonance imaging in diagnosing diseases, has increased in Africa. In as much as this offers advantages such as early detection, rapid and precise diagnosis, these advantages could quickly be outweighed by unfavorable impacts related to inappropriate, ineffective imaging, and subpar examinations [1]. This increase in technological innovation has the potential to greatly increase population exposure to ionizing radiation or inaccurate diagnosis due to improper usage of X-ray equipment without the required specialized support [2]. For medical imaging to have the needed impact, among other things, the equipment must perform at its optimum [3]. Medical physicists - are health care professionals with specialized training in the medical applications of physics, who can ensure that radiation medicine is applied safely and effectively in diagnosis or treatment, improving quality of services and health related quality of life. However, in Africa there is shortage of these health professionals in the practice of diagnostic medical imaging.

The International Atomic Energy Agency through the Technical Cooperation Regional Project RAF6/053 has developed a quality control manual for diagnostic X-ray imaging in Africa. The Medical Radiation Physics Centre, Radiological and Medical Sciences Research Institute (RAMSRI), Ghana Atomic Energy Commission (GAE) sought to implement this quality control manual which aims at improving the overall safety and effectiveness of diagnostic radiology services in Ghana through appropriate quality control (QC) / quality assurance (QA) and dose optimization programme conducted by medical physicists.

II METHODOLOGY

Measurements were untaken at 19 facilities within the Greater Accra region of Ghana. Measurements were untaken according to the processes outlined in the manual provided by the International Atomic Energy Agency. The general radiography section of the manual has fifteen (15) tests, Computed Tomography (CT) has fifteen (15) tests, Mammography has nine (9) tests whiles fluoroscopy has five (5) tests. The tests were undertaken using the Radcal Multimeter and accessories. For each test, the objective, frequency, equipment needed, and procedure are clearly spelt out. The Acceptance parameters for evaluating the machine after the results has been analyzed is also provided.

III. RESULTS

A total of nineteen (19) facilities took part under this implementation program. Of the number, fifteen were public (government) hospitals whereas four (4) were quasi-government hospitals. Table 1 presents the distribution of imaging machines used during the study. The various tests were conducted on a total of thirty-four (34) X-ray generating machines distributed across the nineteen (19) facilities visited.

Table 1: Distribution of X-ray machines tested.

Modality	Number
Radiography	24
Computed Tomography (CT)	7
Mammography	3
TOTAL	34

Eight (8) out of the fifteen (15) tests, five (5) out of the fifteen (15) test and seven (7) out of the nine (9) tests were undertaken on the Radiography, Computed Tomography and Mammography machines respectively. All the results from the test conducted were within tolerance level as recommended by the quality control manual. For the Radiography and Mammography systems, the test that were not done was due to the nature of the systems available at the facilities. There were no Screen Film (Cassette) systems available at the facility visited and hence tests were not undertaken. For the CT systems, the unavailability of the Electron Density phantom made it impossible to undertake test that required the use of that phantom. For some test, the procedure required that the Engineer puts the machine in the service mode in order for the test to be undertaken and the non-availability of a resident Engineer made it impossible to undertake the tests.

IV. ACHIEVEMENT

The quality control tests were performed at facilities where new Medical Physics employees had been posted by the Ministry of Health. The exercise gave them the opportunity to learn at first hand some of the important quality control tests that the Medical Physicist is to undertake. It also provided for them reference quality control data that result from future test can be compared with. Graduate Medical Physicist who had also been posted by the Allied Health professions Council to undertake a six (6) months internship programme also benefitted from the implementation of the quality control manual.

V. RECOMMENDATION

It is recommended that; the quality control manual be updated to include Computed Radiography systems so as to ensure that a lot more test can be done by Countries where Screen Film systems are not available or are limited. There should be the introduction of quality control test on Dental X-ray machines as well. It is recommended that Entrance Surface Dose (ESD) estimates/calculations be added to the tests that should be undertaken. With ESD estimates, further studies such as Diagnostic Reference Level (DRL) could be estimated.

VI CONCLUSION

The IAEA/AFRA Harmonized Quality Control Protocol for Diagnostic Radiology have been implemented on some selected diagnostic radiology machines within the Greater Accra region of Ghana. Generally, the results of the test conducted was within the tolerance levels. The test will be conducted on other machines in the near future.

VII. ACKNOWLEDGEMENT

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HOW TO

A STEP-BY-STEP GUIDE TO MANUAL B_0 SHIMMING FOR IN VIVO PROTON MRS OF THE BRAIN

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Abstract — ***In vivo* proton magnetic resonance spectroscopy (MRS) has been around for nearly thirty (30) years and has proven itself to be an indispensable tool at the hands of an experienced practitioner. However, in certain occasions such as when there are hemorrhagic foci inside the volume of interest, the spectral resolution is hindered, due to paramagnetic effects. In these cases, spectra acquired with automatic shimming of the static magnetic field B_0 field may present broad linewidths and overall poor spectral quality. In such a scenario, the MRS practitioner must perform a manual shim, by appropriately adjusting the strengths of the gradient coils. The purpose of this study was to provide a step-by-step guide for manually shimming the B_0, to improve spectral resolution of acquired spectra and, thus, to potentially increase the diagnostic power of the method. Furthermore, the effect of spectral resolution on the signal-to-noise ratio (SNR) of metabolite peaks was also investigated in a phantom study at two field strengths, where all acquisition parameters and conditions were identical, with the exception of the spectral linewidth which ranged from 1 Hz to 8 Hz (at 1.5T), or equivalently from 2 Hz to 16 Hz (at 3.0T).**

Keywords — ***in vivo* proton MRS, manual shimming, spectral resolution, metabolite signal-to-noise ratio.**

I. INTRODUCTION

Proton magnetic resonance spectroscopy (MRS) has played an important role in the clinical environment since the early days of its introduction to the clinical practice [1-9]. Nowadays, most commercially available MRS sequences are based on a saturation-recovery (SR) scheme, thereby employing either three slice-selective 90° – 180° – 180° pulses (i.e., PRESS) or three 90° slice-selective pulses (i.e., STEAM). Both techniques have advantages and disadvantages, but a comparison between them is beyond the scope of this study.

In the clinical setting, *in vivo* brain MRS has shown tremendous capabilities in oncology [10-16] and has provided notable contributions in the fields of neuropsychiatry [17] and neurology [18], among others.

However, spectra are not acquired under identical acquisition conditions, and on many occasions the acquisition conditions are far from optimal. For example, acquired spectra may suffer from a low signal-to-noise ratio (SNR) due to poor acquisition parameter adjustments, while the spectral lines of the metabolites might be broad, due to static field inhomogeneities. Spurious artifacts might arise due to suboptimal eddy current compensation or patient motion. Other issues include ineffective water suppression and various reproducibility issues. There is, therefore, an imperative need for optimization of the acquisition procedure and conditions. Additionally, the implementation of the post-processing steps, as well as the interpretation of the spectra, may also be proven very tricky.

All current MR systems used in the acquisition of *in vivo* MRS spectra are equipped with an automatic shimming scheme which takes place during acquisition preprocessing, during which, the gradient strengths across all spatial directions get adjusted automatically, and the main water peak is identified. In our experience so far, automatic shimming is sufficient for approximately 75% of MRS acquisition conditions, in a clinical setting.

If the practitioner wants to ensure robust and repeatable spectral quality, therefore maximizing the amount of relevant and pertinent clinical data, allowing an accurate interpretation of the acquired spectra, leading to a correct differential diagnosis, sometimes, the static B_0 field homogeneity must be improved in a non-automatic way, through a process which is commonly known as *manual shimming.*

II. MATERIALS AND METHODS

Presented spectra were acquired with either a 1.5T GE Signa HD28 system or a 3.0T GE Signa Premier V.29.0 scanner, both equipped with PRESS [19] and STEAM [20] spectroscopic pulse sequences. A step-by-step practical guide is provided, with screenshots taken directly from the MR consoles while using the manufacturer's spectroscopy reference phantom, which is designed for quality assurance assessments in in vivo proton MRS.

All single-voxel spectra were acquired with the commercially available pulse sequence known as PROBE-P [21] which acquires both water-suppressed, and water-unsuppressed MR spectra. PROBE stands for PROton Brain Examination, and the -P at the end stands for PRESS. Similarly, one can use PROBE-S, which uses a STEAM-based pulse sequence.

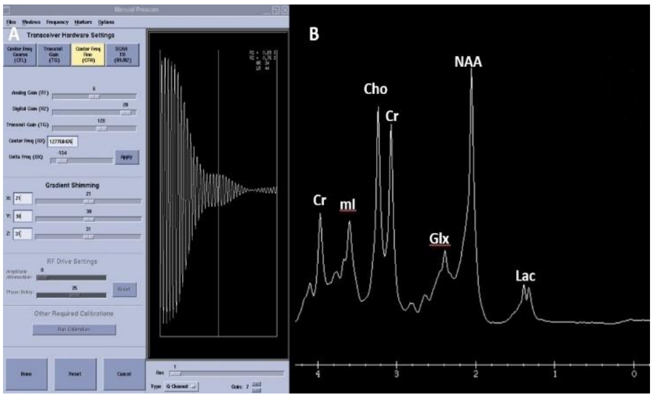

Fig. 1 Screenshot of the manual pre-scan submenu on a GE 3.0T scanner console with the respective poorly shimmed FID signal on the left sub-window **(A)**, and the produced low-resolution post-processed spectrum on the right **(B)**.

Metabolite signal intensities in the PROBE-P pulse sequence package are evaluated through the product of each peak's linewidth with its height (area-based). The height itself is computed with reference to the creatine metabolite peak, and the metabolite peaks that are automatically reported are myoinositol (mI), choline (Cho), creatine (Cr), and N-Acetylaspartic Acid (NAA). Automatic peak reporting follows the Rose criterion [22, 23], wherein a peak must have at least five (5) times more signal than the background noise, for it to be accurately distinguished from noise, and thus be reported back to the practitioner as a measured metabolite peak.

Finally, all phantom spectral acquisitions were run consecutively to minimize inter-day variations. The same voxel size was used in all acquisitions to eliminate SNR differences due to voxel dimensions. Furthermore, spectra were obtained from the same area of the phantom (at its center) to eliminate metabolite differences due to phantom inhomogeneities. Finally, the same transmitter and receiver gains (to obtain the same scale-up factors) were used across all spectral scans. Therefore, any potential differences observed would result from the influence of spectral resolution on the overall spectral quality.

Table 1 Average signal-to-noise ratio (SNR_{av}) values with corresponding standard deviations (SD) for the four major metabolites (per spectral group) measured at 3.0T

	First Group (2 Hz)				Second Group (10 Hz)				Third Group (16 Hz)			
	NAA	Cho	Cr	mI	NAA	Cho	Cr	mI	NAA	Cho	Cr	mI
SNR_{av}	*65.9*	*40.8*	*44.0*	*14.1*	*37.7*	*26.2*	*27.7*	*11.0*	*22.0*	*16.2*	*15.5*	*7.8*
±SD	*5.33*	*3.15*	*3.32*	*1.59*	*1.81*	*1.81*	*1.43*	*0.66*	*1.41*	*0.87*	*1.02*	*1.34*

III. RESULTS AND DISCUSSION

In Figure 1A, the manual pre-scan menu on the console of the 3.0T system is shown. Upon selecting the option "manual pre-scan", the user is directed to the window shown in Figure 1A, on the "Center Frequency Coarse" channel, of the submenu "Transceiver Hardware Settings". The user must then select the third option in the submenu, namely, the "Center Frequency Fine". Following this, the user must change the channel at the bottom of the page, from the P-channel (or Absorption channel) to either the Q-channel or the I-channel. The Q and I channels are precisely identical, with the exception that the I-channel corresponds to the same free induction decay (FID) signal as in the Q-channel, multiplied by a 90^{o} phase factor (representing the imaginary portion of the signal received at the phased array coil elements).

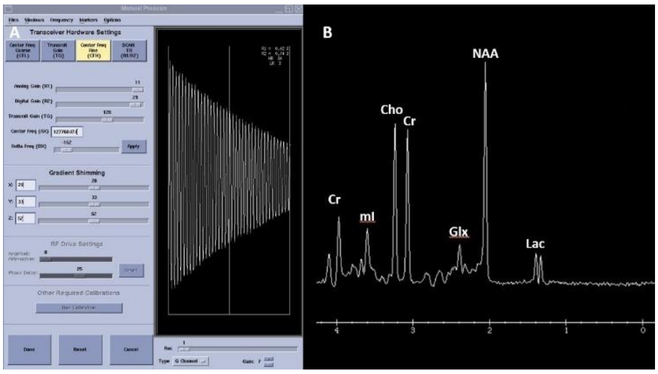

Fig. 2 Screenshot of the manual pre-scan submenu on a GE 3.0T scanner console, with the respective well-shimmed FID signal on the left sub-window **(A)**, and the produced high-resolution post-processed spectrum on the right **(B)**.

After selecting the appropriate coil channel, the user must amplify the FID by adding more "Gains" on the bottom right side of Figure 1A. Following appropriate signal amplification through the option "Gains", the user must then go to the Delta Freq (DX) option and move away from the central water frequency by approximately 100 Hz (at 1.5T), or about 150 Hz at 3.0T. This enables the visualization of the FID wiggles [24, 25], which allows the user to visualize the FID signal received on the coil element representing the collective voxel signal inside the PRESS-box. The FID for GE's quality assurance MRS phantom, which contains known concentrations of metabolites commonly found in a healthy adult brain, is shown in the right sub window of Figure 1A. If no manual shimming is performed, this FID signal, will yield the MR spectrum presented in Figure 1B, which is characterized by a linewidth of approximately 16-17 Hz at 3.0T (or equivalently 8-9 Hz at 1.5T).

After reaching the submenu shown in Figures 1A and 2A, the process of manual shimming can be initiated. The entire goal of the process of manual shimming is to apply different gradient strengths across all three dimensions for the decay of FID wiggles to appear smooth (right sub window in Figure 2A). Since the z gradient is the biggest one, it is safe to assume that it might produce the largest effects on our FID signal. Therefore, one can routinely start the process of shimming by adjusting the z gradient first.

Table 2 Average signal-to-noise ratio (SNR_{av}) values with corresponding standard deviations (SD) for the four major metabolites (per spectral group) measured at 1.5T

	First Group (1 Hz)				Second Group (5 Hz)				Third Group (8 Hz)			
	NAA	Cho	Cr	mI	NAA	Cho	Cr	mI	NAA	Cho	Cr	mI
SNR_{av}	*27.1*	*16.3*	*19.0*	*9.04*	*18.6*	*11.3*	*13.1*	*6.3*	*13.0*	*8.3*	*9.4*	*6.1*
±SD	*1.96*	*1.67*	*2.03*	*0.83*	*1.58*	*1.67*	*2.03*	*1.09*	*2.3*	*1.63*	*2.27*	*-*

By choosing a specific direction (left or right), the user is advised to continue in the same direction until it becomes apparent that the FID either definitively improves or definitively deteriorates. Then, the process is repeated for other gradient directions (x and y). When the FID gets the desired shape, we return our central frequency (Delta Freq) back to the original position (at the center of the water peak at 4.8 ppm), where the FID wiggles are no longer visible. However, since the total magnetic field inside our PRESS-box will not be the same as it was in the beginning (i.e., the effect of shimming), one would have to further adjust by a few Hz either to the right or to the left. The user can then confirm the choices made by selecting “Done” and start the acquisition. Figure 2B presents the MR spectrum of the quality assurance phantom following manual shimming, which is characterized by a linewidth of approximately 2 Hz at 3.0T (or equivalently 1 Hz at 1.5T).

Figure 3 shows representative spectra of a quality assurance phantom by the scanner manufacturer at two field strengths, with a linewidth of 1 Hz (A) at 1.5T, linewidth of 2 Hz (B) at 3.0T, 8 Hz (C) at 1.5T, and 16 Hz (D) at 3.0T.

The average SNR for creatine across the 1 Hz spectra was 47.5 a.u. The average SNR for creatine across the > 5 Hz spectra was 16.4 a.u. This means that by shimming the B0 field prior to acquisition the practitioner may achieve a considerable increase in SNR. Equivalently, the root mean square (RMS) across the high-resolution spectra was 3.5 arbitrary units, whereas the RMS across the lower resolution spectra was 13.8 a.u.

In a more detailed experiment, additional forty-two (42) MR spectra of the phantom were acquired. Acquisition parameters for all spectra can be found in Table 1. The spectra spanned three groups of fourteen (14) spectra per group, which were acquired at 1.5T with (a) a linewidth of 1 Hz, (b) a linewidth of 4 Hz, and (c) a linewidth of 8 Hz. The voxel (20x20x20 mm^3) was placed at the center of the phantom, which was positioned at the center of a 16-channel neurovascular (head and neck) phased-array coil. Transmit and receive gains were identical across all spectral acquisitions.

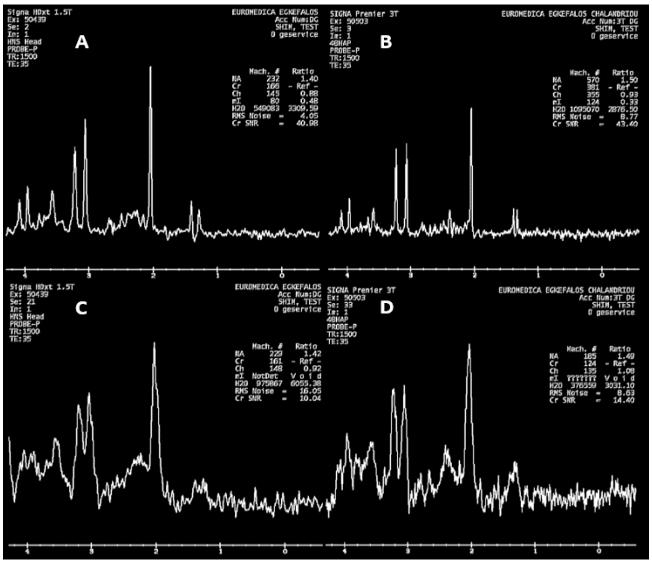

Fig. 3 Representative MR Spectra acquired at 1.5T from 8 cm^3 voxel sizes, located at the center of the same phantom, with transmit/receive gains equal to 13×30×131, and linewidths **(A)** 1 Hz, and **(C)** 8 Hz. Similarly, 3.0T Spectra with linewidths **(B)** 2 Hz, and **(D)** 16 Hz.

The SNR of the four major metabolites as a function of linewidth (1 Hz, 5 Hz, and 8 Hz) can be found in Table 1. Similarly, from measurements performed at 3.0T, the corresponding metabolites’ SNR as a function of linewidth (2 Hz, 10 Hz, and 16 Hz) can be found in Table 2. Myo-inositol, being a small peak, together with being closest to the main water peak (at 4.8 ppm), suffered the most out of all other main metabolites, with increasing linewidth.

This study, nevertheless, suffers from several limitations. The step-by-step procedure described above pertains to GE MR systems. To our knowledge, this practical guide also may also apply to Siemens MR scanners (similar interface and signal visualization options). However, Philips MR scanners do not provide the option of manual shimming. Instead of that, the user is given the option to upload preparatory scripts on the MR console, whose purpose is to do baseline corrections and advanced compensation of eddy currents.

Furthermore, due to raw MRS data (p-files with software versions > 28.0) incompatibility with external offline software packages (i.e., SIVIC [26], INSPECTOR [27] and TARQUIN [28]), we were unable to cross-validate our findings pertaining to the extent of the effect of spectral linewidth on the overall metabolite SNR.

IV. CONCLUSIONS

In conclusion, B_0 shimming is a very important aspect associated with the acquisition of highly diagnostic MR spectra and should not be skipped under any circumstances. When the automatic pre-scan yields large water spectral linewidths (e.g., > 12 Hz at 3.0T, or > 6 Hz at 1.5T), the practitioner must shim the B_0 field manually, to obtain robust spectra of high diagnostic accuracy, with sharp peaks. Furthermore, the improvement of spectral resolution prior to the acquisition of in vivo MR spectra has a definitive and positive impact on metabolite SNR. Therefore, we believe that manual B_0 shimming inside the PRESS-box must be performed even for borderline cases (e.g., linewidth = 12 Hz at 3.0T). A minimum 50% increase in metabolite SNR can be realized by manually shimming the B_0 field. Thus, the SNR benefit is deemed worth the time spent for manual shimming (approx. 2 minutes), in addition to the spectral resolution benefit from the same process. Exception may be cases with increased paramagnetic effects, either from the volume of interest or from an external source (e.g., prosthetics).

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ULTRASOUND-BASED ELASTOGRAPHY: PRINCIPLES AND CLINICAL APPLICATIONS

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Abstract— **Ultrasound-based elastography is a non-invasive medical imaging technique that provides an estimation of tissue stiffness. In the past decade, researchers have explored the potential use of ultrasound-based elastography in diagnosing abnormal organs based on the obtained stiffness value. This article details the physics and principle of ultrasound-based elastography as well as the clinical applications of this technology at various anatomic structures.**

Keywords— **2-dimentional Shear Wave Elastography, Point Shear Wave Elastography, Transient Elastography, Stiffness, Strain Elastography.**

I. INTRODUCTION

Manual palpation is a core skill in physical assessment. General physicians typically use digital palpation to assess the elasticity properties of a tissue, referred to as stiffness in the detection disease tissue. The elasticity properties of tissue often change in pathological condition. Fibrosis is a pathological state where excessive deposition of extracellular matrix (ECM) in organs occurs, which commonly accompanies chronic diseases in many organs, such as the liver and kidney [1] . Production of ECM occurs as a reaction against injury, and fibrosis itself is intrinsically a process to promote tissue repair. However, fibrosis can deteriorate the function of the affected organ if it occurs in excess. Organs with established fibrosis are mechanically stiffer as a result of increased collagen and elastin cross-linking [2]. However, manual palpation assessments are subjective, and little is known about their accuracy or repeatability. Recently, researchers have developed alternative techniques to quantify tissue elasticity.

II. METHODS OF TISSUE ELASTICITY EVALUATION

Elasticity or stiffness is the ability of a deformed object to return to its original shape after the deformation forces are removed. There are two methods of applying external force - the quasi-static and dynamic methods [3]. In quasi-static elastography, a constant stress σ is slowly applied (equal to an external force per unit area) to tissue. Consequently, strain, ε, defined in Equation 1, is obtained by spatial differential of displacement, Δ_2- Δ_1 which is the ratio of the difference in displacement between the two points to the original length, L (Fig. 1):

$$\varepsilon = \frac{\Delta_2 - \Delta_1}{L} \quad (1)$$

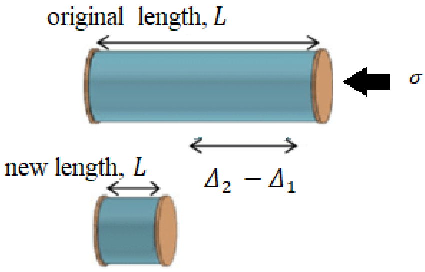


Fig 1 The rod compressed under stress to a new length. The strain is the ratio of this small deformation to the rod's original length.

Stress is always normal in the case of a change in length or volume of a medium. When linearity is satisfied, stress and strain exhibit proportionality, as shown by Hooke's law and its coefficient is referred to as the elastic modulus. There are three types of elastic modulus: Young's modulus (YM), shear modulus, and bulk modulus, as defined on the basis of the method of deformation and is expressed in pressure units - Pascals, or more commonly kPa [4].

Young's modulus, E is defined in Equation 2 when normal stress (quotient of the tensile force divided by the cross-sectional area) σ is applied longitudinally to a long, thin cylindrical object. The strain (the change in length divided by original length) ε_L occurs as shown in Fig. 2a [3] [4].

$$\mathrm{E} = \frac{\sigma}{\varepsilon_L} \quad (2)$$

When the applied stress is tangential to the surface due to the application of force parallel to the surface, then the stress is called shear stress, σ. The shear modulus, G is defined in Equation 3 for the shear deformation shown in Fig. 2b [4].

$$G = \frac{\sigma}{\varepsilon_S} \quad (3)$$

in which, ε_S is shear strain.

When a normal stress is applied from all the sides and changes the volume of a medium, it is called volume or bulk stress, σ. The bulk modulus, B is defined in Equation 4 for the change of volume shown in Fig. 2c.

$$B = \frac{\sigma}{\left(\frac{\Delta V}{V}\right)} \quad (4)$$

where ΔV is change volume (m^3) and V is original volume (m^3).

In dynamic methods, an external force, either a short transient mechanical force or an oscillatory force with a fixed frequency, is applied to tissue [3]. Although the ordinary ultrasound pulse–echo imaging uses longitudinal waves, transverse waves (shear waves) are used for elasticity evaluation. Using the shear modulus G, the speed V_s of shear waves is expressed in Equation 5.

$$V_s = \sqrt{G/\rho} \quad (5)$$

where ρ indicates the density of the medium [4]. Based on the equation, the larger the G (the stiffer the medium is), the faster the wave propagation.

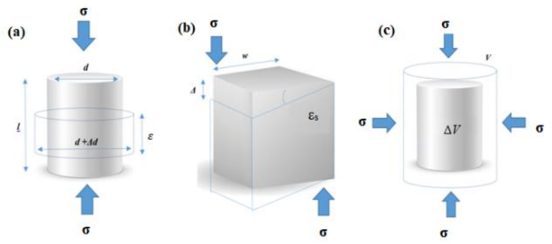


Fig I Three types of deformation: (a) deformation by normal stress, (b) deformation by shear stress and (c) deformation by bulk stress (*d*: diameter, *l*: length, *w*: width, ε_L: strain, ε_s: shear strain, *V*; original volume, *ΔV*: change volume).

III. Principles of ultrasound elastography

Ultrasound-based elastography techniques is a new non-invasive medical imaging technique that provides an estimation of tissue stiffness by measuring the degree of distortion caused by soundwaves. It is divided into strain and shear wave elastography techniques. There are three types of shear wave elastography, which includes transient elastography, point shear wave elastography (pSWE) and two-dimensional shear wave elastography (2D SWE)[5].

Strain Elastography

Strain ultrasound elastography is also named real-time ultrasound elastography (RTE) and is the most widely available type of strain ultrasound elastography. A deformation force either by the precompression with the transducer or by physiological movements, such as breathing or heartbeat is applied to tissues, resulting in changes in dimensions and shape [6]. Most of the displacement will be in the direction of the propagation of the ultrasound pulse. The displacement is obtained by calculating the correlation between the echo signal, before and after compression. Multiple images are recorded using conventional imaging at standard frame rates. The relative deformation (strain) is estimated using tissue Doppler techniques. This results in the elastographic image which appears as a colour-coded image superimposed on the B-mode image and displayed next to it on the screen [7].

The intensity of the operator's free-hand pressure is displayed with a numerical scale. As such, the operator can assess the validity of the compression cycles in real-time. This technique allows a qualitative and a semi quantitative assessment of tissue elasticity. The qualitative assessment of the elastography images, also known as elastogram, represents a mapping of the amount of tissue strain at each location [7].

Colour coding depends on the system and usually red represents hard, stiff tissue (small deformation, lowest elastic strain or no strain) and blue represents soft tissue (large deformation, greatest elastic strain) (Fig. 3). There is also a semi quantitative measurement method (the strain ratio), which represents the ratio of strains of the ROI to an equally measuring area in the reference tissue [8]. Two ROIs are manually applied on the screen, one on the target tissue and the second on the reference normal tissue allowing the calculation of their strain ratio by the immediate real-time ultrasound machine analysis.

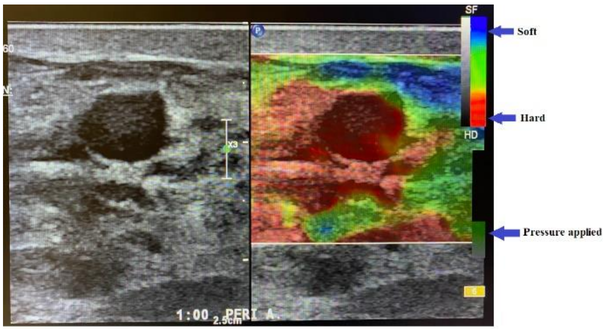


Fig 3 Display method of an elastogram. The translucent colour-coded elastogram within the ROI is superimposed on the corresponding B-mode image.

Clinical Applications of Strain Elastography

Strain elastography has been widely applied in the breast imaging [9]. One of the largest published studies on visual score on strain elastography was conducted on 1786 non-palpable breast masses by Yi et al. [10]. This study applied elasticity scores (5-point) that were based on the visual assessment of the degree and distribution of strain in the hypoechoic mass and surrounding tissue. The mean elasticity score of malignant lesions was higher than that of benign lesions (2.94±1.10 vs. 1.78± 0.81). In the decision to biopsy, strain elastography has higher specificity than B-mode ultrasound in the differentiation between benign and malignant masses and has the potential to reduce biopsies with benign results. Although the results were encouraging, however, authors highlighted that the sonoelastography score, which was based on the B-mode ultrasound findings was the main limitation of strain elastography. Thus, studies were conducted to evaluate the diagnostic value of semi-quantitative parameters *(i.e.*, strain pattern, width ratio, strain ratio) in differentiating between benign and malignant breast masses [11, 12].

According to Alhabshi et al [11], the semi-quantitative assessment with strain ratio and width ratio in strain elastography were useful parameters in differentiating a benign lesions from a malignant lesions. They proposed a cut-off point values for width ratio of more than 1.1 and strain ratio of more than 5.6 showed a high predictive value of malignancy with specificities of 84% and 76%, respectively ($p < 0.001$). However, operator dependence is a recognised pitfall of ultrasound elastography especially when using the strain method [12]. Moreover, the YM cannot be calculated by strain elastography because the force applied is operator dependent and unknown. Furthermore, this technique is limited to superficial organs only, such as the thyroid and breast because the force applied by the operator is insufficient to deform the deeper organ such as the liver.

Shear Wave Elastography

A shear wave is a slow wave and propagates by creating a tangential ‘sliding’ force between tissue layers. Shear waves are explicitly related to tissue stiffness. To quantify tissue stiffness in kPa, the YM from Equation 2 can be derived into Equation 6, where V_s is the shear wave velocity and ρ is tissue density.

$$\frac{\sigma}{\varepsilon_L} = 3\rho V_s^2 \qquad (6)$$

Transient Elastography

Transient elastography works by measuring the transmitted spherical shear wave to the surface of the medium, produced by a vibrating actuator that attached on a single-element ultrasound transducer (Fig. 4a) [13].

The displacements induced by the shear wave are tracked using ultrasonic waves generated and received by the single-element ultrasound transducer. The displacement generated, which is a function of depth and of time, is thus estimated by correlations of retro-diffused echoes (via ultra-sound speckle) recorded at a framerate higher than one thousand time per second with a mono-dimensional ultra-sound transducer (5 MHz)[14]. By measuring the phase of each depth, the system manages to extract the phase speed of the shear wave at the central frequency. The results are converted to YM in unit kPa.

Clinical Applications of Transient Elastography

Early detection of cirrhosis by detection of fibrosis is a key element to manage treatment, monitor disease progression, and assess response to therapy. The development of transient elastography provides clinicians with a non-invasive and accurate tool to estimate liver fibrosis. Study from Serra-Burriel, et al. [15] involved six prospective cohorts in Europe and Asia with a total of 6295 patients. They proposed a 9.1 kPa transient elastography cut-off provided the best accuracy for the diagnosis of significant fibrosis (≥F2) in general population settings, whereas a threshold of 9.5 kPa was optimal for populations at-risk for alcoholic liver disease. Additionally, their results showed that transient elastography performed better than serum biomarkers for fibrosis detection using liver biopsy as reference standard. Due to its outstanding diagnostic performance reported by numerous studies, it is likely that liver stiffness examination (LSE) by transient elastography will be widely used in liver units. Therefore, the reproducibility of transient elastography from different observers is crucial.

Boursier, et al. [16] evaluated the learning curve characteristics of liver stiffness with transient elastography in five novice observers with different professional status among hospital staff. Results showed that LSE assessed by transient elastography presents no learning curve effect. A novice observer can perform a reliable LSE after an initial training session (devoted to device presentation and one LSE demonstration by the expert). Time taken to perform LSE also progressively decreases because of a progressive increase in success rate. However, novice–expert agreement for LSE results varied with liver stiffness level in which a poor interobserver agreement for expert LSE < 9 kPa and an excellent agreement for expert LSE > 9 kPa. Although transient elastography provides quantitative measurement, it does not provide grayscale ultrasound images (Figure 4b). Without the ultrasound image guidance, placing the transducer would become challenging, especially for obese patients or patient with narrow intercostal space [17]. Moreover, transient elastography is not capable of obtaining adequate results in patients with ascites. These limitations could affect the reproducibility of transient elastography. Another limitation of this technique is it only limited to liver and spleen study.

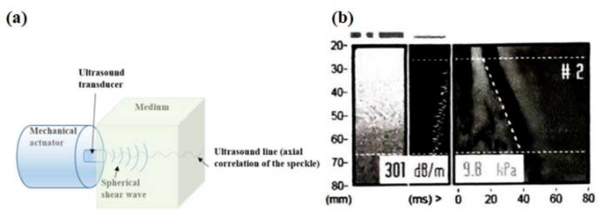


Fig 4 (a) Adjustable low frequency pulse from 10Hz to 500 Hz is generated by the vibrator in the medium thus creating shear waves (Gennisson, 2013). (b) Transient elastography indicates 9.8 kPa for liver stiffness. Note that no anatomical image is shown in transient elastography.

Point Shear Wave Elastography (pSWE)

pSWE uses the acoustic radiation force impulse (ARFI) or acoustic radiation force to generate shear waves in a single focal location that propagate perpendicular to the main ultrasound beam, away from the original region of excitation. The speed of propagation of the shear waves of a homogeneous and isotropic target is directly proportional to the density and to the shear modulus of the tissue (elasticity). Thus, for a given density, a radiation force moves farther at the focal spot of soft tissues than stiffer tissues, presenting a lower shear modulus and taking longer to reach their maximum deformation, with slower recovery [18].

Meanwhile a low-intensity tracking ultrasound beams are continuously emitted parallel to the main beam to monitor tissue displacement (Fig. 5). To obtain a series of data concerning the tissue response, such as the time-to-peak displacement and the recovery time, the tracking beams intercept the shear wave at several predetermined locations and time intervals [18]. From these data obtained mainly through time-of-flight algorithms (time taken for the wave to travel a distance through a medium), quantitative estimates of shear waves propagation speed and the resultant and tissue stiffness are obtained [3].

Clinical Applications of pSWE

Unlike transient elastography, pSWE is integrated into a conventional ultrasound device. One of the benefits of this technique is that it permits the quantitative measurements of the liver while providing grayscale ultrasound images. Furthermore, pSWE generates shear waves within the targeted structure, thus, adequate results for patients with ascites could be obtained. For the past decade, several meta-analyses of measurements of liver stiffness in patients' chronic liver diseases using pSWE and transient elastography have been published [19-21]. Researchers concluded that pSWE seems to be modestly accurate in detecting significant fibrosis with similar predictive value to transient elastography for significant fibrosis and cirrhosis. However, compared to transient elastography, pSWE is able to obtain reliable measurements thrice higher than transient elastography [20]. Due to the promising results, researchers have extended the application of pSWE to renal imaging.

Studies have shown positive correlation between stiffness values of renal and glomerular filtration rate (GFR) [22-24]. A clear relationship seems to emerge between stiffness values and the degree of fibrosis. According to Yang, et al. [25] and Wang, et al. [26], patients with a severe grade of interstitial fibrosis had a higher SWV compared to moderate and mild grades. Leong, et al. [27] revealed that glomerular sclerosis, interstitial fibrosis, and tubular atrophy are associated with an increase in kidney stiffness, measurable using pSWE. A YM cut-off value equal or more than 5.81 kPa indicates a moderately impaired kidney. However, these results were contradicted by [28, 29] in which a lower stiffness values were observed in patient with deranged GFR and severe grade of interstitial fibrosis. Inconsistent results from pSWE renal imaging likely due to certain limitations from this technique.

The kidney has a complex architectural whereby its mechanical properties varied according to the measurement direction. This is known as anisotropy. Kidney anisotropy has a significant impact on the propagation speed of shear wave in which affects the stiffness measurement obtained. In pSWE, the region of interest (ROI) size is fixed and only allows single stiffness measurement at a time. Patients may find it difficult to hold their breath for a long time if more image acquisitions are needed. Thus, slight changes in breath hold pattern from the patient or unintentionally include the renal medulla in the ROI by the operator could increase measurement variability. Similarly, to transient elastography, pSWE is only applicable to deep structure.

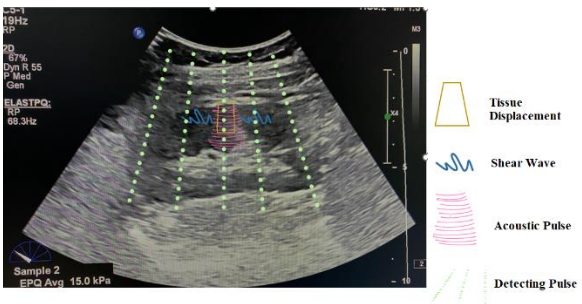


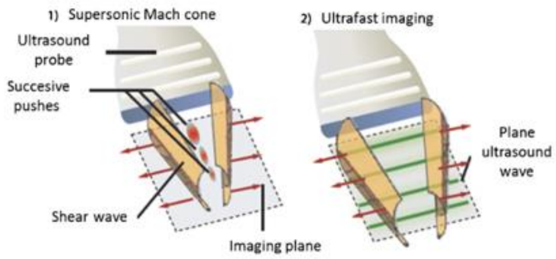
Fig 5 Acoustic pulses are generated together with the main ultrasound beam. The Acoustic pulses induce tissue displacement in a single focal zone to produce shear waves, which propagate perpendicular to the main ultrasound beam [18].

Two-dimensional Shear Wave Elastography (2D SWE)

In this technique, ARFI is used to induce tissue displacement in multiple focal zones which are interrogated in rapid succession. ARFI moves faster than the shear waves thus allowing the ultrasound beam successively focusing at different depths. The different spherical waves generated for each focal beam interfere constructively along a Mach cone, creating two quasi plane shear wave fronts propagating in opposite directions [3] (Fig. 6Fig).

The use of constructive interferences increases their amplitude and improves their propagation distance. When the wave touches the targeted tissue, the tissue is pushed in the direction of propagation, causing the tissue to deform or displace. Since shear wave is induced in multiple focal zones in the tissue with no external vibrator required to generate it, SWE depends on the measurement of the shear wave propagation speed in soft tissue [30]. Based on YM formula, assessment of tissue elasticity can be derived from shear wave propagation velocity, where elasticity is proportional to the square of shear wave propagation velocity (Equation 6) [30].

The shear waves generated must be tracked by the ultrasound system. Ultrafast imaging image the entire propagating wave with good temporal resolution in a single acquisition by reaching frame rates of 5000 to 30000 images per second [3]. Therefore, it allows complete acquisition without repetition for the entire displacement field and can be displayed in real-time, much like conventional ultrasound images. The YM map are then reconstructed by estimating the speed of the shear wave between two points in the image, using a time-of-flight algorithm [31].



Source: Reproduced from Gennisson, JL, Deffieux, T, Fink, M & Tanter, M. Ultrasound elastography: principles and techniques. Diagnostic and interventional imaging 2013; 94: 87-495. Copyright © May 2013 Elsevier Masson SAS. 236 All rights reserved.

Fig 6 Ultrasound beams are successively focused at different paths to create push force by radiation pressure. The constructive interference of the shear waves forms a Mach cone, in which the speed of the source is higher than the speed of the generated wave, and a quasi-plane shear wave is created (a) (Gennisson, 2013).

Clinical Applications of 2DSWE

Compared to transient elastography and pSWE, the application of 2DSWE is more extensive which include superficial and deep structures. This technique is replacing strain elastography in breast imaging rapidly due to its high reproducibility rate and the availability of absolute stiffness value. According to Youk, et al. [32], 2DSWE is now an adjunct tool in breast ultrasonography. One of the advantages of SWE is the characterization of breast masses that are categorized as BI-RADS 3 and 4a, to avoid unnecessary breast biopsies [33, 34]. The combination of SWE with conventional B-mode ultrasound increases the diagnostic performance in characterize breast lesions, compared with conventional B-mode ultrasound alone. Furthermore, SWE can provide additional information on predicting breast cancer prognosis and response to neoadjuvant chemotherapy (NAC). Lesion stiffness is related to the collagen content in the stroma, stromal stiffness measured by SWE could serve as a potential imaging biomarker for stromal structural abnormalities and the response to NAC [35].

Among the shear wave elastography techniques, 2DSWE has the highest sensitivity in detection of significant fibrosis and advanced fibrosis [36, 37]. Based on a phantom study by Leong, et al. [38], 2DSWE is more accurate than pSWE when compared with dynamic mechanical analysis, the reference standard. One of the possible justifications to these results could be the technical factor. Unlike pSWE, 2D SWE could produce a 2D elastogram, a colour-coded map or a confidence map reflecting tissue stiffness is displayed (Fig. 7). This allowed operators to obtain stiffness measurements from an area with the best shear wave quality (homogeneity and temporal stability) [39]. This provided an effective guide to obtain better image quality and reduce measurement variability.

In 2DSWE, dynamic stress is induced by ARFI in multiple focal zones. This allows a real-time monitoring of shear wave for stiffness measurements at several locations at one image acquisition. This has overcome the breath hold challenge encountered by patients, especially to those who have shortness of breath.

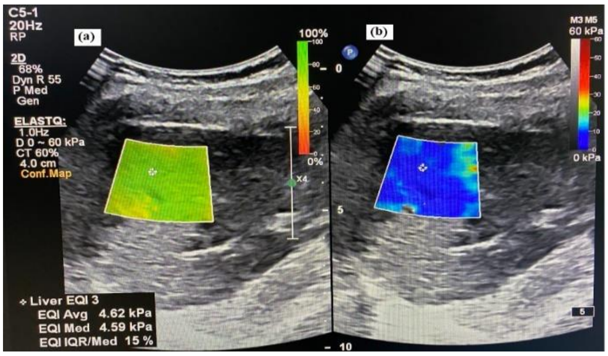


Fig 7 (a) colour-coded confident map indicates area with the best shear wave quality (homogeneity and temporal stability). (b) 2DSWE of liver with tissue stiffness expressed either in kPa or m/s. Note elastogram is available in 2D SWE.

IV. Conclusion

Ultrasound- based elastography is widely available and easy to operate in a clinical setting. The fact that ultrasound-based elastography can be done bedside along with the B-mode examination (except transient elastography) enables the application of elastography feasible in a lot of different anatomic areas. Although the outcome of ultrasound- based elastography is encouraging, standardized scanning protocol and validated for each elastography device should be proposed and applied to provide a more accurate diagnostic performance in differentiating normal and disease organ/ lesions.

Conflict of Interest Statement

The authors declare no conflict of interest.

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BOOK REVIEWS

BRIDGE BUILDER
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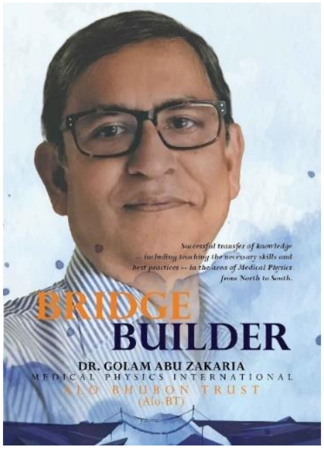

II. REVIEW

"Bridge Builder" is definitely not the typical type of medical physics book - from its dedication, the introductory part, all the way through the content up to the very last sentence "…succeeded in inspiring as many of his young compatriots as possible, towards this path!". **This is a life story driven by medical physics and dedicated to the development of the profession with the sole objective of bringing benefit to the society.**

The book is a tribute to the untiring commitment of Professor Golam Abu Zakaria in Germany, Bangladesh, South Asia and beyond. It contains 43 articles divided into six sections, written by eminent authors from Austria, Bangladesh, Canada, China, Egypt, Germany, Lebanon, Poland, Rwanda, South Asia, and USA, but also colleagues, co-workers, friends, acquaintances, relatives, and students:

- Study and Professional Life in Germany
- Historical Developments of Medical Physics in Bangladesh
- Medical Physics in Bangladesh: Cooperation Between Germany and Bangladesh
- Medical Physics in South Asia and Beyond: International Perspectives and Cooperation
- Development of Medical Physics: Views from the Students in Bangladesh and Germany
- Professor Zakaria with His Friends: Other Aspects

The book has been edited by Prof. Arun Chougule (India), Prof. Hasin Anupama Azhari (Bangladesh) and Dipl.-Ing. Volker Steil (Germany). Foreword was written by Prof. Tomas Kron (Australia).

Prof. Golam Abu Zakaria was former Chairman of the Department of Medical Radiation Physics, Gummersbach Teaching Hospital, University of Cologne, and presently Professor of Clinical Engineering at the University of Applied Sciences, Koethen, Germany. He is the founder Chairman, South Asia Centre for Medical Physics and Cancer Research (SCMPCR).

"Medical physics is the application of principles of physics and problem-solving skills to problems in health ranging from prevention to detection, treatment, and care of human diseases. "(Professor Tomas Kron, Peter MacCallum Cancer Centre, Melbourne, Australia). "Medical physicists are required by law to be included in cancer treatment in many countries. Together with medical doctors they are jointly responsible for the precise and safe treatment of patients. "(Professor Wolfgang Schlegel, German Cancer Research Centre, Heidelberg, Germany). **Experts from around the world emphasize the need to build bridges between disciplines as well as cultures for the benefit of the millions who suffer from ailments, especially cancer, needing medical physics.**

Among the various aspects of medical physics covered by the book, I would like to particularly draw readers' attention to the promotion of medical physics at national and regional level through international collaboration, delivering expertise on-filed, nurturing, and supporting the new generation of medical physicists. This may be considered an investment in the future of the profession and healthcare, but also a bridge built to connect the past, present and future of our profession.

EFFECTIVE MEDICAL WRITING
THE WRITE WAY TO GET PUBLISHED
by Wilfred C.G. Peh, José Florencio Fabella Lapeña, Jr., Kwan Hoong Ng

Magdalena Stoeva [1,2]

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I. Book details

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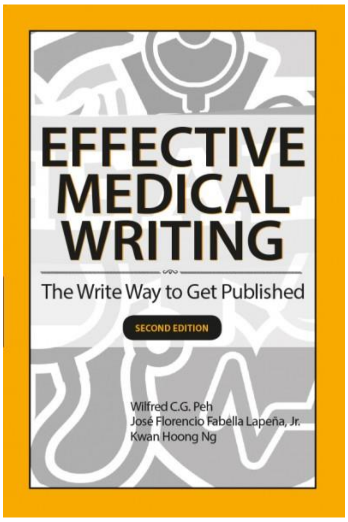

II. Review

Contemporary medical writing in any of its aspects could be a challenging task when it comes to presenting the right information in the right format and to the right audience.

With 40 chapters detailing each step of the writing and publication process, the book extends much further than the classical how-to guide. It adds the right amount of experience sharing, professional advice and positive thinking to motivate future authors. Well-illustrated and accompanied by a number of practical examples, each chapter serves a stand-alone guide solving specific aspect of the writing process.

Starting with the existential question "Why write?", going through the formal side of the recording of the scientific work which eventually leads to the writing, and the potential benefits, the book opens an entirely new space to early career researchers. Paper type and structure, the proper selection of title, the right focus of the abstract, the formal writing process and the production of the manuscript are just one side of the medical writing process. Then the comes the publisher and quite often, especially in the early stages of their career authors are not quite familiar with all the important details at this stage – from submitting the manuscript, communicating with the editor, the peer-review process and the final publication. The last part of the book is focused on the ethical issues, plagiarism, conflict of interest and of course the sanctions resulting in case of scientific misconduct.

My favorite part is the chapter on title selection. A small part of the entire paper indeed, but actually these few words that summarize the authors' entire work and attract or reject the readers from the paper. One sentence that coneys authors' message and experience to the scientific audience. Catchy, informative, short and sophisticated at the same time. The title is the door that welcomes the reader to the paper, but also the door the authors have to open in order to start the medical writing process.

Another useful section are the brief guides on the different types of publications – case report, technical note, pictorial essay, review article, systematic review, invited commentary, qualitative research paper, letter to the editor, editorial, book review, book chapter.

Co-authored by a team of professionals with remarkable experience in scholarly medical writing and publishing, the book is the right resource to successfully guide you through the complex medical writing process, from the idea to the final product:

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“Effective Medical Writing: The Write Way to Get Published” is directed to both early career and more experienced scientists, including but not limited to medical and postgraduate students, clinical specialty trainees, aspiring researchers, newly appointed academic staff, allied health professionals, and all who are looking to write scientific papers and get published or simply get an update of the current practices.

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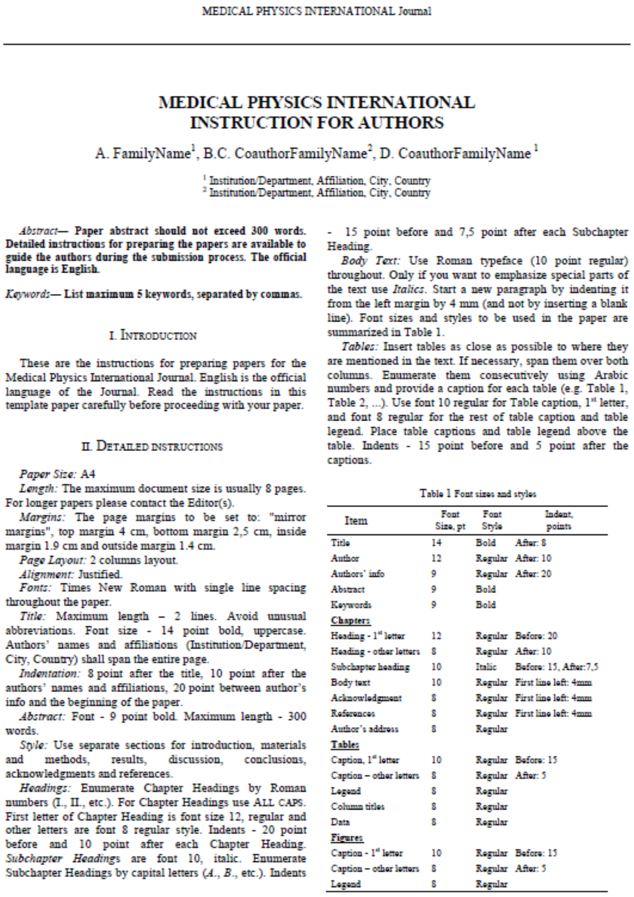

MEDICAL PHYSICS INTERNATIONAL Journal

MEDICAL PHYSICS INTERNATIONAL
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Abstract— **Paper abstract should not exceed 300 words. Detailed instructions for preparing the papers are available to guide the authors during the submission process. The official language is English.**

Keywords— **List maximum 5 keywords, separated by commas.**

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Indentation: 8 point after the title, 10 point after the authors' names and affiliations, 20 point between author's info and the beginning of the paper.
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Title	14	Bold	After: 8
Author	12	Regular	After: 10
Authors' info	9	Regular	After: 20
Abstract	9	Bold	
Keywords	9	Bold	
Chapters			
Heading - 1st letter	12	Regular	Before: 20
Heading - other letters	8	Regular	After: 10
Subchapter heading	10	Italic	Before: 15, After:7,5
Body text	10	Regular	First line left: 4mm
Acknowledgment	8	Regular	First line left: 4mm
References	8	Regular	First line left: 4mm
Author's address	8	Regular	
Tables			
Caption, 1st letter	10	Regular	Before: 15
Caption – other letters	8	Regular	After: 5
Legend	8	Regular	
Column titles	8	Regular	
Data	8	Regular	
Figures			
Caption - 1st letter	10	Regular	Before: 15
Caption – other letters	8	Regular	After: 5
Legend	8	Regular	

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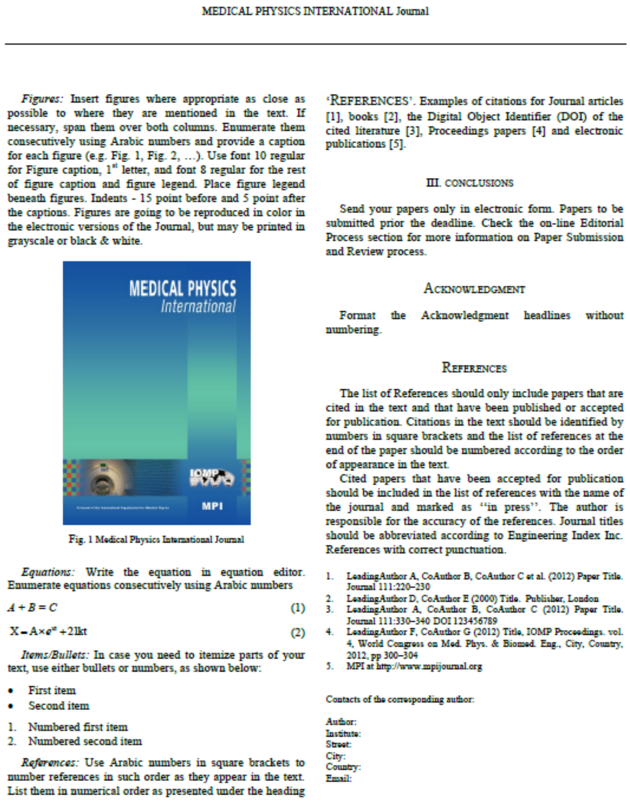

MEDICAL PHYSICS INTERNATIONAL Journal

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$$A + B = C \quad (1)$$

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BOOK OF ABSTRACTS

1st Regional Conference of the Federation of African Medical Physics Organizations (FAMPO); Marrakech, Morocco. 10 – 12 November 2022

and

Middle East Federation of Organizations of Medical Physics (MEFOMP) 2023 Medical Conference; Muscat, Oman. 19 – 22 May 2023

ANNEX 1

Ministry of Higher Education, Scientific Research and Innovation

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The 1st Regional Conference of the Federation of African Medical Physics Organizations (FAMPO)

MEDICAL PHYSICS IN AFRICA : FROM IMAGING TO TREATMENT

Elekta BEST HEALTH varian RaySearch Laboratories iba STANDARD IMAGING PTW GAMMA GEC

His Majesty King **MOHAMMED VI**

The Behaviour of Contamination Particles in 18 MV Beam Breast Treatment

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Abstract

Radiation therapy is one of the most widely used methods of treating solid tumours. The medical accelerators used in radiation therapy have a variable energy beam depending on the depth and position of the tumour. The use of high-energy beams such as 18 MV is usually accompanied by contamination particles, which are not taken into account in treatment planning systems (TPS). This study demonstrates by Monte Carlo simulations the behaviour of contamination particles during the treatment of the left breast. The simulations are based on the transport of contamination particles from the MIRD phantom modelled by the G4Linac_MT code.

Keywords:

MIRD phantom; Monte Carlo simulation; contamination particle; tumour; transport

Photon Specific Absorbed Fraction Estimation from Internal Irradiation in MIRD Stylized Phantom using DoseCalcs Newly Developed Code

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Abstract

The injection of a radiotracer inside a patient's body makes the body of the patient to emit radiation, which could cause biological damage to the patient. It is mandatory to properly estimate the internal radiation dose in order to balance the benefits with the radiological risks associated with the procedure. Free and commercial softwares are available for the estimation of internal radiation dosimetry quantities, such as Absorbed Dose (AD), S value (S), Absorbed Fraction (AF), and Specific Absorbed Fraction (SAF). The use of C++, GDML, TEXT and STL methods for geometry inputs and taking advantage of distributed memory techniques for simulation speedup, is not supported by most of these tools. For these reasons, we developed an open-source Geant4-based code called DoseCalcs to assess the performance of the present applications. The mathematical MIRD phantom input geometry data was implemented with a combination of C++, GDML, TEXT, and STL methods. The organ composition was taken from MIRD reference. Eight discrete monoenergetic photons having energies ranging from 0.01 to 2 MV were considered. In our model, the organs simulated as sources of radiation were the liver, kidney, and adrenal. The comparison between the DoseCalcs obtained SAF values has shown good agreement with MIRD Pamphlet No. 5, which means that DoseCalcs can be used as a powerful tool to well-estimate the involved internal dosimetry quantities.

Keywords:
DoseCalcs, Nuclear Medicine, Monte Carlo, internal dosimetry, Geant4, computational phantom, GDML, STL.

Machine-Generated Radiation Dose Assessment for Common Computed Tomography Examination at the Komfo Anokye Teaching Hospital, Kumasi, Ghana.

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Abstract

The aim of this study was to assess the radiation dose imparted to patients during common computed tomography (CT) examinations with the newly installed 128 slice Siemens CT scanner at the Komfo Anokye Teaching Hospital, Kumasi, Ghana. A quantitative-retrospective study design approach with a purposive sampling technique was used to sample the computed tomography dose data of patients pertinent to the study. Data such as patient demographics, volume CT dose index ($CTDI_{vol}$), dose length product (DLP), pitch and effective dose (ED) were collected from the CT scan control console. A total of 380 computed tomography dose data of the head, chest and abdominal region were retrieved from the CT console area. Out of this number, males were 221 (58.2%) and females were 159 (41.8%). The mean and the standard deviation (SD) of the ages of the patients were 43.49±20.94 years, ranged (1 – 100) years. The mean and standard deviation for $CTDI_{vol}$, DLP and ED for male and female head CT examinations were 28.70 ± 5.00 mGy, 630.33 ± 148.94 mGy.cm,1.45 ± 0.34 mSv and 26.72 ± 6.12 mGy, 542.34 ± 146.33 mGy.cm, 1.25 ± 0.34 mSv respectively. The mean and standard deviation for $CTDI_{vol}$, DLP and ED for male and female chest CT examinations were 4.78 ± 1.35 mGy, 200.45 ± 70.62 mGy.cm, 3.41 ± 1.20 mSv and 6.22 ± 3.53 mGy, 227.12 ± 109.45 mGy, 3.86 ± 1.86 mSv respectively. Again the mean and standard deviation for $CTDI_{vol}$, DLP and ED for male and female abdomen CT examinations were 5.07 ± 1.93 mGy, 244.10 ± 97.42 mGy.cm,3.66 ± 1.46 mSv and 7.39 ± 2.82 mGy, 353.18 ± 137.58 mGy.cm, 5.30 ± 2.06 mSv respectively. The machine generated CT doses that were recorded for the study were within the ICRP recommended dose reference levels and that of other countries suggesting dose optimization.

Keywords:
Computed tomography, paediatric and adult patients, Diagnostic Reference Levels, machine-generated dose, radiation dose.

^{23}Na -MRI as a Biomarker for Lung Cancer Diagnosis

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Abstract

The function and expression of the voltage-gated sodium channels (VGSCs) are regulated by the epidermal growth factors (EGF) through phosphoinositide-3-kinase (PI3K) or extracellular signal-regulated protein kinase (ERK1/2) pathways leading to changes in the tissue sodium concentration (TSC), intracellular sodium concentration (ISC) and the extracellular volume fraction (EVF) that promotes cancer metastasis. Sodium (^{23}Na)-MRI offers a unique opportunity to visualize these changes in the sodium biochemical parameters (TSC, ISC, EVF) that reflect cell viability, structural integrity, energy metabolism, and rapid treatment response before morphological changes occur. Here we evaluated the feasibility of non-invasively monitoring the epidermal growth factor receptor (EGFR) mutated non-small cell lung cancer (NSCLC) progression using a combination of ^{23}Na- and diffusion-weighted (DW)-MRI. A 3D radial projection ultra-short echo (UTE) sequence with and without triple quantum filters (TQF) was optimized for ^{23}Na-MR imaging of ISC and TSC. The ^{23}Na signal to concentration conversion was performed with the calibration equations obtained from the linear fitting of the signal intensities and their corresponding known sodium concentrations of the calibration phantoms. A longitudinal ^{23}Na- and DW-MRI studies without intervention were undertaken serially every 2-3 days on mice xenograft NSCLC tumour models with EGFR double mutation T790M/L858R (H1975), EGFR exon 19 del, E746 – A750, (HCC827), and EGFR wild-type (H460) for 21 days. ^{23}Na-, ^{1}H-, and DW- MR images were acquired every day for the first week of therapy and then periodically until sacrifice. The TQF preparation time for maximization of the acquired TQF signal was obtained to be $\tau\_opt = 9.8$ ms. The non-interventional ^{23}Na-MRI studies revealed an overall elevation of the sodium biochemical parameters in the untreated H1975 and H460 tumours at baseline which continued to increase with malignant tumour progression. However, the sodium levels detected in the HCC827 tumour model were similar to that of normal tissues. TSC and ISC levels were observed to be high in H1975, moderate in H460, and low in HCC827. This indicates that T790M mutation in the H1975 (L858R/T790M) xenograft tumours not only confers resistance but also grants a proliferative advantage over HCC827 and H460 tumour types. Hence, the sodium parameters can serve as biomarkers for screening of EGFR T790M mutation status. Though H1975 had a high ADC at baseline, DW-MRI showed an overall reduced and relatively constant ADC values as the H1975, HCC827 and H460 tumours progressed without intervention. Our results indicated that ^{23}Na imaging together with DW-MRI can provide additional information that could be useful in NSCLC treatment personalization and overall outcome. Hence supports the continued clinical testing of ^{23}Na- and DW- MRI for monitoring of NSCLC and demonstrates its complementary insights to 1H-MRI for oncology applications.

Keywords:

^{23}Na-MRI, Biomarkers, TSC, EGFR, Xenograft Tumour, Lung Cancer

Impact of Ionizing Radiation in a Biological Environment: Monte Carlo Simulation Code

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Abstract

The passage of ionizing radiation through matter releases a large number of electrons of various energies depending on the intensity of the incident radiation. The study of transport of ionizing radiation in a biological medium is useful in understanding the mechanisms governing the collision and interpretation of many phenomena. In this study, the effects induced by ionizing radiation on the irradiated medium, such as energy deposits and therefore the dose distribution in a considered medium of interaction were examined using a Monte Carlo program, GEANT4, to simulate the transport of electrons in liquid water, the main constituent of a biological medium. A comparative analysis of our results with the results obtained by other authors on the calculation of the mean free path of an electron in water was made. A good agreement was observed in the comparison.

Keywords:

Dose distribution, GEANT4, electron mean free path.

Dose Metrology: Study of the Performance of the OSL and TLD Dosimetric System

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Abstract

Performance evaluation and comparison in terms of measured dose accuracy, energy response, and coefficient of variation between two types of passive radiation dosimeters, thermoluminescent (TLD) and optically stimulated luminescence (OSL), used by radiation workers for individual radiological monitoring and control of external exposure at different times (cumulative dose for 1 month) is very important. It offers the method to determine to judge the quality and identify the dosimetric aspects of TLD/OSL passive dosimeters. This study was set up to determine both the accuracy of the dose measurement R(10) and R(0.07), which is considered as the ratio of the measured dose [Hp(10) or Hp(0.07)] to the delivered dose [Hp(10) or Hp(0.07)] for each photon energy. The validity of the results of this study is based on the acceptance limits of the ICPR and the international standard ISO 62387, the relative energy response which is used to calculate the ratio of measured Hp(10) to delivered Hp(10), and measured Hp(0. 07)/delivered Hp(0.07) normalized to 662 keV (Cs-137) energy to find which energy response is closest to the ideal case, and the coefficient of variation that allows to determine the statistical fluctuation in the doses found. The results obtained for the accuracy test are satisfactory for the OSL and TLD dosimeters as they are within the ICRP limit. The energy response of OSL shows a good performance for Hp(10) and Hp(0. 07) than the TLD, and the coefficient of variation for OSL meets the requirements of the ISO 62387 standard for Hp(10) and Hp(0.07) while the TLD meets the requirements of the same standard only for the measurement of Hp(0.07).

Keywords:
TLD, OSL, radiation protection, Energy dependence, ICPR trumpet graph, Hp(10), Hp(0.07)

The use of LINAC Log File for Patient Specific Quality Assurance in Volumetric Arc Therapy Treatment Plans

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<u>Abstract</u>

Gamma Index analysis is a globally accepted methodology for checking pre-treatment Intensity Modulated Radiation Therapy (IMRT) plans to confirm deliverability of the plans before patients start actual IMRT treatment. Gamma index utilizes the percent dose difference (DD) and distance to agreement (DTA) to evaluate the deliverability of a treatment plan. A number of methods have been described in the literature on how to achieve the gamma index including use of two-dimensional array detector, MV portal dosimeters, films and among others. In this research, the data collected from LINAC treatment console was used to reconstruct DICOM RT files and re-planed the reconstructed DICOM RT files to compare with the original treatment plan that was delivered. The study was conducted Varian Medical Systems (Varian, Pal Alto, California) and some programming languages such as Python to reconstruct the DICOM RT files. A comparison of these results with those of the initial treatment plans will serve as a special in-vivo treatment planning quality assurance. The LINAC log files contain the MLC movements, Gantry movements, instantaneous field sizes and MU delivered at each control point. This information is quite useful for dosimetric quality assurance as it gives the true picture of what was delivered during dynamic volumetric arc treatments.

Keywords:

Deliverability, Treatment planning, in-vivo, Quality assurance, LINAC Log files, volumetric arc treatments

Review of Advances in Nuclear Applications 2019-2022

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Abstract

The idea that prosperity is linked to health is supported by a prolonged usage of nuclear technology in the medical industry. Between 2019 and 2022, a detailed evaluation of the global and African trends in nuclear application in the health sector was conducted. The most important advancement in the treatment of gyneacological cancer is the introduction of intra-operative instruments like the portable gamma-camera. The IAEA has recently provided Namibia a new machine to tackle the rise in cancer incidences, particularly skin cancer. In order to accomplish SDG 3: Promote well-being, the Peaceful Uses Initiative (PUI) has funded 16 programs that aim to combat cancer on a worldwide scale. It's a great idea to include the electron beam in the IAEA's external audit service. Brazil, Cuba, Germany, Greece, Indonesia, Italy, Malaysia, Mauritius, Mexico, Spain, and the United States of America are among the countries that are advancing the use of SIT for mosquito control.

The participation of Africans in IAEA programs is highly recommended for development.

Keywords:

Nuclear, Health, cancer, radiological, mosquito

Local Diagnostic Reference Levels (LDRLs) for Full-Field Digital Mammography (FFDM) and Digital Breast Tomosynthesis (DBT) Procedures in Morocco

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Abstract

This study was designed to establish local diagnostic reference levels (LDRLs) for full-field digital mammography (FFDM) and digital breast tomosynthesis (DBT) in Moroccan health care facilities. Data from 146 women were collected retrospectively from three facilities. The proposed DRLs were defined as the 75th percentile of the average glandular dose distribution (AGD). The mean AGD recorded in this study for the three centres was 1.47 mGy for all centres, and 1.42 mGy and 1.64 mGy for the CC and MLO projections, respectively. The mean compressed breast thickness (CBT) values recorded in this study were 55 mm, the LDRLs reported for all centres were 1.7 mGy, the CC projection was 1.6 mGy, and the MLO projection was 1.8 mGy. In addition, the LDRLs reported in the current study were compared with previous studies from other countries, including the United Kingdom, Japan, Ghana, and Sri Lanka. This work provides an assessment of local DRLs for mammography in Morocco and is proposed as a starting point for professionals to evaluate and optimize their practice. Furthermore, the definition of national DRLs is a necessary process for the optimization of Moroccan medical exposures, towards which a major project has been implemented by the governmental authority according to the IAEA guidelines.

Keywords:

Full-Field Digital Mammography, Digital Breast Tomosynthesis, local diagnostic reference levels, average glandular dose.

Influence of Shield and Cold Head 2nd Stage Temperatures on Magnet TN150 Pressure in 4K-GM Cryocooler

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Abstract

In this paper, an experimental analysis was performed to establish the relation between temperatures of shield and cold head (2nd stage) and pressure variations inside the Mitshubishi TN150 Magnet in MRI device. Measurements of these parameters were taken for one month. Two applications were used to extract the data. These applications are: SVU_COM_TOOL software and HyperTerminal. A correlation was used to calculate the optimal values of pressure and temperatures. These values can be applied for good functioning of the MRI device. The geometric programming was used for optimization.

Keywords:

MRI, pressure, Shield temperature, Cold head 2nd stage temperature, correlation, Geometric programming, optimization.

Dosimetric Comparison of Brain Tumour Ballistics Coplanar VMAT and Dynamic Conformal Arc Therapy

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Abstract

Stereotactic radiosurgery (SRS) with a medical linear gas pedal based on the use of dynamic conformal arctherapy (DCAT) for the treatment of brain metastases remains the conventional strategy. However, volumetric modulation arteriotherapy (VMAT) allows a good conformation to the tumour volume, a strong dose gradient and a dose reduction at the level of organs at risk (OAR) which leads to a decrease of early and late complications in order to improve the quality of life of the patients. DCAT and VMAT plans were created for 15 patients. The two modalities were compared in terms of target compliance, target coverage, and dose to normal brain tissue. Both compliance indices (RTOG-CI and IP-CI) and the dose gradient index were significantly better in the VMAT plans than in the DCAT plans. Analysis of dose to normal brain tissue revealed that V23.1Gy, V15Gy, V12Gy, and V5Gy were significantly lower in the VMAT plans than in the DCAT-based plans. In comparison, the VMAT plans significantly improved target compliance and reduced doses to normal brain tissue.

Keywords:

Radiosurgery, metastases, DCAT, VMAT, organ at risk

Measurement of the Radioactivity in Drinking Water Consumed in the Eastern Region of Morocco by Gamma Spectrometry

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Abstract

This study was developed to determine the activity concentration of the main radionuclides (U-238, Th-232 and K-40) present in mineral water. The identification and quantification of these radionuclides was done using a NaI (Tl) detector coupled to a multichannel MCA analyzer connected to a computer. The activities measured in all samples for U-238, Th-232 and K-40 varied from 0.95 to 3.38 mBq/L with an average of 1.94 mBq/L, 1.55 to 3.56 mBq/L with an average of 2.46 mBq/L and 200.68 to 269.19 mBq/L with an average of 236.6 mBq/L respectively. The annual effective dose evaluated were 1.610 µSv/y, 1.133 µSv/y and 0.925 µSv/y for infant, children and adults respectively, based on the recommendations that are published in guidelines for drinking water quality by the World Health Organization (WHO, 1998), which requires that the maximum annual effective reference dose due to drinking water consumption is 0.1 mSv, this dose presents 10% of the maximum annual dose due to natural sources in ingestion mode received by the living being which is recommended by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) which gives a typical range of 0.2 to 1 mSv per year, it was found that the values measured in our study are lower than those mentioned by UNSCEAR and WHO. The cancer risk index evaluated in this study was a maximum of 5.63×10^{-6}, which is well below the 2.5×10^{-3} recommended by experts' organizations.

Keywords:

Gamma spectrometry, NaI (Tl), Bottled drinking water, Natural radioactivity, Dose assessment.

Over 50 years of IAEA/WHO Postal Dose Audits: Results from African Region

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Abstract

The International Atomic Energy Agency (IAEA) in collaboration with the World Health Organization (WHO) provide dosimetry audits for radiotherapy (RT) centres worldwide for over 50 years. Many hospitals in Africa participated in the reference beam postal dosimetry audits, and the aggregated results of their participation are presented in this study. IAEA/WHO dose audits are provided on request free of charge for up to three beams per hospital per year. Each dosimeter set has two capsules to be irradiated in reference conditions with a dose of 2 Gy and one capsule for monitoring background radiation. Upon return, the dose delivered to the dosimeters is evaluated and compared with the user stated dose. Every discrepancy exceeding 5% acceptance limit is followed up with another dosimeter set for a second irradiation and an expert visit if the problem persists. The audit results merged with the radiotherapy infrastructure data from the directory of radiotherapy centres (DIRAC) provides insightful information on the audit coverage and performance of hospitals in the African region (RAF). During the period between 1969 and 2021, 165 hospitals from 29 RAF countries checked 375 their external beam RT units with 1534 dosimeter sets through the IAEA/WHO postal dosimetry audit service. According to DIRAC, 33 RAF countries have 236 RT centres with 425 external beam RT machines to date. Throughout the years, some countries have expanded their RT capacity while in others, some units have been decommissioned, but it is certain that more than half of RAF hospitals benefited from participation in IAEA/WHO dosimetry audits. Averaged over the 50 years, the percentage of acceptable results is 91.9% (95.3%) after the first (second) irradiation attempt respectively. The participation rate has grown from less than 20 beams checked before 1999 to over 100 now. The averaged fraction of acceptable results in the last 10 years reached 94.0% (97.8%), which is comparable to the average worldwide results of 94.8% (98.2%) for the same period. The IAEA/WHO dosimetry audit provision for RAF countries has grown over the past 50 years, and the current audit results are comparable to the average worldwide results. All radiotherapy centres that do not have access to a national audit service are encouraged to request an audit from dosimetry@iaea.org.

Keywords:
Radiotherapy, Dosimetry audits, DIRAC

3D Gynaecological Hybrid Brachytherapy for Cervix

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Abstract

Brachytherapy (BT) plays a major role in the therapeutic management of patients with cervix cancer from stage I to IV. The rapid dose fall-off allows a very high dose to the central pelvis, while relatively sparing bladder, rectum, sigmoid and small bowel. Hybrid adaptive and MRI guided brachytherapy is used when intracavitry alone could not cover the volume. This study presents the results of 9 cases in which the technique was used. A dedicated applicator was used for this technique. The application was done at the theatre using CT scan and MRI scan images to place the applicator after contouring the targets and OAR by physicians. This was followed by the reconstruction of applicators, then optimisation and evaluation according to GEC ESTRO recommendations before the actual patient's treatment. Hybrid adaptive and MRI guided brachytherapy significantly improves the coverage of large target volumes, while retaining sufficient organs at risk. In addition, it allows a synchronous parametrial complement which results in a considerable gain on the spreading total of radiotherapy. It constitutes the best all-in-one technical solution available to date for the implementation of interstitial brachytherapy in centres that do not have sufficient expertise to apply a free-hand gynaecological brachytherapy.

Keywords:

Cervix cancer, brachytherapy, Hybrid, OAR

Failure Mode and Effect Analysis for Linear Accelerator-Based Stereotactic Body Radiotherapy

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Abstract

Stereotactic body radiation therapy (SBRT) is becoming a very popular choice of treatment due to its effectiveness in controlling early-stage primary and oligometastatic cancer at delicate locations like the abdominopelvic and thoracic cavities, and at spinal and paraspinal sites. Recent Technological advances in respiratory motion management, treatment planning, and image guided treatment delivery, have allowed high doses of radiation per Fraction (≤5 fractions) to be safely delivered and the use of very small beams. Because of targeting very small lesions that usually doesn't require the use of PTV, and delivering high biological effective dose, the accuracy of treatment delivery is therefore an important factor that determines the success of this procedure. However, the use of traditional prescriptive quality management (QM) methods that focuses on monitoring all aspects of the functional performance of radiotherapy equipment by comparing parameters against tolerances set at strict but achievable values, may not be enough to match the increasing complexity of modern radiotherapy planning and to provide the required accuracy for SBRT treatments. Many errors that occur in radiation oncology are not due to device and software failures, but rather to workflow and process failures. Therefore, it seems obvious that an appropriate understanding of the probability and clinical impact of possible errors throughout all the stages of SBRT is necessary to ensure maximum safety and quality of treatment for patients. Considering all these points, we have decided to evaluate the process of SBRT treatment using a risk-based method called Failure Mode and Effect Analysis (FMEA). This method makes it possible to identify and treat the potential causes of failures and errors before they occur, thanks to a complete analysis of the process, and a strategy based on failure anticipation.

We aim to optimize the SBRT workflow and to minimize the frequency of errors using the Failure Mode and Effect Analyze (FMEA), therefore we will try in this project to identify and study the potential failure modes (PFM) from each step of the SBRT process. For each step in the SBRT delivery process, potential failure modes will be derived and three factors assessed: the probability of each occurrence, the severity if the event occurs, and the probability of detection by the treatment team. A rank of 1 to 10 will be assigned to each factor, and then the multiplied ranks of each factor yielded the relative risks (risk priority numbers). The failure modes with the highest risk priority numbers will be then considered to study and to analyze process improving methods. Risk based methods and process analysis are demanding in terms of collaboration with the stereotaxis team and in terms of time, however, they remain highly efficient to evaluate the process and to improve the quality and safety of our practice of stereotactic body radiation therapy (SBRT).

The Effect of Various Treatment Parameters on Neutron Production

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Abstract

To improve the efficacy of treatments, high-energy medical accelerators are commonly used in radiotherapy. However, unavoidable neutrons can be produced during treatment through photonuclear reactions and interaction of high-energy photons with different high-Z nuclei of the materials in the head of the accelerator components. The purpose of this study was to investigate the effect of some treatment parameters (photon beam energy, field size, the distance to the isocentre, etc.) on the production of neutrons. The whole head of the accelerator was simulated using Monte Carlo (MC) Gate/Geant4 code. Thereafter, the obtained MC results were compared with theoretical and experimental results available in the literature. Finally, these results could be useful in finding solutions in protecting patients against the risks of neutrons contamination.

Keywords:

Monte Carlo, photons, accelerator, field size, isocentre

Comparaisons des Trois Techniques Pour L'irradiation des Cancers Tête Et Cou

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Abstract

Les cancers tête et cou constituent la troisième localisation des cancers traités au Centre National d'Oncologie, Nouakchott (CNO). Ces patients sont souvent diagnostiqué à des stades tardifs ce qui rend difficile leurs irradiations. Nous comparons sur le plan dosimétrique à travers cette étude trois techniques d'irradiation, radiothérapie conformationnelle 3D (RT3D) classique avec ou sans électrons et radiothérapie par Irradiation avec Modulation d'intensité Volumétrique par ArcThérapie (VMAT).

Pour chaque patient et après contourage des volumes cibles, la planification est faite par VMAT et deux plans réalisés en technique conformationnelle 3D avec et sans électrons. La prescription est de 70 Gy en fractionnement et étalement classique sur 95% du volume de planification (PTV). Pour la RT3D classique sans électrons, une première série à la dose de 50 Gy sur les PTV en utilisant des faisceaux multiples en photons. Dans une deuxième série, de 50 à 70Gy on utilise deux champs en photons sur le volume réduit. Pour la RT3D classique avec éléctrons, Un premier temps de 0 à 40Gy sur le PTV avec deux faisceaux latéraux et un faisceau antérieur. Dans un deuxième temps, 50Gy sur le PTV avec deux faisceaux latéraux réduits, deux faisceaux spinaux en électrons. Enfin, le dernier temps la dose de 70Gy est donnée par deux faisceaux latéraux en photons. La planification VMAT repose sur la planification inverse.

50 patients atteints des cancers tête et cou ont été inclus, l'analyse des Histogrammes Dose Volume de 50 patients. La dose de 67Gy est délivrée à 95 % du PTV en VMAT contre 65 Gy en RC3D sans électrons et 63 Gy avec les électrons. Pour 80% des patients les doses maximales à la moelle et au tronc sont respectivement entre 42 et 45 Gy en VMAT contre 45 et 48Gy en RC3D sans électrons et 45 et 49 Gy avec électrons. Les parotides sont épargnées puisqu'on a la dose moyenne pour 90% des patients la dose moyenne inférieure 26Gy en VMAT contre 55 Gy en RC3D sans électrons et 67 Gy en RC3D avec électrons.

A défaut de la technique VMAT, la technique RT3D sans électrons parait meilleur par rapport la technique RT3D avec les électrons pour la réduction de la dose aux organes à risques tels que la moelle épinière et les parotides ainsi avec une meilleure couverture de la dose au niveau du PTV.

Optimizing the CBCT Technique and Analysis for LINAC Synchronized NIPAM 3D Dosimetry

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Abstract

The advantage of LINAC Synchronized NIPAM (LS-NIPAM) 3D dosimetry is the possibility of the measured dose being inherently synchronized with the on-board imaging coordinate system. However, the main challenges are the limited signal strength and the lack of robust and widely available tools for the analysis process. Our goal is to optimize a CBCT technique for comprehensive LS-NIPAM 3D dosimetry, and investigate the use of a recently developed clinical 3D dosimetry software (VistaAce) as an analysis tool. A simple 3-field plan (6 MV-FFF, 25 Gy) was delivered to a 1L jar of NIPAM gel dosimeter using the same configuration described in a previous study. Comparison of iterative and standard reconstruction algorithms as well as the impact of a variety of imaging metrics (exposure, tube current, number of projections, etc...) on NIPAM image quality was conducted. VistaAce (v 0.7) was used for data analysis. TG119 C-shape plan was delivered to a large jar (2L) of NIPAM, as a clinical verification of both the adopted CBCT technique and analysis tool. Results show that the Contrast to Noise Ratio increased considerably when the iterative reconstruction algorithm was used (CNR increased from 4.7 to 11.8). The measured dose agreed with the dose from the treatment planning system for the 3-field plan, with a pass rate of 95.626% for 3%3mm and 94.48% for 5%2mm. Line profiles showed a good agreement between the planned and the measured data. The results from VistaAce were verified via a second analysis using MATLAB and 3D Slicer with both analyses methods in agreement. The initial analysis of the TG119 C-Shape plan shows promising results. A CBCT technique was developed for LS-NIPAM 3D dosimetry that demonstrated high CNR and high agreement with TPS dose which uses averaged pre-irradiation CBCTs subtracted from averaged post-irradiation CBCTs and using an iterative reconstruction technique. The VistaAce software could possibly be used as a robust 3D dosimetry analysis tool, including for LS-NIPAM 3D dosimetry.

Keywords:
Dosimetry, VistaAce, CBCT, analysis, imaging

Output Factor Measurement for Non-Square Small Fields using Different Devices and Methods

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Abstract

The aim of this work is to calculate the output factors for 48 small fields with rectangular shapes. This has been performed using different detectors, such as: Pinpoint 31016, Diode E 60012, Diode P 60008, Diode SRS 60018, Diamond 60019, and as a benchmark the EBT3 Dosimetric Films. The XVMC Monte Carlo code of MONACO 5.11.03 planner used as a reference for the simulation. All measurements were done with an Elekta linear accelerator, Infinity model with Agility head, and 5 mm multilayers with 6 MV photon energy. Two different equivalent-field size methods for calculating the output factor for rectangular shape were used. One of this method is described by formula $S_{eq} = 4\frac{A}{P}$, where A is the area and P is the perimeter. The other one is defined as $S_{eff} = \sqrt{x \cdot y}$, where x and y are the sizes for the rectangular fields, S_{eff} is the side characteristic of the equivalent square of the small field. For these two types of calculations, we applied the Daisy Chaining method and the field output correction factor for fields collimated by an MLC given in Technical Reports Series 483 Table No. 26 and 27.

Keywords:

Photon, energy, calculations, Monte Carlo, XVMC, dosimetric

Evaluation of Iodine-131 Absorbed Dose in Graves's Disease Therapy: A Gate Geant 4 Monte Carlo Simulation Study in Niamey, Niger

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Abstract

A Monte Carlo simulation in Gate Geant4 was applied to calculate the iodine-131 absorbed fractions for electrons and gamma with mean energies of 167 keV and 397 keV respectively. They were uniformly distributed in ellipsoid phantoms made from PMMA material. The simulations for the electrons and gammas sources were thus done separately in order to observe the contribution of each type of radiation. Each patient was simulated with the same activity received and the volume of the ellipsoidal phantom corresponding to the size of his thyroid. The absorbed fractions for electrons and gamma were thus evaluated for all 45 patients referred to the nuclear medicine departments of the IRI in Niger and the University hospital of Bab el Oued, Algiers, for Radioiodine therapy of Graves' disease. The mean beta absorbed fractions were 5.11×10^{-5} and 4.99×10^{-6} for gammas rays. The mean S factor was 1.04×10^{-3} for the absorbed fractions of β and γ. The mean absorbed dose evaluated using MIRD method was 205.01 Gy, while the simulations gave an average absorbed dose of 256.35 Gy. This approach shows that the Gate code GEANT4 is an important tool for dose calculations in internal dosimetry in nuclear medicine applications, as well as in radiation protection dose estimates.

Keywords:

Evaluation, absorbed fractions, Gate GEANT4, Monte Carlo simulation, Graves' disease

Dose and Image Quality Optimization for Computed Radiography (CR): A Phantom Study

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Abstract

The enhancement of radiological diagnosis requires a good image quality, which is automatically affected by the dose, this is a function of the different technical parameters used in the current radiographic procedures. Furthermore, in radiological practice, dose optimization involves the evaluation of all parameters that influence both the dose received by the patient and the image quality of radiographic examinations. The current study is a phantom study that aims to reduce the radiation dose to the patient while maintaining the acceptability of the image quality.

Keywords:

Phantom, image quality, optimization, radiographic procedure, dose, CR

The Impact of Patient Centring Towards the Bowtie Filter on Patient Dose and Image Noise in CT

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Abstract

Patient dose in CT has called for continued efforts to keep radiation exposure as low as reasonably achievable. A bowtie filter reduces unnecessary radiation dose to the peripheries of a patient and equalizes radiation signal to the detector. To achieve this goal, the patient must be correctly centred in the CT field of view. Otherwise, the region less attenuated by the filter would be exposed to more dose and the noise would be increased in the region that is in the part of the filter that attenuates more. A Catphan® 500 phantom was positioned on the CT table so that its centre was aligned at 0, 2, 4 and 5.75 cm below the isocentre, then at 2, 4, 6, 8, 10, 12 and 14 cm above the isocentre and a PMMA phantom at 0, 2, 4, 5.75 and 8 cm below the isocentre. The clinical centring error was studied on a sample of 10 patients who had a thoracic or abdominal CT using ImageJ software. The more the centre of the Catphan© 500 phantom is placed far from the isocentre, the more the image noise increases. Moving away below from the isocentre, it increases in the upper part which is the most attenuated by the bowtie filter while it increases in the lower part moving away above from the isocentre since it is the most attenuated by the filter in this case. The image noise was increased with a reconstruction filter hard. The correction was done with the ASiR tool. The dose decreases by 12.07% and 27.94% in the centre of the PMMA phantom and in the 12H position respectively, while it increases by 47.88% in the 6H position. On the other hand, there was no significant change at the 3H and 9H position. The increase and decrease tend to be balanced and the impact on the overall $CTDI_w$ dose is negligible when it was calculated using the peripheral mean. The image quality and dose optimization can be improved in CT using the bowtie filter by ensuring a good patient centring.

Keywords:
Patient centring, bowtie, CT, optimization, PMMA,

A Study of the Conformity Index and the Homogeneity Index for Cervical and Prostate Cancer Radiotherapy Plans at Mpilo Central Hospital

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Abstract

The treatment of cervical and prostate cancer involves a multidisciplinary approach in which radiotherapy plays a key role. This study aims to demonstrate the conformity and homogeneity levels achieved by 3D conformal radiation therapy for cervix and prostate malignant tumours patients. Conformity and homogeneity indices are good quantitative tools for assessing and comparing the dose conformity and homogeneity of various treatment plans of one patient. In this study, 60 plans with advanced cervical tumours and 35 prostate plans were selected. The CI and HI mean values were calculated using Microsoft Excel 2016. The prostate cancer had a CI range of 0.98 to 2.5 with a mean value of 1.54, and HI range of -0.083 to 0.016 and mean value of 0.0125. The cervical cancer had a CI range of 0.98 to 5.05 and mean value of 3.03, and the mean HI in the cervical study was 1.124, with a minimum HI of 0.498, maximum HI of 2.684 and standard deviation of 0.476. The CI mean values do not fall within the RTOG range. This is attributed to the late cancer stages that invade uterus, pelvic and lymph nodes. However, improvements need to be made in the beam-delivery techniques and the treatment equipment used at the department.

Keywords:

Radiotherapy, prostate, conformity, homogeneity, tumour

Comparison of Hand and Ocentra Master Plan TPS Monitor Unit Calculations

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Abstract

A comparison of the monitor unit calculation between TPS and manual calculation is very important in the department of Radiation Oncology. In this paper, we calculated the MU of 3DCRT plans for prostate and breast cancer using the data obtained from the master plan TPS. The MU of each beam was recalculated manually and compared with the TPS values. We obtained that, the manual calculation and TPS values were in good agreement. The MU difference between TPS calculation and manual calculation was ± 0.78 with a standard deviation of 1.83 for the prostate case with a p-value of 0.07 using a t-test which shows that there were no significant differences between re-calculation and TPS. For the breast case, the MU means difference was 2.90 with a standard deviation of 3.38 and a p-value of 0.007 which indicates a significant difference between re-calculation and TPS. In this study Primus TM Linear Accelerator with 6 MV and 15 MV was used. The monitor unit was calculated by Ocentra Master Plan TPS. The hand calculation was performed with aid of a spreadsheet. The excel sheet was developed based on AAPM TG 71 algorithm. Two types of cases were chosen based on their homogeneous and inhomogeneous distribution of the tissues. A total number of eight patients were chosen among them were three with prostate cancer and five were breast cancer. The AAPM TG 71 formalism used for manual calculation. The results show the variation of MU calculated by TPS and hand calculation. The tolerance of variation was recommended to be ± 3.5% as proposed by Mijinheer et al. and Wambersie et al. From our results above, the difference in the means of MU between TPS calculation and hand calculation was ± 0.78 with a standard deviation of 1.83 for the prostate case with a p-value of 0.07 using t-test which shows that there was no significant difference between manual calculation and TPS. Manual calculations are usually used to confirm the TPS calculations of MU. The present study shows good agreement for prostate.

Keywords:
Prostate, manual calculation, MU, TPS, accelerator

Local DRL in Nuclear Medicine Department of Cancerology Institute of Libreville

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Abstract

Diagnostic Reference Levels (DRLs) have been introduced for assisting the optimization of radiological investigation. There is urgent need to establish DRLs in nuclear medicine imaging studies to reduce unjustified medical radiation exposure and social concerns, as well as to optimize radiation protection. This study was focused precisely on local reference levels in nuclear medicine department. The data of this study were collected from the only nuclear medicine department of Gabon during few months. The nuclear medicine investigations were carried out using a SPECT/CT equipment from Philips brand and 30 adult patients (more than 30 years old) were administered with Tc-99m for bone scan examinations. All datasets of patient weight lower than 45 kg were excluded and less than 20% of the group weighed over 90 kg. Actual administered activities were calculated by the difference between the measured activity and residual activity after injection, the decreasing activity was also considered for actual activities. Then, the median and mean of actual administered activities were evaluated to get local reference levels. DRL values were found within the international range. For bone scan, the DRLs were 700,76 MBq and 686,74 MBq respectively from the median and the mean of administered activities compared to international range of 500 – 1110 MBq. Nevertheless, the patient weight was not considered for the administered activity while the ICRP recommended that such consideration should be given to adjust administered activities based on agreed factors linked to weight. This work presents data on administrated activities used in clinical practice for diagnostic nuclear medicine procedures in Gabon to provide the DRL at a national level. The values obtained are comparable with those reported in other countries. The patient weight factor is not included in this review and should be added in future studies. Local reference levels should continuously be reconsidered to optimize protocols, to ensure best practices and to reduce radiation exposure to patient and workers.

Keywords:
DRL, optimization, nuclear medicine, activity, patient

Pre-treatment Verification of Carcinoma Breast VMAT Plan based on Mono-isocentric Technique: Assessment of the Combined Fields Feature of New 2D MatriXX Arrays Resolution

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Abstract

This study was set up to verify the Mono-Isocentric technique-based Volumetric Modulated Arc Therapy (VMAT) plan for carcinoma breast and regional nodes employing the new 2D arrays MatriXX Resolution from IBA dosimetry systems, Schwarzenbruck, Germany loaded with the combined field feature. This study included 12 Mono Iso-centric VMAT plans for breast cancer with supraclavicular and axillary nodes. The radiotherapy planning was performed by the Monaco TPS (5.51 Elekta Limited, Crawley, UK) following the departmental planning protocols employing 6 MV photons using the XVMC algorithm for Dose calculation. The plans were optimized using an arc geometry with 25 increments in gantry angle spacing between control points with a 3 mm resolution dose grid size and 1% per calculation dose to medium, minimum segment width 0.5 cm and high fluence smoothing. These plans were delivered clinically by an Elekta Infinity linear accelerator equipped with Agility 160- leaf MLC (Elekta Limited, Crawley, UK). Two CT scans of the MatriXX resolution inserted in the Mini Phantom R were acquired using a CT simulator (GE discovery (General Electricals, USA). Out of these two scans, the first one was taken as the default CT and the second one as the extended CT, to use for large fields combination. In this study, normal and combined fields were compared using myQA patients’ software (IBA Dosimetry, Germany) based on the gamma index analysis and point dose measurements with the ion chamber CC04 according to IAEA Protocol TRS398. The new 2D array detector provided good agreement for dose maps without combined field features over the field lengths ranging from 22 cm to 24 cm and excellent agreement for maps with combined fields for lengths ranging from 24 cm to 28 cm. VMAT Clinical cases passed with more than 95% for the set criteria of 3% DD & 3 mm. The absolute point dose measurement agreement was found to be more than 98%. The MatriXX Resolution is a convenient, fast, robust, and practical tool for routine large-field pre-treatment verification in IMRT, VMAT and other advanced techniques.

Keywords:
Patient-Specific Quality Assurance, Combined Field, My QA Software, 2D Array detector.

Computed Tomography Dose Measurements Using RANDO Anthropomorphic Phantom

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Abstract

In recent years, there has been significant increase in the use of computed tomography (CT) systems in Ghana. Knowledge of the amount of radiation delivered to patients undergoing CT examination is the first step in dose optimization. The aim of this study was to physically measure organ doses using thermoluminescence dosimeters (TLDs) on RANDO anthropomorphic phantom and verify the measured doses with CT-Expo software. A total of 50 TLDs were placed in the phantom and exposure performed using frequently used CT clinical protocols at the facility. Images from the CT examinations were all accepted by the resident Radiologists, hence the dose report were suitable for the study. The TLD measured organ doses varied between 3.97 mGy for oesophagus and 56.22 mGy for brain. High doses were recorded in brain (37.80 - 56.22 mGy) and eye lens (29.94 - 36.16 mGy). Comparing organ dose measurements between TLD and CT-Expo, the maximum organ dose difference was realized in the eye lens (31.60%). For the chest CT examination, the maximum variation was -27.03% for the heart and 26.95 % for the oesophagus. The comparison between the two methods for the other organs were all less than 30% with the least difference being stomach (-0.76%). The mean organ dose for the direct measurement were mostly lower than the simulated, except for brain, heart, bladder and gonads. The effective dose from TLD measurements were 2.78, 6.67 and 17.39 mSv for head, chest and abdominopelvic CT examinations respectively. For CT-Expo, the corresponding effective doses were 2.20, 10.30 and 16.70 mSv. A major reason for the difference in dose measurements between the two methods was the dissimilarity of the organ position in the Rando anthropomorphic phantom and the standard mathematical phantom used by CT-Expo.

Keywords:
Computed Tomography, organ dose, effective dose, TLD, anthropomorphic phantoms

Dosimetric Evaluation of Tungsten Eye Shield Versus Gold Shield with Different Electron Energies in Radiotherapy

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Abstract

For over 50 years, electron beam therapy has been an important radiation therapy modality. A single electron beam delivers a uniform ‘plateau’ of dose ranging from 90% to 100% of maximum central-axis dose with the dose distribution steeply falling off both laterally and distally This has allowed superficial cancers and disease (within 6 cm of the patient’s surface) to be irradiated with little dose to underlying normal tissues and structures. In electron radiotherapy, shields are placed above the patient's body surface to block beams and scattered rays. By appropriately shaping the shield, which is most commonly made of lead or low melting point alloy (LMA), radiation can be concentrated to the appropriate area by forming an irradiation field. This study aims at the evaluation of transmission from tungsten eye shield that used frequently in high percentage of cases that treated with electron beam in radiotherapy as squamous cell carcinoma in eye lid in comparison to local gold eye shield that used in these cases to protect eye from any extra dose can cause damage to the eye. This study was performed with tungsten eye shield and local gold shield using pinpoint ionization chamber detector in the measurement of dose transmission under eye shield with different electron energies 6 MeV, 9 MeV, 12 MeV and 15 MeV at SSD of 100 cm with applicator size 10 × 10 cm^2 in solid phantom as medium of measurement for patient simulation. The results show that the use of tungsten eye shield in protection of eye from any extra dose cause sharp decrease in dose transmission under eye shield in comparison to local gold shield that give bad protection for the eye as shown in figure 1, 2,3 and 4 where the dose transmission decrease from 0.36% with gold shield to 0.021% with tungsten shield at energy 6 MeV, this difference is more clearly shown at energy 15 MeV where the dose transmission under gold shield reached 90% and dropped to 0.08 % under tungsten shield, all figures show significant difference between two types of eye shield at all electron energies 6 MeV, 9 MeV, 12 MeV and 15 MeV (p-value = 0.0066). To sum up the results of this study, it is clear that there is significant difference between tungsten and local gold shield where the tungsten cause less transmission for the dose, hence more protection for the eye in comparison to gold shield that give poor protection for the eye, although the local gold shield is more easy to insert inside the eye in contrast to tungsten eye shield but this advantage can be neglect due to its bad protection, so it is recommended to use tungsten eye shield with electron in radiotherapy when the tumour close to the eye.

Key words:
Tungsten; Gold; Electron; Radiotherapy, eye, carcinoma

Determining the Best Transfer Learning Approach to Multiclass Classification of Glioma, Meningioma and Pituitary Tumour

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Abstract

Brain tumours are one of the deadliest types of cancers as only 36% of brain tumour patients survive five years after diagnosis. Brain tumours are detected and classified by biopsy, an invasive procedure with the potential to impede brain function and introduce infections. Diagnostic imaging approaches using anatomical magnetic resonance imaging (MRI) have minimized the use of pre-treatment biopsies for detection, but current visual classification of brain tumour images using expert readers have not improved classification accuracy enough to eliminate biopsies. Transfer learning is a machine learning technique where a previously trained model serves as the foundation for a model on a new problem. Recent advances in Convolution Neural Network (CNN), offer promise in using brain MRI to accurately classify brain tumours. Here, we evaluated the performance of 26 Keras applications (CNN models) previously developed for general image classification in the classification of brain tumours. We retrained 3064 T1-weighted contrast-enhanced MR images from 233 patients with either meningioma (708 images), glioma (1426 images), or pituitary tumour (930 images) using pre-trained weights from the ImageNet dataset and compared classification accuracies of the Keras applications. This is an exhaustive evaluation of various state-of-the-art CNN approaches has been performed using a relatively large publicly available multiclass brain MRI dataset. Of the 26 models, EfficientNetB3 classified with an accuracy of 98.98% while DenseNet121, EfficientNetB2, EfficientNetB5 and EfficientNetB4 correctly identified the tumour type with an accuracy of more than 97%.

Keywords:
MRI, convolution central network, meningioma, pituitary tumour, transfer learning

Global Representatives Initiative of the American Association of Physicists in Medicine

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Abstract

In the current structure of the American Association of Physicists in Medicine (AAPM), one of the major divisions is International Council formed few years ago. One of the Committees of this Council is Global Needs Assessment Committee (GNAC) which comprises two Subcommittees: Equipment Donation Subcommittee and Global Representatives Subcommittee (GRSC). The objective of the latter is to establish a network of Global Representatives allowing us to better assess local needs and more efficiently administer our help to our colleagues overseas. Africa is our partner number1. There is a lot that our committee can contribute to the local Medical Physics community. To facilitate this process, we need to establish a reliable network of local representatives with whom AAPM can regularly communicate. Therefore, we will try to arrange roundtable discussions at this meeting to discuss the urgent needs. Once the local representatives are identified, we can include them as guests or consultants to GRSC, so they can participate in our regular online meetings. As a part of our collaboration, we can offer free 2-year AAPM memberships to a certain number of eligible candidates and open access to the AAPM website containing numerous publications and other resources. Part of GNAC work is to provide collaborative microgrants to develop clinical service in some areas of the world that need our support, and there will be another opportunity for African Medical Physicists to participate in the next round of applications at the beginning of 2023.

Keywords:

AAPM, collaborative, microgrants, global needs assessment, medical physics

2021 IAEA Regional Intercomparison Exercise on Individual Monitoring for External Exposure

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Abstract

The organization of this regional intercomparison exercise on individual monitoring in Africa region was implemented under the framework of IAEA Technical Cooperation Project RAF9068. The SSDL of CNRP of Morocco hosted this intercomparison exercise (irradiation of dosimeters sent by participating dosimetry service and evaluation of final results). Results of this intercomparison exercise were discussed during the virtual meeting held on 13-15 December 2021, Vienne – Austria. In this meeting Intercomparison results for each country checked and validated with special interest on consistency, accuracy (trumpet curve criteria compliance); influence of background radiation; unexceptionally too high or too low values; & typographic errors. Results were analysed country by country to identify specific issues or otherwise in each case. The results of the intercomparison study show that some participants have a very satisfactory performance and also that a number of services could improve the quality of their systems by improving the calibration of their systems. Additional information specific to the tested systems and provided by the participants for statistical analysis allowed more detailed analysis of the results with respect to different parameters, e.g. dosemeter type, detector material, and other parameters. The influence of such parameters on the response values of the dosemeters was studied and discussed. With the aid of the intercomparison results the participants can show compliance within their quality management system, compare their results with those from other participants and develop action plans for improvement of their system.

Keywords:
Intercomparison, calibration, dosimetry, IAEA, consistency, accuracy

Preliminary Diagnostic Reference Levels for Conventional Radiography Examinations in Senegal

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Abstract

The aim of this study is to estimate local reference levels in conventional radiology at six diagnostic centres in Senegal. The purpose is to encourage health professionals to investigate patient radiation doses and to determine whether these doses comply with the principles of radiation protection in medical fields. It is also intended to improve practices by reducing patient exposure without reducing clinical effectiveness. To perform this work, patient effective doses from different radiological examinations have been investigated, including the following nine routine types: chest (PA), abdomen (AP), pelvis (AP), cervical spine (AP), lumbar spine (AP, Lat), hip (AP),), thoracic spine (AP, Lat). Three types of data were collected, X-ray tube machine data, patient data and output measurements. The entrance surface dose and dose area product for each plane radiography were calculated. The data were analysed statistically and the minimum, median, mean, maximum, and third quartile values were calculated. Derived doses were compared with recommended international diagnostic reference levels. Values for the entrance surface dose (0.66 mGy) and dose area product (96.85 mGy.cm^2) for chest PA were up 35% and 76% higher, respectively, than their corresponding European Commission Report RP 180 Part 2. These observations and others, such as poor radiographic techniques, and lack of modern X-ray equipment, have shown the critical need to carry out quality assurance programs in Senegal.

Keywords:
X-rays, diagnostic radiology, entrance surface dose, dose area product, and optimization.

The Sensitivity of the Gamma Analysis Used as a Verification Method for Volumetric Modulated Arc Therapy (VMAT) Plans

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Abstract

Considerable progress in the delivery of radiation for therapeutic purposes has been made over past 30 years. With the evolution of technology, new treatment techniques, such as intensity modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT), were developed. These techniques, however, uses small, non-intuitive in shape beam apertures to create the required modulation. Verifying that the plan parameters are correct can no longer be performed visually. Furthermore, the ability of the dose calculation algorithms to calculate the doses of these small, irregularly shaped beam apertures accurately, and the ability of the treatment machine to deliver the calculated fluence, were called into question. This necessitated the use of physical measurements to verify the dose delivered to the patient prior to the patient's treatment. The most widely used method for patient specific QA is the gamma index analysis. However, recently, some issues with respect to the gamma index analysis have been raised in some studies. The aim of this project was to investigate the sensitivity of the gamma index analysis with the pre-selected DD and DTA criteria used at Tygerberg Hospital. This retrospective study involves using the public domain radiotherapy-plan, radiotherapy-structure and CT data sets available for download on the Varian website (link: https://medicalaffairs.varian.com/halcyon-case-studies-index). The radiation-plan data set was edited to simulate clinically relevant errors in the collimator angle and the dose at the treatment machine. The dose distribution of the edited plan as measured with the EPID was then compared to the dose distribution predicted by the treatment planning system. Various recent studies have found the gamma-index metric to be insensitive to clinically relevant errors when using the commonly used criteria (namely 3%/3mm). The sensitivity of the gamma analysis technique, with the gamma criteria used at Tygerberg Hospital (namely 2%/2 mm), to collimator angle errors and dose errors, was also investigated. The findings of this study corroborates the results of previous studies and highlights the need for a new way of quantifying the error of the delivered plan.

Keywords:
Gamma index, VMAT, treatment planning, calculation algorithm, beam aperture

A New Dosimetric Investigation of a Head Volume Irradiated by Carbon Ions in the Presence of an Axial Magnetic Field

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Abstract

To improve the irradiation accuracy in hadron therapy, a lot of studies have been conducted on how to integrate MRI and PET in the treatment of cancer patients. These two future techniques will offer simultaneously the monitoring of the beam during the irradiation. In this study and for the first time, we calculated the dose distribution in a head volume for several carbon ion energies and at different values of the magnetic field B using Fluka MC code. Afterwards, either longitudinal or radial dose deflection was simulated with and without B. Basically, the Z axis is entered by the beam and the radial deflections mean the ones corresponded to the X axis which has the same direction of B. The maximum longitudinal deviation of Bragg pick depth was 0.672 mm at 200 MeV and the maximum radial deflection was almost 4.23 cm at 100 MeV. Both of them are in the presence of B = 1.5 T. Our results are in a good agreement with previous experimental results (a maximum relative error founded of 2.08%). The results of this study will offer the monitoring of the dose deposition with good accuracy in the presence of a magnetic field in carbon ion therapy.

Keywords:

MRI, PET, hadron therapy, dose distribution, MC code

Implementation of IAEA/AFRA Harmonized Quality Control Protocol for Diagnostic Radiology: The Ghana Experience

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Abstract

Quality control tests have been undertaken in selected public and quasi-government diagnostic radiology Centres in the Greater Accra Region of Ghana, with the aim of improving the overall safety and effectiveness of diagnostic radiology service within those departments' while developing the skills of trained medical physicists who have been recently employed. The tests were performed as part of implementation of the new "IAEA/AFRA Harmonized Diagnostic Radiology Quality Control Manual" developed under the Technical Cooperation Regional Project RAF6/053 entitled: "Enhancing Capacity Building of Medical Physicists to Improve Safety and Effectiveness of Medical Imaging". Test were performed on twenty (20) conventional X-ray, seven (7) CT systems and three (3) mammography systems. The tests were undertaken using the Radcal Multimeter and accessories. Tests performed on the systems include beam perpendicularity, output reproducibility, accuracy, beam quality, leakage, timer accuracy and reproducibility, and dose. Generally, results obtained were with tolerance levels for most of the tests performed. A few of the tests could not be performed on some of the imaging systems due to peculiar challenges such as unavailability of screen-film (cassette) systems, lack of some phantoms and tools, etc. The newly developed QC protocol has been found very important towards improving quality of practices in diagnostic radiology centres. It was observed that the test for entrance surface dose was not included in the manual. It is recommended that protocols for Computed Radiology (CR) systems and other newer imaging modalities should be included in the protocol.

Keywords:
QC protocol, IAEA, computed radiology, accuracy, reproducibility

Re-Evaluation of Dosimetric Treatment Plan of Patients Treated with IMRT for Nasopharyngeal Cancers Using CBCT

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Abstract

Anatomical changes in patients during radiotherapy treatment can have a significant dosimetric impact on target volume coverage or protection of organs at risk. Adaptive radiotherapy can adjust for these variations, but its implementation in clinical routine is hampered by a significant additional workload for medical staff. The aim of this study was to re-evaluate the dose received by the patient from the CBCT images. In this study, we started by simulating the changes on several phantoms. Then, to highlight the importance of adaptive radiotherapy, we focused on the dosimetric re-planification results of 25 patients treated using various methods. With CBCT images obtained at least once during the fourth week of treatment using the OBI®, we were able to track the patient's morphological and dosimetric changes. For the first method, it should be remembered that the TPS starts measuring the dose at the outer contour. Because of this, we were able to re-use the planned CTi and only change the external contour and parotid contour that were imported from the CBCTn. Therefore, we have updated the contour of the CTi to provide a CTn. Since there are no significant modifications, the rest of the OARs are unchanged. The second method of calculating dose is based on CBCT, and it consists of assigning density values to the structures after segmenting the image (1 HU to the whole external contour, -800 HU for air cavities, and +800 HU for bones) to create the forced CBCTn (CBCTn, forced). Using Eclipse version 13.7, regarding CTi, CTn, CTn, forced, CBCT, CBCTn and CBCTn, forced planning, we used the same ballistics with the same processing isocenter. We have noticed that the absolute dose, at a point, for the phantom case may increase by 5% once the volume is reduced by 10 mm, although the difference varies from site to site. Regarding the clinical analysis, it was discovered that the D95% of the PTV varied between CTi and CTn for the initial approach by around 5.5% and 5.0%, respectively, between CTi and CBCTn. The decrease in coverage of the PTV leads us to the importance of adaptive radiotherapy. For the comparison of the D95% of the PTV on CBCTn and CBCTn, forced, we found a mean difference of about 1.03%, and for CTi and CTn, forced, we found a mean dose difference of 5.96%. For the right parotid and the oral cavity, the difference in doses between CBCTn and CTn was 3.2% and -0.5%, respectively. The oral cavity was more responsive, with a difference of 1.5% in the second method, while the right parotid gland exhibited a difference of 2.5% between CBCTn and forced CBCTn, forced. We found that the dose to the OARs varied based on the method used. This is especially apparent in regions where the anatomical changes were more pronounced (especially in the neck, where there is fat). The TNM classification and the tumor's localization both affect the deviations that were detected. The electron density uncertainty for a given pixel could be eliminated using the forcing method. However, it presented a challenge for structures like the lymph node volume that could not be acquired with the KV detector. It is therefore concluded that the modified CT (CTn) method gives a good option for performing dosimetry by removing the uncertainties from the HU and the cut-off CBCT images. Although the two approaches were comparable, the first one was quicker and easier.

Keywords:

IGRT, ART, CBCT, CT, nasopharyngeal, Eclipse, TPS, planification.

Comparative Study Between Calculation Algorithms and Validation by Monte Carlo

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Abstract

In radiotherapy, it is essential to have a precise knowledge of the amount of radiation delivered in target volume and the neighbouring critical bodies. To be useable clinically, the models of calculation must take account of the exact characteristics of the beams used and densities of fabrics. Today, we use more efficient calculation algorithms with a more precise distribution of amount of radiation and with a better knowledge of its distribution. A simulation of the head of irradiation of accelerator UNIQUE in photons mode and a dosimetric study of the amount of radiation in a water phantom and in a heterogeneous medium have been conducted. This study was carried out with Monte Carlo GATE simulation code adapted for applications of medical physics; the results are compared with the data those of the TPS ECLIPSE verison 13.6.

Keywords:

Radiotherapy, volume target, accelerating, head of irradiation, dosimetry, ionizing radiation, TPS

Mathematical Models for Diagnostic and Therapeutic Approaches in the Treatment of Tissue Lesions

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Abstract

Advanced numerical modelling has become a crucial approach in many fields. To accelerate the development of diagnostic and therapeutic methods in medical biophotonic, many approaches are developed, generally based on numerical solutions. The most robust numerical method is Monte Carlo. The Monte Carlo method becomes a benchmark to model the radiation and biological tissue interactions. We used a generic tissue that approximates a real one, using the optical properties of the lesions and healthy tissues. The model was constructed in respect of the anatomy of the studied tissue. We constructed a multilayer tissue model with lesions, by varying the optical and spatial parameters. We explored the effect of these parameters and wavelength of non-ionizing light source, in the strategies of the diagnosis or therapy of the lesions. Results are presented and discussed.

Smart Radiation Shielding Designs for Building Versatile Radiotherapy Treatment Facilities

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Abstract

The importance of providing accurate, readily available treatment for cancer patients cannot be described in words, but the warranty of providing a safe environment where these treatments take place is as important and deserve to be constantly kept in mind. The advancement of LINACS technology and thus the delivery techniques and methods often cause the needs for the review of the treatment rooms' shielding. In order to offer a radiation shielding that embrace the dynamics and evolution of treatment options, such as the adjusting to high dose rate-based treatment, whether it is simple radiosurgery using FFF beams or using extreme high dose rates such as in Flash radiotherapy treatment, we developed a modulable – Lego-like high density radiation shielding blocks, Verisheilds, that offers a solution to the above problem and simplifies the physics of the radiation shielding as it provide balanced TVLs for both photons and neutrons simultaneously. In addition, thanks to the modules' high density, the treatment rooms' footprint is reduced, saving project realization time and money. In this communication, we will present the underlying physical properties of the high-density shielding blocks that enable their radiation shielding capabilities and present a typical use case to illustrates the pros and cons of building a radiotherapy cancer centre using the Verishields blocks.

Keywords:

Verishield blocks, radiotherapy, shielding, treatment room, high density, physical properties

Large Scale Clinical Implementation of In-Vivo Dosimetry With SUNCHECK: Results and Discussions

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Abstract

Different types of uncertainties (planning, anatomy changes, patient positioning...) that occur during radiotherapy can have a significant impact on the patient's treatment quality. Fully automated EPID-based systems have proved their efficacy as an in-vivo dosimetry QA tool and a potential base for adaptive planning. Since 2018, our Institution has implemented an automated EPID-based system (PerFRACTIONTM, SunCHECKTM, Sun Nuclear Corporation), for pre-treatment and in-vivo dosimetry (EIVD) measurements. To evaluate the impact of this system, a clinical study was conducted on 3709 patients. A further application to the results of this study was comparing treatment uncertainty for ultra- (5fx) vs conventional (15x) hypofractionated breast radiation. EPID based transit dosimetry images were taken during treatment and compared with the calculated predicted dose images. This study was conducted on 18193 fractions measured from September 2020 to August 2021. The analysis was performed by an automated software* using corresponding templates for each treatment region. Tolerance levels and thresholds were adjusted taking the treatment site into account to maintain an accurate ratio between clinically relevant issues and false positive data. The results of the analysis are then investigated by the physicist to determine the cause of failing. Actions in form of decision trees were introduced in the clinical workflow to classify the failed fractions. Causes of the failed fractions were categorized into groups: technical problems (43%), patient anatomical variation (33%) and setup errors (23%) (Figure 1). Actions for failed fractions mainly consisted of performing extra imaging and repeating the measurements. The comparison of the breast standard and ultra-fractionation using daily online IGRT showed more failed fractions 12% vs 3.8% respectively. The causes can be classified into positioning errors (7.4%), technical issues (3.1%) and breast swelling (1.4%) for 15 fractions group vs 2.2%, 1.2% and 0.5% respectively for the 5 fractions group, proving that daily online IGRT can reduce treatment errors. EIVD and the analysis of the failed fractions gives an overview on the potential causes of treatment errors. However, as tolerance levels will vary with new techniques and experience, revision will be required on regular intervals for a correct identification of failed fractions. A further optimization of the workflow would be to use Machine Learning models as a classifier between technical issues (beam interruption, imager calibration, machine related problems...) from patient related issues such as positioning or anatomical changes that might have relevant clinical implications.

Keywords:
Anatomical changes, optimization, automated software, breast, measurement

On the First Experience of Automatic Assistant Contouring Using MIM Maestro in Morocco: Possibilities and Challenges

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Abstract

Automatic contouring of tumours and organs at risks (OARs) using advanced Atlas and Artificial Intelligence is becoming mainstream in radiotherapy practice. Several radiotherapy software technologies such are leading the way in this rapidly changing field. A premier pilot experience consisting of deploying the MIM Maestro for automatic contouring is on the way at the radiotherapy cancer centre in the Regional Hospital in Agadir – Morocco. In this communication, we will report on the phasing out of the manual contouring on the XIO platform and the rolling out of the MIM Maestro platform for automatic contouring using both atlas and Artificial Intelligence. Several clinical cases, namely, head and neck and thoracic malignancies are presented and discussed. A detailed comparison of the workflow efficiency and production time cost function comparing our previous platform (XIO) and our new platform MIM-Maestro.

Keywords:

Tumour, OAR, artificial intelligence, cost function, MIM

A Novel Curricular Model for Medical Physics and Radiation Protection Education – An Alternative Possible Way Forward for Africa?

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Abstract

In Malta the Medical Physics and Radiation Protection professions have faced an acute shortage of entrants to the professions owing to the low popularity of two-year Master's programmes and the irregular number of physics/engineering graduates. A formula needed to be found to: (a) address the paradox of having to reduce the masters programme to one year at a time when the knowledge-skills-competences required for modern medical physics and radiation protection practice are expanding rapidly (b) ensure that the potential stock of entrants to the profession would be independent of erratic student numbers in other departments and faculties. We also wanted to address what we believe are shortcomings of the present model of medical physics education particularly the low level of medical science and lack of early hospital experience (given that Medical Physics is a healthcare profession). The programme also needed to be cost-effective and very importantly attractive to the young people of today. An extensive literature review and survey of Medical Physics undergraduate and Master's programmes was carried out. Best practices were identified and used as inputs to the model. We have opted for an undergraduate inter-faculty programme that combined physics, medical sciences, medical physics, radiation protection and hospital experience. This ensured that the resulting degree would satisfy the undergraduate requirements for Medical Physicists and Radiation Protection Experts as stipulated by the European Guidelines on the Medical Physics Expert, EFOMP and IAEA guidelines for Medical Physics and the ENETRAP, IRPA and HERCA guidelines for Radiation Protection Experts. The resulting four-year programme consists of 5 parallel strands namely physics/ mathematics/ statistics, medical-sciences, medical-physics, radiation-protection, research and hospital placements. Those opting for a Medical Physics career can then follow with a Masters in Medical Physics. Because of the solid undergraduate background, we can now make the MSc Medical Physics more comprehensive and including all traditional specialties of Medical Physics plus machine learning, pattern recognition, advanced signal and image processing and physiological measurement. This innovative curricular experiment has been a great success and has attracted many students. The inter-faculty nature of the programme (where students share lectures with both physics students from the Faculty of Science and healthcare students of the Faculty of Health Sciences) together with the element of clinical practice have been found to be the most appealing features. We recommend the model to African countries.

Keywords:

Medical physics, curriculum, radiation protection, IAEA

Comparison of Stereotactic Plans Performed on Precision and Eclipse Treatment Planning Systems for Craniopharyngiomas

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Abstract

Dose escalation or hypofractionation requires a high quality planning and patient setup. The objective of this study was to compare two planning methods for the management of craniopharyngiomas in stereotactic condition. A multi centric study (Saint Quentin Hospital Center and Amiens University Hospital) was conducted to compare the planification performed on the TPS Précision® and the TPS Eclipse®.

Keywords:

Hypofractionation, quality planning, patient setup, craniopharyngiomas

Implementation of AlignRT in Tomotherapy Breast Treatments

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Abstract

The implementation of the Surface Guided Radiation Therapy (SGRT) system in Tomotherapy for the breast treatments aims to improve the patient's setup and reducing MVCT frequency and/or length. The primary objective of this study is to quantify MVCT shifts for two setup methods: Tattoos based setups and AlignRT ® (Vision RT Ltd., UK) based setups.

Keywords:

Surface, radiation therapy, MVCT, SGRT, tattoos

Choice of Reference Isodose for SRS Treatments on a Novalis Machine Using Dynamic and Conformal Arcs

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Abstract

For stereotactic treatments, the normalization method has an impact on the Dosimetry quality. This method should be defined according to the machine, energy and the used collimator. Several studies were carried out regarding Cyberknife and Gammaknife treatments for whom the recommended reference isodoses are 80% for the CK and 50% for the GK. Fewer similar studies were carried out for conventional accelerators, hence our interest for this topic. The aim of this study is to define the most suitable normalization method for intracranial stereotactic using a Varian/Novalis machine with Dynamic Conformal Arcs (DCA) and a 120HD MLC for a 6XSRS energy. The selected normalization isodose should allow the increase of tumour control while decreasing the probability of radionecrosis.

Keywords:

Conformal, cyberknife, gammaknife, dosimetry, arcs

Robustness Comparison Between Two Extended Fluence Methods for Breast Cancer VMAT Treatments

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Abstract

One of the challenges in breast cancer treatments using VMAT is to account for breathing movement and morphology changes during treatment. In order to do so, one should extend the fluence beyond the body. The aim of this study is to assess the robustness of a VMAT breast treatment without extended fluence and to compare the robustness of two extended fluency methods. This robustness is assessed by applying a positioning error of 5 mm to the treatment isocenter in the three directions, x, y (antpost, right left) and z. The DVH is then analyzed for those two methods after the error is applied.

Keywords:

VMAT, morphology, fluence, isocentre, cancer treatment

Dosimetric Comparison of VMAT, SWIMRT and DCA in Intracranial Stereotactic Radiotherapy

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Abstract

Intracranial stereotactic for the brain metastases can be performed using a standard linear accelerator. There are different options for planning and the delivery of intracranial stereotactic treatment. The VMAT technique, newly introduced, is the reference technique used at the Salah Azaïez Institute (ISA). The objective of the study is to compare the dosimetric parameters of brain metastases managed by VMAT with those obtained by intensity modulation Sliding Windows (SW IMRT) and the dynamic conformal arcs (DCA). Eighteen patients were enrolled in this study. The average prescribed dose was 26.96 Gy (range, 23.1-30 Gy) in 3 to 5 fractions. For each patient, three plans were created. The VMAT plans and the SW IMRT plans were optimized and calculated in Eclipse v. 13.7 (Varian, Palo Alto, CA) using a 6 MV X-ray. An AXB algorithm (v. 13.7) was used with a 1 mm grid resolution and an optimization done with the PO algorithm (v. 13.7). The plan realized by the DCA was made by 3-5 non-coplanar arcs. The SW IMRT plan with non-coplanar multi-fields (9-13 non-coplanar beams) was generated for the same plan with the same dose prescription. The dosimetric analysis for the coverage of the planning target volume (PTV) including the parameters and the indexes recommended by the IRCU 91 such the Conformity Index (CI) and the Gradient Index (GI). The healthy brain constraints were reported, as a function of the number of fractions, according to the QUANTEC recommendations. A comparison of the number of Monitor Units (MU) was also performed. The mean volume of the planning target volume was 17.75 cm^3 (range 3.9-32.33 cm^3). The PTV coverage generated by the three techniques met the dosimetric criteria. The mean of the relative Minimum Dose was 95.42% for VMAT, 90.063% (range: 82.35-93.98%) for the DCA plan and 95.248% (range: 89.76-101.5%) for the SW IMRT plan. The mean of the relative Maximum Dose was 118.45% (range: 117.9-123.14%), 130.11% (range: 126.9- 135.16%) and 119.62% (range: 110.22-136.7%) for VMAT, DCA and SW IMRT plans respectively. The CI was 1.27 for VMAT, 1.31 (range 1.18-1.43) for DCA and 1.4 (range 1.28-1.59) for IMRT. The GI was 0.63 (range: 0.5-0.73) for DCA versus 0.73 (0.6-0.78) for VMAT and 0.87 (range: 0.62-1) for SW IMRT ($p<0.001$). For patients treated with the 3-fractions, the V21 Gy of the healthy brain was met (<20.9 cm^3) with an average of 9.006 cm^3 (range: 2.086-15.456 cm^3) and 12.431 cm^3 (range: 1.857-19.8 cm^3) for the DCA and SW IMRT plans respectively. The V24 Gy of the healthy brain was also respected (< 16.8 cm^3) with an average of 5.335 cm^3 (range: 0.649-10.19 cm^3) and 6.972 cm^3 (range: 0.338-13.5 cm^3) and 5.887 cm^3 respectively for the DCA and the VMAT and SW IMRT plans. The number of MU was lower for the conformal dynamic arc technique with a mean of 1187 (range: 948-1484) compared to 1824 (range: 1449-2418) and 2220 (range: 16885-2875) for VMAT and SWIMRT. The homogeneity was similar between these three treatment techniques

The reduction in treatment time by VMAT will allow a rapid delivery of the dose and thus potentially limit the intra-fractional movement. The dynamic conformal arcs (DCA) planning does not differ from VMAT or Sliding Windows IMRT in terms of target coverage and preservation of the OAR, and it have the plan resulted have a better gradient with a significantly lower total number of MUs which may have a clinical impact.

Keywords: VMAT, SWIMRT, DCA, intracranial stereotactic, dynamic conformal

Usefulness of Locally Constructed Phantoms for the Validation of Planned Radiation for Breast Cancer Radiotherapy Treatment

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Abstract

GLOBOCAN estimates, indicate that 4482 new cases were diagnosed, and 2055 death occurred due to breast cancer in Ghana in 2021; making it the commonest female cancer and a major public health challenge. To ensure the facilities in Ghana implement quality control measures, this study was designed to determine and compare planned with actual doses delivered to the breast during treatment. To achieve this, the major limitation of the non-availability of phantoms was addressed by the construction of phantoms, using perspex and locally available materials that mimic organs of the female thoracic cavity. Based on scanned images, two phantoms were constructed. Balloons, mango seed, cassava stick, and candle were radiologically assessed and used as surrogates for the lung, heart, spinal cord and glandular tissue of the breast respectively. Higher photon energies from a ^{60}Co and LINAC machine were targeted at the left breast of a standard and the two constructed phantoms. EBT3 film dosimeter was used to measure absorbed doses to the breast and non-target organs. The deviations of delivered doses from planned doses when the standard anthropomorphic phantom, constructed phantoms A and B were used, ranged as follows, -0.05 – 0.03 Gy; -0.08 – 0.01 Gy; -0.14 – 0.01 Gy respectively, when the radiation was delivered by a Cobolt-60 machine. When the radiation was delivered by a linear accelerator system, the deviations were -0.05 – 0.03 Gy; -006 – 0.07 Gy; -0.06 – 0.04 Gy respectively. The left lung and spinal cord received the highest and lowest unintended dose, 0.74±0.04 Gy (Co-60) and 0.78±0.01 Gy (LINAC), and 0.03±0.02 Gy and 0.05±0.01 Gy respectively. The study has demonstrated that local materials are potentially useful for the construction of phantoms, which can be good substitutes for standard commercial phantoms in ensuring the safety of patients under-going radiotherapy treatment for breast cancer.

Keywords:
Phantom, cobolt-60, LINAC, breast, glandular tissue

Elaboration of a Clinical-Economic Guide by Comparison of Three HDR Brachytherapy Technologies

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Abstract

This study was set up to establish a Clinical-Economic Guide of HDR brachytherapy Technologies with radionuclide and electronic sources. This guide is intended to help radiotherapy professionals to make educated choice about the appropriate brachytherapy device for their practices. We studied three HDR brachytherapy devices, two of which use radionuclide sources (^{60}Co and ^{192}Ir) and the third uses an electronic source (Axxcent-Xoft e-HDR system). We elaborated to a technical matrix comparing the different technologies with respect to their clinical use and their technical maintenance requirements as well as their financial cost. We also conducted a field survey of various clinics to cross-check our comparative matrix with respects to the actual use of these technologies within the Moroccan radiotherapy clinics. An economic study targeting the capital cost of these various HDR technologies based has also been conducted. Based on the above, we developed a calculator to evaluate the effectiveness of cost versus clinical use of these tree technologies. In Conclusion, the results show that electronic brachytherapy (Axxent Xoft) has superior effectiveness cost function. It proves more advantageous because clinically it provides low dose to organs at risk, offers additional treatment options (IORT, APBI...) and reduces radiation hazard to personnel, no radiation leakage. Economically it requires no radiation bunker, requires no periodic source maintenance and produces no radioactive waste while it provides stable treatment time (no decay).

Keywords:

HDR Brachytherapy, Co-60, Ir-192, Axxent Xoft, System-Calculator, Clinical-Economic Guide.

Determination of the TG-43 Parameters of the Oncoseed 6711 I-125 Seed

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Abstract

The American Association of Physicists in Medicine formed Task Group 43 in 1988 to review the dosimetry of interstitial brachytherapy sources and recommend a dosimetry protocol. The protocol is based on measured or measurable quantities. These include the anisotropy function, the dose rate constant, the geometry factor, the radial dose function, and the air kerma strength. The OncoSeed 6711 seed contains iodine-125 that is adsorbed on a silver rod, which is encapsulated in a titanium capsule. The aim of this study was to accurately determine the various dosimetric and physical characteristics of a single I-125 seed. The geometry function was determined by measuring seed dimensions with a vernier caliper. Dosimetric measurements were done in two specially designed solid water phantoms using calibrated thermoluminescent dosimeters (TLDs). The TLDs were supplied as 3x3x0.9 mm chips. These measurements, in conjunction with the obtained geometry function, were used to determine the radial dose function and anisotropy. The measured dose rate at the reference point was divided by the manufacturer supplied air kerma strength to obtain the dose rate constant, taking into account the radioactive decay of the seed during the measurement. Air kerma strength / apparent activity was verified with a calibrated Sourcecheck 4π chamber. The geometry function matched nominal seed data within 1% at 5mm and better at larger distances. The ratio of measured apparent activity vs manufacturer stated activity was 0.999±0.031 over seven batches of seeds. The calculated dose rate constant was 0.96±0.20 cGy/h/U. The measured anisotropy and radial dose function were well within one standard deviation from published data. TG-43 seed parameters were obtained for the OncoSeed 6711 I-125 seed. The solid water phantoms can now be used to determine these parameters for other commercially available seeds.

Keywords:

Kerma strength, geometry function, interstitial brachytherapy, anisotropy function

Assessment of PTV Margin Before and After the Treatment Using CBCT on Halcyon LINAC

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Abstract

In this work we evaluated planning target volume (PTV) before and after treatment for breast Cancer using CBCT imaging modality and VMAT technique. Set-up and random errors were calculated for 10 patients presented for breast cancer treatment with VMAT technique. CBCT images were carried out for each patient before and after treatment to evaluate intrafraction motion. CTV was contoured by radiation oncologist according to our clinical protocol for breast cancer Van Herk formula (PTV margin = $2.5\sum+0.7\sigma$). With respect to systematic error along the lateral axis, longitudinal and vertical was 0.22, 0.24 and 0.4 respectively before treatment and 0.01, 0.01 and 0.4 respectively after treatment. The Random error was 0.52, 0.52 and 0.31 along lateral axis, longitudinal and anterior-posterior respectively before treatment and 0.07, 0.18 and 0.07 respectively after treatment. The calculated safety margin to cover clinical target volume (CTV) taking the breast variability into account measured 1.26, 0.98 and 0.34 cm for lateral, longitudinal and anterior posterior respectively before treatment and 0.09, 0.25 and 0.16 respectively after treatment. The calculated safety margin smaller than 1 cm for all direction except in the lateral direction that was 1.26 cm before the treatment. The PTV margin after treatment was not the same as expected.

Keyword:
Margin, CBCT, Van Herk formula, cancer,

Application of the IAEA Staffing Model in Diagnostic Radiology and Nuclear Medicine in Africa

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Abstract

Within the framework of the regional project RAF6/053 a survey was done based on a staffing model developed by the International Atomic Energy Agency (IAEA). This model takes into account the number and complexity of equipment, patient numbers, radiation protection and safety related activities, service-related activities, clinical training of medical physicists, as well as time dedicated to teaching, training and research, to estimate the number of medical physicists required in diagnostic and interventional radiology, as well as nuclear medicine. This was done to investigate the adequacy of current medical physics staffing levels across Africa. Results of the survey were published open access in "Health and Technology". However, they will also be presented at the first FAMPO conference. A survey based on the IAEA staffing model was conducted for five months. This was followed by data verification and evaluation. 82 responses were received from 21 countries, including data from 97 diagnostic radiology and 40 nuclear medicine departments, as well as 75 interventional radiology departments and/or catheterization laboratories. Only 26.8% of surveyed centres employed an adequate number of medical physicists. 63 imaging medical physicists were employed at the surveyed centres, but 134.3 were required according to the algorithm. Data analysis indicated that the number of imaging medical physicists is largely inadequate, at least by a factor of 20 in almost all countries in Africa. This was the first study to investigate the use of the IAEA staffing survey across a whole region. Results indicate that the number of medical physicists in Africa is insufficient and needs urgent addressing.

Keywords:
Medical physicist, radiology, nuclear medicine, staffing model, survey

Performance of Different Strength Aperture Shape Controller in Optimization with VMAT Technique for Head and Neck, Pelvic and Breast Cancer Using Halcyon Machine.

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Abstract

Before starting optimization for VMAT technique, the choice of the convenient strength aperture shape controller can be one of the most important factor that affect the plan quality. It is necessary to evaluate different optimization options for different localizations. Three different clinical cases including head and Neck, Pelvic (Prostate, Cervix and Endometrium) and Breast Cancer treated using VMAT technique were chosen. Treatment plans were generated with Eclipse TM treatment planning software (v16.1.0) using a 6X flattening filter free energy and 600 MU/min dose rate. By keeping the same conditions, plans were re-optimized by varying aperture shape controller (OFF, VERYLOW, LOW, MODERATE, HIGH, VERY HIGH). For plan evaluation, homogeneity index, conformity index, target coverage, dose maximum and near maximum and the treatment time delivery (HI, CI, D98%, DMAX, D2%, MUs and gamma index passing rate) were analyzed. Dose coverage for pelvic was very close, between 96.5% and 97% for D98% and for V98% was between 95% and 96% for all optimization techniques, except in VERY HIGH that was under 95%. The best results for maximum and near maximum dose obtained in VERY LOW with 106.5% and 103.75% respectively. For Breast treatment, DMAX was between 110% and 110.5% for all techniques, and between 106% and 106.5% for D2% always with 0.5% lower in VERY LOW optimization technique. An improvement of 5% to 6% in dose coverage for in Head and Neck treatment is obtained by HIGH and VERY HIGH optimization techniques, and only 106% maximum dose is achieved as the best value for HIGH optimization technique. The best results in MUs calculation achieved by OFF optimization technique for Pelvic and Breast, for Head and Neck it was by VERY HIGH optimization technique. Changing the strength aperture shape controller before starting optimization for VMAT technique can significantly affect the plan quality.

Keywords:
VMAT, optimization, MU calculation, pelvic, gamma index,strength aperture

MIRD Human Phantom External Exposure Scenarios to Ionizing Radiation: Modelling with Geant4

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Abstract

From radiation protection perspectives, the availability of a database collecting dose factors for different types of exposure to radioactive sources is fundamental for the prediction and prevention against the harmful effects of ionizing radiation. In this context, the use of Monte Carlo codes in general and Geant4 in particular, whose basic principle is based on the random choice of the interaction of radiation with matter, seems at first sight, inconsistent with the rigor and precision required for during metrology measurements. Nevertheless, the considerable benefits that they are supposed to bring, in particular the very comprehensive consideration of the elementary physical phenomena involved in each interaction and the possibility of a very precise description of the geometry and chemical composition of the detector or dosimeter in its real environment, allow us to expect a precise and targeted determination of the physical quantities required, in particularly those items that are inaccessible to the experiment. In this study, we introduce a scenario of external exposure to ionizing radiation simulated by Geant4 (Monte Carlo code C++ developed at CERN in the form of a data library and tools that the user can assemble according to his specific needs), where a person (MIRD human phantom provided by Geant4 toolkit) will be exposed to different configurations of radioactive sources that may actually occur as mentioned in reference. The objective is to evaluate the absorbed dose as well as the equivalent dose of each configuration adopted in this scenario.

Keywords:
Absorbed dose, Equivalent dose, Geant4 code, Radiation protection.

Calculation of Bremsstrahlung and Photoneutron Spectra from Tungsten and Gold Targets using EGSnrc, GATE/GEANT4 and MCNP6 Monte Carlo Codes

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Abstract

High-energy photon beams produced by linear accelerators are widely used in radiation therapy. These photon beams, called Bremsstrahlung radiation, are the result of bombarding a thick target by high-energy electrons. In this study, the spectral distribution of Bremsstrahlung from tick targets of tungsten and gold was calculated using EGSnrc, GATE/GEANT4 and MNCP6 Monte Carlo simulation codes. The influence of target thickness and incident electron energy was investigated. The photoneutron spectra, generated in the target by photonuclear reactions, have also been evaluated for different incident electron energies as well as different thicknesses for both targets with GATE/GEANT4 and MNCP6 Monte Carlo codes. All calculations have been performed at the isocentre in a standard 10×10 cm^2 field with a statistical uncertainty less than 2%. The simulation results, generally, show a good agreement between different simulation codes.

Keywords:

Target, Bremsstrahlung, Photoneutron, EGSnrc, GATE/GEANT4, MCNP6

Dosimetric Analysis of Three Volumetric Modulated Arc Therapy Plans for Prostate Cancer

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Abstract

This study sets out to determine the dosimetric difference between three plans of Volumetric Modulated Arc Therapy (VMAT) by evaluating the dosimetric influence of increasing the number of arcs and using different collimator angles for prostate cancer. We studied thirteen patients with prostate cancer, who received 76 Gy in 38 fractions in our centre between 2017 and 2022. They were treated by VMAT technique with two, three or four Arcs. The photon beams were delivered by Varian UNIQUE™ linear accelerator. The treatment parameters are set as: two full arcs with collimator rotation (20° and 340°), three full arcs with collimator in (20°, 340° and 15°) and four full arcs with collimator rotated in (0°- 90°), using an Eclipse treatment planning system. Different indexes were calculated as homogeneity index HI and conformity index CI to compare and analyze the difference between the three VMAT plans. Results show that the three plans were clinically acceptable, but there were significant differences in the Monitor Units (Mus) obtained. In fact, plans of 2 and 3 arcs reduced the monitor units from 809 to 494. The p value of D95% and D50% were < 0.05 in 4 arcs versus 3 and 2 arcs, indeed 4 arcs conducted to ameliorated PTV parameters. The 4 arcs plan resulted also in decreasing V60% of bladder and rectum.

Key words:
Prostate cancer, radiotherapy, VMAT, HI, CI, p value.

Assessment of Entrance Skin Dose for Adult Patients Undergoing Diagnostic X-Ray Examinations in the Souss Massa Region of Morocco

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Abstract

The entrance skin dose (ESD) is one of the basic quantities for measuring the patient dose and as well for optimizing the patient dose in conventional radiography. It is recommended as an additional diagnostic reference levels quantity. The objective of this study was to evaluate the entrance skin doses for adult patients undergoing diagnostic X-ray Examinations in the Souss Massa Region of Morocco. Data from 720 adult patients in four radiology departments in the Souss Massa region were collected (The regional hospital of Agadir, the provincial hospitals of Inzegane, Chtouka Ait Baha and Taroudant). The data concerned the following examinations: Thorax posterior anterior (PA), unprepared abdominal x-ray, pelvis, hip, cervical spine anterior-posterior (AP) and lateral (Lat), lumbar spine anterior-posterior (AP) and lateral (Lat). The following parameters were reported for each examination: Age, weight, patient thickness, voltage (kV), electrical charge (mAs), and the skin source distance. The Entrance Skin Dose (ESD) and the Diagnostic Reference Levels (DRL) are calculated for each X-ray examination. DRLs in terms of ESD for the same x-ray examination differ widely from one hospital to another. They ranged from 3 to 14 mGy for the unprepared abdominal x-ray, from 2.6 to 9.4 mGy for the pelvis, from 3.1 to 17 mGy for the hip, from 1 to 49.2 mGy for the cervical spine Lat, from 2 to 32.6 mGy for the lumbar spine AP, and from 18.1 to 50 mGy for the lumbar spine Lat. The variation of doses received by patients in the four hospitals calls into question radiological procedures and practices and calls for a standardization of guidelines for each radiological examination.

Keywords:
Entrance skin dose (ESD), diagnostic reference levels (DRLs), X-ray Examinations, radiation doses.

Cross-Sectional Survey of Physicians' Knowledge about the Computer Tomography Radiation Risk in Morocco

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Abstract

The aim of this study was to evaluate the Moroccan Physicians' knowledge about the doses received by patients, and to estimate the eventual risk from exposure to ionizing radiation during computed tomography (CT) procedures. This is a cross-sectional study. A questionnaire with 27 multiple-choice questions was addressed to CT prescribers such as general practitioners, residents, specialists and radiation therapists. The first eight questions asked about the demographics of the participants, and the remaining questions explored their knowledge of ionizing radiation, patient dose, relative risk, and radiation protection of patients training. Data analysis was performed using Excel 2010 software. Statistical tests were calculated by the Statistical Package for the Social Sciences (SPSS version 07.0). A total of 223 physicians participated in this survey were analyzed. Radiation therapists, considered as the reference group, had a better knowledge of ionizing radiation and non-ionizing radiation from medical imaging compared to the other groups ($p=0.00330$). 67% of the reference group declared to take into account the number of scans performed by the patient during the last year, unlike the other groups ($p=0.001998$). Furthermore, the knowledge of the different groups on the risk from exposure to ionizing radiation was globally low (2%) with a p-value of 0.73. Regardless of their specialties and seniority, only 12% of the participants informed the patient at the time of prescription about the risk of ionizing radiation. Finally, only 21% of the participants declared having had training in radiation protection, with no significant differences between the subgroups ($p=0.832$). The results obtained are similar to those reported by previous studies. They showed that Moroccan prescribers have a low level of knowledge about the risks associated ionizing radiation exposure from CT. Training on patient radiation protection should be included in the initial curriculum of interns, and the continuing professional development of physicians should be reinforced.

Keywords:
CT scan; ionizing radiation exposure; patients’ radiation protection; X-ray risk.

Comparison of Photon Beam Absolute Dose Calibration Protocols in External Radiotherapy: A Local Study of IAEA TRS 398, AAPM TG 51 and DIN 6800-2

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Abstract

The present work reports comparisons of procedures and results in absorbed dose determination according to the IAEA TRS-398 protocol, the American AAPM TG-51 protocol, and the German DIN6800-2 protocol for photon energies of 6 MV and 18 MV. The absorbed dose to water measurements under reference conditions according to TG-51 and DIN6800-2 are very close to those of IAEA TRS-398. The difference in absorbed dose to water between TRS-398 and TG-51 was 0.65% and 0.76% for 6 MV and 18 MV photons, respectively. Thus, the differences between TRS-398 and DIN6800-2 were 0.36% and 0.64% for 6 MV and 18 MV photons, respectively. We then concluded that the TRS-398 protocol is the most advantageous because it contains procedures more suitable for our hospital environment.

Keywords:

Absorbed dose, photon, reference condition, measurement

Evaluation of Set-Up Errors Observed on Daily Image Guidance during SRS and Lung SBRT Treatment

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Abstract

Small malignant tumours can now be treated non-invasively with high doses of radiation using stereotactic radiotherapy (SRT). It is based on the convergence of small photon beams obtained by collimation. Several modalities exist and differ according to the location of the tumour (intracranial or extracranial), the fractionation (unfractionated SRT or radiosurgery and hypo-fractionated SRT), and the type of radiotherapy machine. The success of this therapy is hampered by the many sources of error and geometric inaccuracy that can potentially deviate the delivered dose from the planned one. The aim of our study is to report our experience with the use of stereotactic radiosurgery (SRS) and stereotactic body radiation therapy (SBRT) to treat lung cancer. For this study, 21 patients with DCA plans and 2 IMRT plans (16 SRS and SBRT lung patients) treated in our clinic were selected. For SRS localization, patients were positioned using BrainLab masks, and for the SBRT group, Orfit immobilization sets were used. These patients' treatment positions were manually restored in the kV-CBCTs using the associated planned CTs to align bone with bone and tumour with tumour. A CBCT or KV is performed for each patient during the session to confirm the intrafraction displacement. The difference between the treatment table value (reference) from the initial session and the next session is determined as the deviation. Plans were produced using 5 arcs for 68% of SRS patients and 14% of SBRT patients. 21% of SRS patients and 14% of SBRT patients selected three arcs. Plans were created using two arcs for 11% of SRS patients and 29% of SBRT patients. The only two SBRT patients who receive IMRT receive a ballistic of 7 fields for 14% of them, and 9 fields for 29% of them. Throughout the course of the study, all patients had a total of 153 CBCTs and 425 KV images acquired. Our patients receive an average of 4 KV and 2 CBCT per session. For SRS patients, the mean values and standard deviations of the setup errors in the vertical, longitudinal, and lateral directions were, respectively, -0.1±1.3 mm, 0.2±1.5 mm, and -0.6±1.5 mm. The results for the SBRT group in the vertical, longitudinal, and lateral directions were -0.2±1.5 mm, 2±11 mm, and -2.3±5.2 mm. Between imaging, setup, and treatment, it takes an average of 35 minutes. Some sessions could last an hour, with the imaging and adjustments taking up most of the time. For SBRT localization, the repeatability of the immobilization sets position on the sofa is insufficient. The main challenge is figuring out how to move the patient underneath. the high value of the table shifts for the SBRT instance is explained by this. Reduced imaging time before to radiation treatment is possible with the use of markers and indications.

Keywords:

CBCT, KV, uncertainties; Radiotherapy; SRS, SBRT

3-D Printed Modified S-Tube for Treatment of Cervical Cancer with High Dose Rate Brachytherapy (HDR-BT)

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Abstract

The indwelling intrauterine tube (IIUT) was first designed at Tygerberg hospital in 1990 and named the S-Tube, in honour of its designer Prof Ben Smit, then head of oncology. Since then it has been successfully used in our hospital, allowing easy and safe administration of multiple fractions of HDR-BT, while eliminating the need for anaesthetics doses with each fraction. Recently new ring applicators were purchased, together with vendor-specific S-Tubes. The oncologists found these S-Tubes to be too flexible and frequently slipping out of position. Unfortunately, stitching the S-Tubes in place is often not possible because of the extent of the disease. The existing S-Tubes could not house the new ring applicators, which needed a larger diameter tube. The division recently obtained a Creality 3-D printer. The original S-Tubes were drawn as computer-aided design drawings and converted into a recognizable printer format. The diameter was increased from 3 to 4 mm in the design. After experimenting with different materials, it was decided to use Polyethylene Terephthalate Glycol (PETG), a non-toxic thermoplastic printer filament, as printing material. This material provided a good compromise between rigidity and brittleness and had good visibility on the patient CT scans following insertion. Six small pillars were added to the outside surface of the S-Tube to provide a ribbed surface and thus an improved grip in the patient. During the design process it was established that the IU tube of the ring applicator had a 6 mm offset at tip of the applicator, meaning the first source position starts lower than the tip of the IU applicator. Therefore, the S-Tube design was changed to incorporate this offset. The S-Tubes were placed in a Hibataine solution for 3 days to determine the durability as part of the quality control process. The new universal printed S-Tubes were named T-Tubes, to keep the honour at Tygerberg hospital. The new design T-Tube accommodates both the straight applicator that is commonly used for 2D brachytherapy treatments at Tygerberg hospital, as well as the IU applicator of the ring applicator sets. Our oncologists are pleased with the new design and the new T-Tubes are clearly visible on the patients' CT data sets. The T-Tubes have been used on three patients to date, without slipping out of position or any other side-effects. The 3-D printed T-Tubes are manufactured on-site and on demand, this is ideal in a low-resource setting. The ribbed surface helps to keep the tube in position during all five treatment fractions. The design of the T-Tube has undergone a number of iterations to get to the existing model. The design is easily adaptable should this become necessary in the future.

Keywords:

Brachytherapy, Cervical cancer, Treatment Planning, S-Tube.

Published Diagnostic Reference Level Data from South Africa until 2021

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Abstract

Diagnostic reference levels (DRLs) are accepted as a dose optimisation tool in X-ray imaging and are required by South African legislation for 26 fluoroscopically guided procedures. The aim of this project was to collect all published DRL data from the country until 2021. This data was already published in the Journal of Radiological Protection, but will be presented at the FAMPO congress. Systematic searches were conducted of applicable databases and all research that proposed a DRL for any imaging procedure was included. Twenty-one works met inclusion criteria, dating back to 2001. These included 11 full-length publications, seven published conference abstracts and three theses. Two-thirds of all work reported DRLs for fluoroscopically guided procedures, providing DRLs for 39 adult investigations. Five studies proposed DRLs for computed tomography. Three studies proposed DRLs for paediatric procedures; no data on mammography or dental radiography was found. Data was collected in six public hospitals and two private hospital groups. Thirty-six authors contributed to the various publications. The data suggests that there is much room for increased interdisciplinary work. There should also be more rigorous standardization of reported parameters, as well as more cogent descriptions of the procedures.

Keywords:
DRL, x-ray imaging, optimization, paediatric procedure

Radiation Oncology in the Land of the Pyramids: How Sudan Continues to Push the Frontiers of Cancer Care in Eastern Africa

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Abstract

When faced with illness, Sudanese patients have traditionally relied primarily on folklore healers. In the recent past, Sudan increased its health care spending and placed ever-greater importance on medical education. Although traditional remedies still play an important role, Sudanese patients increasingly consult conventional medicine. Not only infectious diseases but also a rising burden of non-communicable conditions, including cancer, represent major health care challenges. Therefore, Sudan will need to make the best out of the limited resources available and further increase investment in health care to confront these trends successfully. Sudan was one of the first African countries to recognize the importance of radiation oncology in multidisciplinary cancer care and began investing in it in the 1960s. Today, there are 4 comprehensive cancer centres in the country, which offer radiation therapy and employ 10 radiation therapy machines for a population of about 45 million people. This proportion is an indication that Sudan still has an underfunded health care system with a lack of infrastructure and human resources. The present manuscript intends to provide a well-rounded overview of radiation oncology in Sudan today. This abstract has previously been published in Elsevier and also presented in FAMPO conference.

Keywords:
Cancer, Sudan, radiation therapy, oncology, conventional medicine

National Diagnostic Reference Levels for Paediatric Computed Tomography of the Head in Cameroon

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Abstract

The aim of this work is to present the National Diagnostic Reference Level (NDRL) values for paediatric Computed Tomography (CT) Departments located in this developing country, Cameroon. For this purpose, data have been collected and analyzed, only from head CT examinations to optimize medical practice. The data have been analyzed by age groups ≤1-, 1–5-, 5–10- and 10–15-y-old in order to compare to those described on previous national researches from Portuguese, Iran, Switzerland, Morocco, South Africa, Thailand and some published researches. Volume CT Dose Indexes (CTDIvol) and Dose Length Product (DLP) were recorded and their 75th percentile were calculated and set as NDRL. The results showed that NDRLs using CTDIvol are 34.2, 36.6, 39.5 and 49.6 mGy and 710.1, 838.4, 964 and 1177.2 mGy.cm for DLP respectively. DLP values were superior than other national and international studies. DRL can be defined locally and nationally in a country to check absorbed dose from patients. This national research reports helpful data for optimization paediatric CT scan.

Keywords:
Reference level, CTDI, DLP, CT, paediatric

Monte Carlo Simulation Study using Gate Code on Dose Enhancement by Gold Nanoparticles in Brachytherapy

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Abstract

Brachytherapy is a cancer treatment technique that uses radiation to kill cancer cells and prevent them from spreading. It can be used as a monotherapy. The main goal of radiotherapy is to focus adequate radiation doses on tumours while protecting healthy tissue. However, to reduce the absorbed dose and better protect the tissues surrounding the tumour, gold nanoparticles (GNP) are injected into the tumour to increase the probability of the absorbing photon emitted from a brachytherapy source. This study was aimed to estimate dose increase during brachytherapy in different GNP-loaded tissues, dose rate constant, and dose-improving factors for GNPs with a 7 mg/ml concentration of iodine source -125 by Monte Carlo GATE V8.2 simulations. All results show that nanoparticles use, such as GNP, could be beneficial in topical therapy due to their dose-enhancing efficacy in cancer cells. GATE V8.2 code can also be used as a fit tool for measuring the dose in nanoparticles presence accurately and obtained results have been validated by comparing them with reference data.

Keywords:

Brachytherapy. GATEv8.2, Nanoparticles, Dosage rate, Monte Carlo.

Monte Carlo Simulation of Novalis-Tx Linear Accelerator using GATE/Geant4 Code for Dosimetry Analysis

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Abstract

External radiotherapy is among the modalities for cancer treatment, which uses intense radiation in the form of a prescribed dose emitted by a medical linear accelerator in order to sterilize the tumour while sparing nearby organs that are not at risk. Simulation by the Monte Carlo method is an important technique for studying the physical process of radiation-matter interaction and is widely used in radiotherapy for dose calculation, which achieves realistic accuracy even in complex cases. In this study, the 6 MV beam from the Novalis-Tx accelerator was modeled by the GATE/Geant4 v8.2 code in a homogeneous water phantom. The simulation was performed by applying the phase space and the variance reduction techniques to speed up the calculation time without losing accuracy. The calculations were performed with different field sizes from 3x3 to 20x20 cm^2 at a distance of 100 cm from the source for the measurements of percent depth dose, lateral profile with different depths and phantom-tissue ratio for assessment of the dose distribution. The simulation results were analyzed by the ROOT platform. Good agreement was obtained between the measured and calculated dose distribution for all field sizes; for a mean dose error of less than 1% and more than 98% of the points passed the 2%/2mm gamma index criterion.

Thyroid Ultrasound: Diagnostic Criteria and Artificial Intelligence Techniques

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Abstract

Thyroid nodules are found in up to 68% of asymptomatic adults in the general population. Approximately 7–15% of thyroid nodules are thyroid cancer, which is the most rapidly increasing malignancy in all populations. The large number of thyroid nodules, with only a fraction being cancerous, calls for a reliable method to accurately differentiate malignant from benign nodules. Routine decision making for patients with thyroid nodules depends on ultrasound or invasive fine needle aspiration. However, the assessment of ultrasound features is time consuming, subjective, and often dependent on a radiologist's experience and the available ultrasound devices. Ultrasound conclusions are often inconsistent and even with fine needle aspirations 15–30% of the samples still yield indeterminate cytological findings. Additional robust methods are needed to improve diagnosis and fine needle aspiration strategies to adapt to the exponential growth of patient needs and burden on medical services. This research could significantly improve the diagnostic performance of radiologists and help reduce the number of unnecessary fine needle aspirations for thyroid nodules. On the basis of our findings, AI diagnostic programmes should be rolled out to clinical practice of thyroid nodule management.

Keywords:
AI, diagnostic programme, thyroid, malignancy, benign nodules

Preliminary Investigation of Rice Husk Ash Concrete for Shielding of Diagnostic Radiology Facilities

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Abstract

Lead and high density concrete are the major materials used for the shielding of diagnostic radiology facilities to enhance radiation protection of the public, staff and patients. The cost of procuring these materials could be high for most facilities in developing nations. This study was therefore set up to investigate the possibility of replacing cement with rice husk ash (RHA) in the casting of concrete used in the shielding of diagnostic radiology facilities. RHA has been used as replacement for cement in other engineering work but the feasibility of using RHA concrete for shielding in diagnostic radiology has not been investigated. Concretes were produced by replacing cement with 5, 10, 15, 20 and 25%wt RHA before mixing with sand, gravel and water at known ratios. The concrete mixtures were placed in 2.5, 5.0, 7.5, 10.0, 12.5 and 15.0 cm thick moulds for the concrete to cure. The concrete samples were exposed to x-ray at different kVp and the transmitted doses recorded. Analysis of results (linear attenuation coefficient, half value layer, tenth value layer) show that concrete samples with 10%wt RHA replacement for cement offered a more efficient shielding in diagnostic radiology than the standard density concrete.

Keywords:
Shielding, concrete, lead, radiation protection, radiology

Tomotherapy in Breast Cancer Treatment: The Sidi Abdellah Center Experience

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Abstract:

125 patients with breast cancer were treated with tomotherapy (Helical 53% and Direct 47%), were randomly selected from our database (wall/breast only 18%; wall/breast and supraclavicular, axillary and internal mammary lymph nodes 46%, Breast and boost 36%). The treatment planning objectives were to cover 95% of the planning target volume using a 95% isodose, with a minimum dose of 90% and a maximum dose of 107%. Our Results 96.92% of the PTV isodose to cover 47.5 Gy for the PTV 50 Gy, 97.28% of the PTV45 to cover 42.75Gy for the PTV 45Gy. The organs at risk (OAR), The average dose for the heart was 3.37 Gy for the Right Breast cancer, and 6.04 Gy for the left side breast cancer. The median V20 for the same side lung were 21.06 % right side and 22.11% left side. The median V5 for the contralateral lung were 26,92 % Right side and 30,09 % left side. Tomotherapy plans provide excellent coverage of planning target volume and improved dose conformity and homogeneity in target volumes with decreasing the high doses to OAR.

Keywords:

Breast cancer, Tomotherapy, OAR.

Commissioning of a 6 MV Elekta Synergy Platform Linear Accelerator using the FLUKA Monte Carlo Model

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Abstract

This study aims to reproduce the therapeutic dose distribution for an Elekta Synergy accelerator using Monte Carlo (MC) simulations. The FLUKA MC was used to simulate the Linac head and the water phantom dedicated to dose calculation. The percentage depth doses (PDDs) and off-axis dose profiles were calculated for field sizes of 2×2 cm^2, 3×3 cm^2, 10×10 cm^2 and 20×20 cm^2. Dose distributions were calculated for a 6 MV high-energy X-ray beam at a source-to-surface distance of 90 cm. Over 95% of the points for all simulations meet the restrictive acceptability criteria of 2%/2 mm. We have demonstrated that it is possible to build an accurate Monte Carlo model of the Linac head for dose distribution simulations and quality assurance, and thus to use it for small field dosimetry, where the MC is one of the key tools.

Keywords:

Radiation therapy, Fluka MC, linac head simulation, Elekta Synergy

Pressure Dependence of Water 1H Spin Relaxation Rates in Model Hydrogel and Intervertebral Spinal Discs

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Abstract

Back pain is a major cause of disability. It is estimated that around 540 million people are currently suffering from back pains. This numbers are likely to increase especially in the low- and middle-income countries which are experiencing an increase in life expectancy. It is projected that 70–90% of people will have to experience some form of back pain in their lifetime with 10% experiencing disability as a result. Spine stiffness, neck and low back ache are the most common forms of back pain. Most cases of lower back pain have been shown to be associated with inter-vertebral disc (IVD) degeneration. MRI is a tool used to qualitatively detect structural deformities to the IVD resulting from degeneration. However, these deformities manifest in the terminal stages of degeneration. A method is needed to improve the sensitivity of MRI to quantitatively measure progression of degeneration from the onset of the disease which can vastly improve treatment outcomes. It has been observed that a reduction in Nucleus Pulpous (NP) hydrostatic pressure is one indicator of disc degeneration and that there is a direct correlation between fluid pressure inside the Nucleus Pulposus and the axial load on the disc. The NP hydrostatic pressure is currently measured using discography; an invasive procedure with the potential to further damages the IVD. Previous studies have also shown that MR spin relaxations rates of water protons are sensitive to mechanical stress on the Nucleus Pulposus. However, it is still not clear whether this is due to changes in the chemical composition due to water efflux or if it is due to hydrostatic pressure per se. In this project, the dependence of spin relaxation times in model connective tissue on the hydrostatic pressure is presented. Samples of gelatine hydrogen 90% w/w and 10% w/w and oxtail Nucleus Pulpous were separately subjected to confined axial compressive stresses and analysis of their relaxation rates made. Measurement was done using NMR relaxation imaging and validated using NMR spectroscopy R1 measurements by inversion recovery technique. R2 measurements were done by Spin Echo technique, FOV 12.8 mm × 12.8 mm, Sync 3 pulse acquired a series of free induction decays then Fourier transformed. The area in each spectrum indicated the level of magnetization left after polarization pulse. The integration was by Bruker Topspin 1.5 software. Plotting areas as a function of time and fitting done using custom made Mathematica 4.1 (Wolfram research, Inc.) program to the equations. The measurement outcomes were inconclusive, with most parts of the experimental results showing that within physiological pressure alone, in the absence of compositional chemical changes, it is not capable of inducing significant changes in relaxation rates. Further studies are proposed to confirm the results.

Keywords:

MRI, Nucleus Pulposus, Hydrostatic pressure, Spin Relaxation

Dosimetric Effect of Carbon Fibre Treatment Couch With and Without Immobilization Devices on Radiotherapy Dose Calculation

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Abstract

The objective of radiotherapy immobilization devices is to improve the reproducibility of patient positioning during treatment sessions. The inclusion of these devices in the treatment protocol may increase the skin dose. In practice, these devices are not systematically taken into account in the dose calculation. In this study, the dosimetric effects of the carbon fibre couch iBEAM Evo Extension 415, with and without three different immobilization devices (a Klarity Breastboard R610-2ECF, a Bionix Butterfly Board, and CIVCO Vac-Lok vacuum bag); were calculated and evaluated on the dose calculation for conformal three-dimensional radiation therapy. The measurements were carried out by comparing the measured dose with the one calculated for three different algorithms, FFT convolution, fast superposition, and superposition algorithms, which are implemented in Xio treatment planning system (TPS). Dosimetric tolerance levels have been respected for specific dose calculations, which do not include the fibre couch with or without immobilization devices. Errors of up to 8% in the dose calculation were obtained for the beams passing through the fibre couch and the breast board base support region. According to the significant attenuation differences of the beam by the fibre couch and immobilization devices, it was concluded that ignoring the device in the dose calculation can change patient's skin and target doses. The fibre couch and immobilization device should be included within external body contour to account for the TPS calculation algorithms dose attenuation.

Keywords:
TPS, radiotherapy, immobilization, patient positioning, treatment planning, FFT convolution

The IAEA/WHO TLD Postal Dose Quality Audits: Ghana's Experience

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Abstract

Over the past years, the IAEA's dosimetry programme has operated a service to validate the calibration of radiation beams in developing Member States using the IAEA/WHO TLD postal dose quality audits. Since 1998, Ghana has been involved in the IAEA/WHO TLD audit programme. This paper gives a summary of various studies performed during the period of involvement, and provides the results of a survey conducted by the IAEA. The survey had the aim of checking the dose delivered by the radiotherapy unit of the National Centre for Radiotherapy and Nuclear Medicine Department. The testing for the accuracy and consistency of basic dosimetric – calibration of radiotherapy beams with an ionization chamber, was done in reference conditions. The maximum acceptable discrepancy between the dose stated by the centre and the dose evaluated by the IAEA is ±5%. In Ghana, the National Centre for Radiotherapy and Nuclear Medicine Department over 15 years, has verified the calibration of its radiotherapy beams. The results from the entire period of study confirmed the high standards in dosimetry and quality assurance, and further gives hope that such high standards may be maintained in the Centre. Only one result was found to be outside the acceptable limit of ±5%.

Keywords:
Radiotherapy, IAEA, WHO, TLD, dosimetry programme

Dosimetric Feasibility Study of a Novel Dynamic Applicator Dedicated to Intensity Modulated Brachytherapy (IMB)

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Abstract

Intensity modulated brachytherapy (IMB) is a cancer treatment technique where shielding is used to protect organs at risk from unwanted exposure. The aim of this study is to develop a novel dynamic and guided applicator in tungsten of different geometries to treat complicated cancer cases in high dose rate brachytherapy by intensity modulated brachytherapy. The results obtained in this GATE/GEANT4 Monte Carlo simulation show an optimum dosimetry compared to conventional brachytherapy, wherein we have significantly minimized the doses received by organs at risk (OAR), including surrounding healthy tissues.

Keywords:

IMB; applicator; Monte Carlo simulation; OAR.

A New Design of an Experimental Prototype for Calibrating Medical Radiation Detectors: DetCal

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Abstract

Dose assessment is an important and sensitive task in patient radiation protection. A calibrated ionization chamber is crucial for radiation monitoring. Tunisia does not have a reference laboratory for calibrating detectors. Therefore, considering the development of this field of research is of great importance to the Country. Tunisia has 5 public and 8 private radiotherapy centres. In all, there are 15 Linear accelerators, 10 Cobalt-60 devices (3 non-exploitable sources), 2 low and 2 high dose rate brachytherapy sources, 4 dedicated radiotherapy scanners, and 10/15 accelerators equipped with Cone Beam Computed Tomography-CBCT, 3/15 Accelerators are equipped with Free Flattering Filter-FFF mode. All these instruments need preventive and curative maintenance to keep a good performance and to do that we need calibrated detectors. A detector that no longer functions correctly would therefore no longer allow correct detection. To ensure that the detector we are using, detects correctly. it should be calibrated periodically. Correction factors must be provided to users considering the correction of several phenomena and parameters. After studying the geometric design of the Cobalt-60 facility installed in CNSTN, we attempted to develop an experimental prototype (accommodating multiple ionizing radiation detectors). To study the optimal design of the experimental prototype, we used Solidworks, a proprietary 3D computer-aided design software running on Windows. Since the Cobalt-60 source is cylindrical and the dose rate distribution in the vicinity is uniform, the shape of the experimental prototype must be cylindrical. The distance between the source and the reference point was set to 100 cm (the standard distance used in the radiotherapy department which is between 80 cm and 100 cm). The experimental prototype requires a flexible and deformable material to easily adjust the setting of the dosimeters, ensure the desired shape, and minimize interaction between photons and the material. Therefore, wood is the best choice to meet these requirements. Among different types of wood materials, plywood is the most suitable material for our prototype. It is a bendable malleable wood. In addition, to maintain the cylindrical stance of the device, we add iron bars. The prototype is cylindrical and measures 4 mm thick, 1 m radius, and 2 m in height. It is mobile prototype with wheels for easy movement. The following parameters will be checked: leakage current, stabilization time, polarizing potential and polarity, ion recombination, directional dependence, electrometer calibration, charge or current calibration, range change factors, linearity, loaded leakage, stability and maintenance, correction factors for photon attenuation and scattering, the electron loses to the chamber wall and quantify these factors through Monte Carlo simulation.

Keywords: Calibration, prototype, dosimeter, Monte Carlo, ion recombination

Radiation Dose from Three-Phase X-Ray Machines: A Comparison between Different Models

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Abstract

The assessment of radiation dose is of great importance in the optimization process. It is crucial to develop strategies for dose estimation in developing countries in lack of dosimeters. The Entrance Skin Dose (ESD) of 731 patients was calculated using the Davies model. Eight radiological procedures: Chest PA and LAT, lumbar spine AP and LAT, Spine AP and LAT, skull PA and LAT and three-phase X-ray machines were considered. Based on the mathematical estimation of the radiation output of X-ray machines, a modified Davies model was proposed. The model was compared to others (Edmonds, Tung and Tsai) using their Mean Relative Errors (MRE) with respect to the reference Davies model and the Student's test of comparison of means. The 3rd quartile values were also compared to those found in Cameroon, Nigeria, Iran, France and UK. The MRE of the proposed model in this work (1.9%) was significantly less than the MRE of the Tung and Tsai model (7.1%), which was in turn significantly less than the MRE of the Edmonds model (55.0%). Results also show that, the 3rd quartile values were mostly higher than reference level in UK. High values of doses are attributable to short Focus to Skin Distance (FSD) and high values of charges. The model proposed in this study is a better alternative to the Davies model in the case of absence of dosimeter. An adjustment of technical parameters (FSD and charge) could help reduce high doses.

Keywords:

Three-phase X-ray machines, Modified Davies model, Dose optimization.

Stimulating the Passion of Medical Physics in Africa's Young Generation: Experience Sharing on the Rise to the Top

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Abstract

Finding myself in the field of Medical Physics could be described as accidental or divine orchestration. Gaining admission in the late 90's to enrol for undergraduate bachelor's degree in Physics came to me with big excitement and at the same time puzzling. My mind was like, how possible can this opportunity of reading "raw physics" at the university offer me satisfactory professional career in the medical field? What seemed like my confusion in thoughts some twenty years ago has fast grown and is becoming a "wonderland" for many young colleagues in Africa. The journey up the road of "Medical Physics Lane" in Africa has been one fit to be described as lengthy, strenuous and challenging, but above all these it has been exciting, inspiring and fulfilling! Working as medical physicist in academia, clinical and research fields for the past fifteen years in Ghana and having had the opportunity to collaborate on several projects in the African region, I am convinced beyond all doubts that Africa is the "next big thing" in Medical Physics globally. The opportunities abound but it will take Africans to make Africa realize this "next big thing". Leaders and policy makers need to urgently tap into the rich pool of young science graduates produced from universities across the region for enrolment and training in medical physics education and training programmes to acquire useful competencies needed to drive cancer and radiation medicine service delivery in Africa. This talk seeks to stimulate the passion of Medical Physics in the young generation of medical physicists, scientists and students from Africa. It will highlight my experiences as student from the LMIC region, rising to become academic head of medical physics at the University of Ghana, deputy director of a medical research institute at the Ghana Atomic Energy Commission, serving in high executive positions of medical physics professional organizations like IOMP and FAMPO and coordinating projects of an international agency like IAEA.

Keywords:
IAEA, FAMPO, Medical Physics, professional, training programme

Implementation of a routine quality control program for radiology facilities at the Abidjan Cardiology Institute (Côte d'Ivoire)

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Abstract

The Abidjan Heart Institute (ICA) is a public hospital dedicated to the treatment of cardiovascular and thoracic pathologies. ICA has been certified to ISO 9001 version 2015 since 2018. The implementation of a routine quality control program for radiology facilities is an opportunity to improve care for patients and practitioners. Quality control is aimed at maintaining the quality of diagnostic images, minimizing patient and staff radiation exposure and making radiological facilities profitable. This presentation will cover the regulations in force, assess the requests for radiodiagnosis and future prospects for quality control in Côte d'Ivoire.

Keywords:
Quality control, radiodiagnosis, thoracic pathologies, cardiovascular, treatment

Norwegian Partnership Programme for Global Academic Cooperation (NORPART) on Ghana-Norway Collaboration in Medical Physics and Radiography Education

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Abstract

Norwegian University of Science and Technology (NTNU) and Universities in Ghana have had a long time collaboration regarding quota students from Ghana at NTNU. The School of Nuclear and Allied Sciences of the University of Ghana and the Norwegian University of Science and Technology (NTNU), and other partner Institutions have been involved in a Norwegian Partnership Programme for Global Academic Cooperation (NORPART) project since 2017. NORPART Project was funded by the Norwegian Ministry of Education and Research and Norwegian Ministry of Foreign Affairs with a grant of NOK 4,950, 000 (US$ 600,000.00). The main goal of this project was to establish a partnership for education and research between institutions in Ghana and Norway within the fields of Medical Physics, Radiation Protection and Radiography. Under the project, two main activities were proposed, namely; (i) Annual Summer School in Ghana and (ii) A student exchange program at master and PhD levels. This paper highlights the experiences of the project after 5 years of implementation. The Ghana Norway Summer School in Diagnostic Imaging and Radiotherapy was held at different locations in Ghana for students and practitioners of Medical Physics, Radiation Protection and Radiography. It included theoretical presentations and practical sessions at the hospital. Under the students' exchange, students from Ghana undertook part of their thesis research in Norway under joint supervision from experienced researchers from the partner institutions. There have been 4 successful editions (2016-2019) of the Summer School with 262 students and Lecturers/Facilitators from Ghana and Norway taking part. 18 exchange students (13 Masters and 5 PhDs) from Ghana to Norway have benefited from the project. A digital mobile X-ray equipment and Quality Assurance kit was donated to GAEC. It is anticipated that at the end of the project cycle, there would be increased mobility, contact, quality and internationalization between staff and students among the partner institutions.

Keywords:

NORPART project, medical physics, radiography, radiation protection

Strengthening the Capacities for Medical Physics in Tunisia: Gaps and Challenges

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Abstract

Medical physicists have long played an integral role in medical imaging, radiation therapy and radiation protection. In Tunisia, the status of the profession is flawed, the most important of which are the system of obtaining certificates and the legislative framework that regulates the sector. Most importantly, this situation can negatively impact treatment quality, patient, and worker safety, whether through reluctance or relocation of staff. Statistical studies were conducted on the number and location of medical physicists and a national report on the status of medical physicists was prepared. Gaps have been identified and solutions presented to relevant decision-makers in the form of recommendations to advance the health care system. Medical physicists exist only in the field of radiation therapy, absent in the fields of medical imaging (diagnostic nuclear medicine and radiology) and radiation protection. Therefore, we will give only statistics on radiotherapy equipment. Since the number of medical physicists is related to the number of devices emitting ionizing radiation. Tunisia has 5 public and 8 private radiotherapy centres with 15 linear accelerators, 10 Cobalt-60 sources (3 sources not usable), 4 brachytherapy sources (2 low dose rate and 2 high dose rate) and 4 scanners dedicated to radiotherapy. However, not all radiation therapy centres have their own scanners. About 33 physicists with hospital technician status and no residency program render the required medical physics services. However, most of those rendering medical physics services have no medical physics background. Since 2011, the Higher Institute of Medical Technologies of Tunis has been running a Master's Degree in medical physics to meet the demands of the Country. About 6-7 medical physics degrees (radiation therapy) are awarded each year. Despite the efforts, there are still quantitative and qualitative deficiencies; some modules are missing compared to international medical physics courses. There is no accredited centre that offers residency programme to train certified clinical medical physicists. Residency program in medical physics is somehow compensated by a PhD thesis supervised by Non-Certified Clinical Medical Physicists. The Organizations of Medical Physics (FAMPO, EFOMP, IOMP …) is hereby requested to assist the Country in capacity building, empowerment and training of medical physicists. Masters and Ph.D. students seeking supervision and guidance often have difficulty finding specific expertise needed for their research in Tunisia. Contribution of IAEA in providing technical support in the field of medical physics is very much desirable. We commend the regional project RAF6058 "Strengthening the capacities for Radiopharmacy and Medical Physics and Radiology for expansion and sustainability of Medical Imaging Services", the Master's Program in Medical Physics from the Abdus Salam International Centre for Theoretical Physics in Italy and the ICTP-IAEA Sandwich Training Educational Programme (STEP). Medical physics in Tunisia should meet the need of hospitals and the current legislative framework must be updated.

Keywords: medical physics, residency, FAMPO, IAEA, radiotherapy

ANNEX 2

BOOK OF ABSTRACTS

of the

Middle East Federation of Organization of Medical Physics (MEFOMP)

Medical Physics Conference 2023

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PART 1: RADIOTHERAPY

INTERSTITIAL HIGH DOSE RATE (HDR) BRACHYTHERAPY WITH MICROSELECTRON HDR FOR EARLY BREAST CANCERS

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Introduction

Treatments for early breast cancers have evolved from radical mastectomy towards breast conserving surgery (BCS) and radiotherapy. In high risk patients, a boost dose to tumor bed, 15-20 Gy is required, by high energy electrons or by interstitial brachytherapy (BT). From the year 2017, interstitial BT for BCS patients are carried out at our center with microSelectron (M/s Nucletron).

Purpose

The pattern of care followed at our center in early breast cancers and biologically effective doses (BED), efficacy of treatment, needs documentation.

Materials and Methods

A 2 plane template is used to implant needles with treating 'distance' 1.2 cm. 10mm on either side of the catheter was kept cold to avoid excess skin/subcutaneous excess dose, maintain cosmoses and prevent skin spots. 2 regimens, 1) HDR BT and External Beam Radiotherapy (EBRT) and 2) Accelerated Partial Breast Irradiation (APBI) with only BT as mono-therapy is followed. 78 patients were treated in 6 years. In 73 patients, doses to 100% covering line was delivered with 6h inter-fraction BT as 8Gy x 2 fractions(n=1), 4Gy x 4fr (n=27), 3.65Gyx4fr (n=24), 3Gyx4fr (n=19), 3Gyx3fr (n=2) along with EBRT by Tele-cobalt tangential fields, 5fr/week, breast cone, 40Gy/15 fr equivalent of 46.7Gy in 2Gy/fr. Second group (mono-therapy) had 5 patients, 3.65Gy x10fr (n=1), 3.40Gy x10fr (n=3) and 5.88Gyx10fr, completing treatment in 5 days.

Results

BED_{10} for BT = 19.93 Gy for 3.65Gy x 4Fr; This BT dose equal to EBRT dose In 2Gy/fr 8.3 = 16.61 Gy. 40Gy/15Fr @ 2.67Gy/Fr is equal to dose of 42.3Gy at 2Gy/fr. Total dose of whole regimen is 58.9Gy (<1.5% to 60Gy). BED_{10} for BT of 3.65Gy x 10Fr is 49.83G, which is equivalent of 41.5Gy EBRT total dose at 2Gy/fr, 5 fr/week. There was no toxicity recorded on short term follow up. An earlier study in a non- randomized pilot group of 10 patients (Parthasarathy et al 2005) reported 100% local control in treated patients.

Conclusion

As more cancer patients are treated with breast conservation, HDR BT can be practiced, with available facilities. Treatment times are very short in breast interstitial BT, and patients tolerate these treatments well.

GLOBAL TO LOCAL AND LOCAL TO VOCAL…LESSONS LEARNED FROM PANDEMIC TOWARDS PROCUREMENT OF LOCAL DOSIMETER FOR DAY-TO-DAY USE IN RADIOTHERAPY QUALITY ASSURANCE PROCESS

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Purpose

Present study conducts the performance check and determination of relative electrometer calibration constant for a local electrometer (make in India)

Materials & Methods

Three local electrometers (SureDose, Rosalina Instruments, Mumbai)) were procured in the pandemic period for meeting daily QA frequency as per regulatory requirement. It was tested for linearity, stability, sensitivity, high impedance and low leakage dose etc) against two reference class electrometers. End to end tests were also carried out on the user beam including output measurements (photon and electron), sweeping field output and Enhanced Dynamic Wedge (EDW) factor measurement. Total 13 Patient specific QA were carried out for the dose verification of complex ten Volumetric-modulated arc therapy (VMAT) and five stereotactic radio-surgery (SRS) plans.

Results

Linearity coefficient was found to be unity for the charges of measured for four different modes of photon energies for Monitor Unit range 10 to 300. Dependency of meter reading on dose rate (200MU/min – 2000MU/min) was found to be negligible. Relative electrometer calibration constant for this electrometer, PTW UNIDOS and Tomo-electrometer against Scanditronix Dose1 (reference class electrometer) were found to be 0.9976, 0.9997 and 1.0047 respectively. All dosimetric output measurements carried out for various range of photon and electron energies were found to be well within ±3% tolerance as stated in TRS 398. Variation in TPS calculated dose and delivered dose as measured for PSQA for 4 SRS patient's plans was found to be within ±2% and for 10 VMAT patient's plans were found to be within ±3%.

Conclusions

Procured local electrometer is found satisfactory, accurate and hence recommended to use it for daily QA of high precision RT equipment. An attempt was made to show positive evidence that the time has come to move from Global to Local and be vocal.

THE EFFICIENCY OF GAMMA KNIFE STEREOTACTIC RADIOSURGERY IN THE TREATMENT OF GLIOMA

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Introduction

Malignant glioma poses a significant challenge in the field of neurosurgery. The current standard treatment for this disease involves maximal resection followed by chemotherapy and radiation therapy. Despite these efforts, tumor recurrence frequently occurs within 2 cm of the original lesion, highlighting the critical need for local tumor control. To address this issue, stereotactic radiosurgery presents a potential solution. However, effectiveness of Gamma Knife radiosurgery (GKRS) in treating glioma remains controversial in the medical community.

Purpose

The objective of this study was to assess the treatment plans for glioma tumors that underwent stereotactic radiosurgery using the Icon version of the gamma knife device**.**

Materials and Methods

Thirty patients with glial tumors were treated at the gamma knife center of Al-Taj Hospital, Baghdad. An oncologist or neurosurgeon diagnoses forwarded patients for gamma knife therapy. The patients were divided into two groups according to glial tumor type high-grade glioma and glioblastoma. Each patient's brain is imaged using CT and MRI to explore tumor features better. The neurosurgeon prescribed the dose depending on the tumor volume, ranging from 12–24 Gy. The gamma knife device with the Icon version manufactured from Elekta was used in this study.

Results

The result shows that the mean volume of patients with glioma was 2.9±0.34 cm^3 (0.3–3.4) cm^3, while the glioblastoma volume was 2.5 ± 0.33 cm^3 (0.6–3.1) cm^3. Findings indicate that coverage and gradient index evaluation parameters were statistically significant in high-grade glioma than (97%), (3.1±0.15) in glioblastoma (92%), (2.79±0.32), respectively. In contrast, glioblastoma exhibited superior selectivity and Paddick conformity index (PCI) values (0.76±0.054, and 0.77±0.09, respectively) than the high-grade glioma (0.71±0.04, 0.72±0.06, respectively). Treatment duration was found to be longer for high-grade glioma (37.22±11.54 minutes) cases compared to glioblastoma (29.54±9.53 minutes). Nonetheless, the efficiency index demonstrated that the gamma knife technique is a viable option for both tumor types, with significant benefits observed in high-grade glioma (0.68±0.032) compared to glioblastoma (0.66±0.051).

Conclusion

The gamma knife procedure is proficient in administering stereotactic gamma radiation to patients diagnosed with high-grade glioma and glioblastoma. However, its effectiveness is comparatively superior in the treatment of high-grade glioma.

DETERMINATION OF SMALL FIELD OUTPUT FACTOR FOR VARIOUS COLLIMATORS USING DIFFERENT DETECTORS

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Introduction

The aim of radiotherapy is the delivery of a maximum dose to the tumor and minimum dose to the surrounding normal tissues which may be comfortably achieved using advanced techniques. The small segments dosimetry should be very accurate in the TPS then only the expected clinical outcome can be achieved. The small segments field dosimetry is more complicated compared to other conventional fields. The small field measuring detectors are having very small volume, high spatial resolution and should satisfy the detector's ideal characteristic studies. The IAEA TRS 483 recommended output correction factor is used in this study to determine corrected output factor for small fields.

Purpose

In this study the 6MV Flattening Filter (FF) and 6MV Flattening Filter Free (FFF) photon beams small-field Output Factor (OF) was measured with various collimators using different detectors. The corrected OFs were compared with the Treatment planning system (TPS) calculated OFs**.**

Material and Methods

The OF measurements were performed with four different types of collimators like Varian millennium Multi-Leaf Collimator (MLC), Elekta Agility MLC, Apex micro-MLC and stereotactic cone. There are ten detectors (four ionization chambers and six diode) were used to perform the OF measurements at 10 cm depth with 90 cm Source to Surface Distance (SSD). The corrected and uncorrected OFs were calculated from the measurement. The corrected OFs were compared with the existing TPS generated OFs.

Results

The uncorrected OF was overestimated for the diodes than the ionization chamber. The use of detector-specific output correction factor (OCF) in PTW diode P detector was reduced the OF uncertainty by less than 4.1% for 1x1 cm^2 $\mathbf{S_{clin}}$ field size. The corrected OF was compared with TPS calculated OF, the maximum variation with IBA CC01 chamber was 3.75 %, 3.72%, 1.16%, and 0.90 % for 5 mm stereotactic cone, 0.49X0.49 cm^2 Apex mMLC, 1x 1 cm^2 Agility MLC, and 1x 1 cm^2 Millennium MLC respectively.

Conclusion

The TRS 483 protocol recommended detector-specific OCF was used to calculate the corrected OF from uncorrected OF. The implementation OCF in the TPS commissioning will reduce the overall uncertainty less than 3% for any type of detectors.

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OPTIMIZED SILICON DETECTORS FOR BEAM MONITORING IN ADVANCED RADIOTHERAPY

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Purpose

This study presents results from tests on Low Gain Avalanche Detectors (LGADs) and thin planar silicon sensors segmented in strips with different therapeutic particle beams to prove their performances for monitoring protons, carbon ions and electrons delivered at conventional and FLASH dose rates.

Materials and Methods

The University and the National Institute for Nuclear Physics of Turin collaborated with Fondazione Bruno Kessler (FBK, Trento, Italy) to design and optimize LGAD and planar strip sensors featuring various geometries, thicknesses, and gain layer doses for a beam energy detector based on time-of-flight and for a fast particle counter based on a custom front-end multi-channel readout chip. The detectors were characterized in the laboratory and then tested with proton and carbon ion beams at the Italian National Center of Oncological Hadron Therapy (CNAO).
Concurrently, planar silicon sensors with different active areas and thicknesses were developed and tested with pulsed electron FLASH beams at SIT ElectronFLASH Linac of the Centro Pisano di Flash Radiotherapy in Pisa (funded by Fondazione Pisa).

Results

Absolute beam energy measurements agree with the nominal ones within the clinically significant 1 mm range difference. The counting error without pile-up corrections is less than 2% for a mean fluence rate up to 100 MHz/cm^2. The beam width measured as FWHM of the profile achieved over 144 strips overlaps with the expected value at isocenter for narrow beams and the reproducibility over 20 identical spills was better than 1% for all the clinical beam energies.
Finally, the dose per pulse response linearity for thin planar silicon sensors was also investigated with FLASH beams, and the maximum deviation is of a few %.

Conclusion

Preliminary tests of LGADs and planar silicon sensors confirmed their potential to control online the fluence, position and energy of therapeutic particle beams. Additionally, they showed potential for monitoring ultra-high dose rate electron beams up to a few Gy/pulse.

COMPARISON OF FOUR COMMERCIAL DOSE CALCULATION ALGORITHMS IN DIFFERENT EVALUATION TESTS

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Purpose

The aim of this paper is to describe performance accuracy of four different dose calculation algorithms include Anisotropic Analytical Algorithm(AAA), Acuros (AXB), collapsed cone convolution(CCC) and Monte Carlo(MC) available in two TPSs, Varian Eclipse and RaySearch Laboratories RayStation.

Methods

The dosimetric performance of AAA, AXB, CCC and MC algorithms was evaluated in homogenous medium based on IAEA-TECDOCE 1540 and heterogeneous medium based on IAEA-TECDOC 1583. In addition, performance accuracy of these dose calculation algorithms was evaluated for volumetric modulated arc therapy (VMAT) plans based on the AAPM TG-119 test cases. Also profile and depth dose comparisons against measurement were carried out in relative mode using the gamma index as a quantitative measure of similarity within the central high dose regions for all evaluated algorithms.

Results

Testing in homogeneous media and in heterogeneous geometries has demonstrated a high level of agreement between measurements and calculations for both treatment-planning systems. The results of gamma index pass rate (GIPR) for dose calculation algorithms in VMAT plans showed that GIPR (3%/3mm) for all the algorithms (AAA, AXB, CCC and MC) in all evaluated tests based on TG119, were greater than 97%

Conclusions

The result of this study showed that generally, dose calculation algorithms which calculate dose in medium (AXB and MC) have better accuracy than dose calculation algorithms that calculate dose to water (CCC and AAA).

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VERIFICATION OF DOSE CALCULATION ALGORITHMS BASED ON THE IAEA-TECDOCE-1583 WITH CONSIDERATION APPLY MEDIUM DEPENDENCY CORRECTION FACTOR (K_{MED})

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Purpose

This study evaluated the measurement of dose in clinical commissioning tests described in TECDOCE-1530 with the application of Monte Carlo (MC) modelled correction factors for bone and lung materials in the 002LFC CIRS thorax phantom (Norfolk, USA) for $D_{m,m}$ and $D_{w,w}$ dose calculation algorithms.

Materials and Methods

In this study, we applied BEAMnrc codes to carry out simulation of radiation source and modelling radiation transport for 6MV and 15MV photon beam. DICOM CT scan images of CIRS phantom converted to a MC compatible phantom using the stand-alone code, CTCREATE, which converts the patient’s CT data to the desired dimension, material type and mass density. PTW 30013 farmer chamber (0.6cc) utilized for each point of measurement in the modeled CIRS phantom. While using farmer chamber, the correction factors were determined from the average of four central voxels in the sensitive volume of the simulated farmer chamber in point of measurement. In both media (bone and Lung) for 6MV and 15MV photon beams, medium dependency correction factor calculated for $D_{m,m}$ and $D_{w,w}$ algorithms.

Results

In bone media: for $D_{m,m}$ calculations using farmer, the average modelled correction factors for 6MV and 15MV were 0.976(±0.1%) and 0.979(±0.1) respectively. Also for $D_{w,w}$ calculations, the correction factors were 0.99(±0.3%) and 0.992(±0.4%), respectively. In lung, for the $D_{m,m}$ calculations, the average modelled correction factors for 6MV and 15MV were 1.02(±0.3%) and 1.022(±0.4%) respectively. For $D_{w,w}$ calculations, corrections factors were 1.01(±0.3%) and 1.012(±0.2%), respectively. In the audit, application of the medium dependency correction factors for bone, improves the mean agreement between treatment plans and measured dose from 2.5%(±2.9%) to 0.5%(±1.8%) and for lung from 1.7% (±1.8%) to 0.3 %(±1.2%).

Conclusion

This study provides a correction factor to correct the measured dose in bony and lung materials for accurate validation of dose calculation algorithms base TECDOCE-1583.

MR GEOMETRIC DISTORTION: OUR EXPERIENCE AND FINDINGS

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Introduction

Measuring MR geometric distortion with a large field of view is crucial for accurate image acquisition in radiotherapy.

Purpose

This abstract presents our experience with MR geometric distortion for large field of view using both existing phantoms and custom-built phantoms.

Materials & Methods

We first developed a purpose-built phantom consisting of 357 rods of polymethyl-methacrylate separated by 20 mm intervals, which provided a 3D array of control points at known spatial locations covering a large field of view up to a diameter of 420 mm. One of its constraints was its weight, which resulted from its composition of water-based materials. Additionally, the phantom's architecture did not allow for an assessment of the through-plane distortion.
To address this limitation, we used an existing phantom developed by GE Healthcare, which consisted of layers of foam embedded with a matrix of ellipsoidal markers and covered a large field of view of 500 mm. We evaluated the in-plane and through-plane geometric distortions and the correction algorithms provided by the vendor. The main limitation of this phantom is that it cannot fit in all types of coils due to the size of its layers.

Finally, we proposed a new design of a customizable phantom composed of 3D printed plastic blocks containing holes that can hold glass tubes filled with any liquid, which can fit any type of RF coil and measure distortion in three dimensions.

Results

The customizable phantom we proposed is not only robust and lightweight, but also modular, making it a practical tool for measuring distortion in three dimensions and able to fit any type of RF coil. proved to be a robust, lightweight, modular, and practical tool for measuring distortion. The measured mean distortion for our MR was less than 1 mm and less than 2.5 mm over radial distances of 150 mm and 250 mm, respectively.

Conclusion

These tools will be part of a quality assurance program aimed at monitoring the image quality of MRI scanners used to guide radiation therapy.

TOWARDS CBCT-ONLY ADAPTIVE RADIOTHERAPY OF THE HEAD&NECK: GENERATION OF SYNTHETIC CT USING DEEP RESIDUAL U-NET

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Purpose

To create a synthetic-CT (sCT) from Head&Neck (H&N) CBCT using Deep Residual U-net (DRU-net). It can be used for adaptive radiotherapy.

Materials and Methods

A database of 93 H&N patients having deformably co-registered CT and day one CBCT with a resolution of 1.26×1.26×3mm³ was considered. It was divided into training and test sets of 68 and 25 patients respectively. Image slices were cropped to 256×256 and H&N masks were applied.
2D DRU-net was designed. 2D DRU-net learns a mapping function that converts a CBCT slice to its corresponding sCT slice based on a training set composed of paired CBCT/CT slices. DRU-net has a symmetric hierarchical structure composed of encoding, bridge, and decoding parts. The encoding part down-samples images to extract larger number of features at different scales in the image spatial domain using a stack of deep residual units (DRU). The bridge connects the encoding and decoding parts and is composed of one DRU. The decoding part propagates information from coarser to fine resolution through upsampling layers. At each level, a copy of the output at the corresponding encoding part is concatenated with the upsampling output and fed to DRU to generate denser representations. After the last level of decoding part, a 1x1 convolution is applied with sigmoid as activation function to map each 64-component feature vector from the previous layer to a CT number.
The performances of DRU-net were assessed on the test set using the mean absolute error (MAE), the mean error (ME), the peak signal-to-noise ratio (PSNR), and the structural similarity index (SSIM) metric.

Results

The mean and deviation values for sCT evaluation measurements were MAE=67.88 (σ=8.39), ME=-0.06(σ=10.7), PSNR=-36.92(σ=1.4), SSIM=0.95 (σ=0.01).

Conclusion

A promising study on the generation of synthetic CT from CBCT was presented. Further work will be done to assess the method dosimetrically.

PREDICTING PATIENT-SPECIFIC QUALITY ASSURANCE RESULTS OF VOLUMETRIC MODULATED ARC THERAPY USING DEEP LEARNING

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Introduction

Automatic patient-specific quality assurance (PSQA) is recently explored using artificial intelligence approaches, and several studies reported the development of machine learning models for predicting the gamma pass rate (GPR) index only.

Purpose

The purpose of this work was to develop a deep learning (DL) approach to generate the synthetic measured fluence using a generative adversarial network (GAN).

Materials and Methods

Two DL models based on conditional GAN (c-GAN) and cycle GAN (cycle-GAN) were developed to generate the synthetic EPID-measured fluence. A total of 164 VMAT treatment plans, including 344 arcs (training data: 262, validation data: 30, and testing data: 52) from various treatment sites, were included for prediction model development. For each patient, portal-dose-image-prediction fluence from TPS was used as input, and measured fluence from EPID was used as output/response for model training. Predicted GPR was derived by comparing the TPS fluence with the synthetic measured fluence generated by the DL models using gamma evaluation of criteria 2%/2 mm (global normalization, 10% threshold).

Results

The synthetic measured fluence predicted by c-GAN demonstrated better accuracy compared to cycle-GAN. The reference GPR (2%/2 mm) was 96.5±2.4% and the cycle-GAN and c-GAN predicted GPR were 98.5±4.90% and 98.1±1.60%. Overall, the GPR prediction accuracy was within 3% for 71.2% of fields and 78.8% of fields for cycle-GAN and c-GAN, respectively.

Conclusion

A method was developed to generate the synthetic measured fluence using GAN. The c-GAN can accurately predict the measured fluence for VMAT PSQA and it has the potential to identify the error locations. The proposed PSQA prediction strategy will pave the way for the virtual PSQA.

GENERATING SYNTHETIC CT FROM DAILY CONE BEAM CT USING DEEP LEARNING

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Introduction

Cone beam CT (CBCT) Hounsfield units (HU) accuracy is one of the important parameters for accurate dose calculation for online adaptive Radiotherapy (OART).

Purpose

The purpose of this study was to generate synthetic CT (sCT) from the daily cone beam CT (CBCT) using deep learning models.

Materials and Methods

A novel 2D convolutional neural network called 'self-attention residual U-Net' (SA-ResU-Net) was designed to generate accurate synthetic CT. The SA-ResU-Net is similar to the traditional U-Net but equipped with a special self-attention mechanism in the long skip connections to learn the important information between the encoder and decoder. A total of 93 head-neck patient images who had pair of planning CT (pCT) and first-day CBCT images were included in this work. The patient data were randomly split into training data (58), validation data (10), and testing data (25). The accuracy of prediction was evaluated on testing data using the quantitative metrics including mean absolute error (MAE), peak-signal-to-noise ratio (PSNR), and structural similarity index (SSIM) which were calculated between the sCT and pCT images. The performance of the proposed architecture 'SA-ResU-Net' was also compared with traditional U-Net.

Results

The average MAE, PSNR and SSIM between pCT and CBCT were 163.35±28.62, 60.12±1.80 and 0.56±0.07. Overall the sCT images generated by both models showed reduced artifact, image noise, and improved image quality. The sCT generated by SA-ResU-Net demonstrated significantly ($p<0.001$) improved images compared to the U-Net in terms of mean MAE (48.4±7.1 vs 54.7±8.5), PSNR (66±1.9 vs 64.8±1.7) and SSIM (0.79±0.04 vs 0.77±0.05) respectively.

Conclusion

The proposed SA-ResU-Net improved the HU accuracy and image quality of sCT and it outperforms the U-Net for synthetic CT generation from CBCT. Our method has the potential to generate accurate sCT for OART planning.

IMPACT OF USING DIFFERENT IMAGE GUIDED BASED BRACHYTHERAPY ON ORGANS AT RISK EQUIVALENT DOSE

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Introduction

Utilizing of two types of image guided Brachytherapy in the treatment workflow can improve the quality of target delineation and applicator reconstruction but on the other hand it can has an impact on organs at risk (OAR).

Purpose

To evaluate the comparison between using different types of image guided based brachytherapy (IGBT) in OAR and their effects on equivalent dose in 2Gy Fractions (EQD2).

Materials and Methods

Thirteen retrospective cases data with gynecological malignancies were collected for this study. Planning CT and MRI scans were performed after the preparation of rectal and bladder and implant procedure. CT and MRI scans were fused focusing on implant applicator. OAR were independently contoured on the different image modalities.

Results

Between the CT and MRI images, a mean of 28 minutes was recorded. 88% of patients' bladder volumes increased with an average of 38% while in 58% of patients, sigmoid volume increased with an average of 5.6%. In 91% of patients, volume of rectum decreased with an average of 14%. During the analysis, on average, the center of the bladder & rectum moved 0.4 & 0. 1 cm shift away from direction from target. Furthermore, the average increase in D2cc, observed in bladder is 2.3%, while there was average decrease of 1.3% & 2.8% in rectum & sigmoid respectively. On the other hand, for EQ2 of bladder, rectum and sigmoid average dose changed by 1.2% (CT 71.4 Gy, VS MRI 72.2 Gy), 0.4% (CT 69.8 Gy, VS MRI 69.5 Gy) & 0.6% (CT 55.6 Gy, VS MRI 55.9 Gy), respectively.

Conclusion

Our institute's time dependent analysis of IGBT pretreatment CT and MRI scans revealed OAR motion between images. OARs deviated from the target due to these modifications, resulting in D2cc variations that did not translate in terms of EQD2 calculation.

OUT-OF-FIELD MEASUREMENTS FOR O-RING LINAC USING OPTICALLY STIMULATED LUMINESCENCE DOSIMETERS

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Purpose

Accurate radiation dose measurement at out-of-field is important in modern external beam radiation therapy due to the increased survival of cancer patients. The purpose of this study was to assess the out-of-field dose of the O-Ring linac equipped with a new dual-layer MLC, compared to the conventional C-arm linac equipped with a standard single-layer MLC using optically stimulated luminescence dosimeters (OSLD).

Materials and Methods

The OSLD nanoDots were calibrated using a solid water phantom with a standard setup for an O-ring linac (Ethos, 6MV flattening filter-free beam) and a C-arm linac (Clinac iX, 6MV-flattened beam). The surface doses were measured for different field sizes (5x5cm^2, 10x10cm^2, and 20x20cm^2) at the central axis and three locations outside the field edge (1cm, 5cm, and 10cm from the field edge). Out-of-field measured doses were normalized to the central axis and a comparison was carried out between two Linacs.

Results

Overall, the out-of-field dose increased considerably with increasing field sizes for both the MLC designs, and the dual layer MLC of Ethos delivered a lesser dose. The out-of-field dose on Ethos measured for field sizes 5x5cm^2 to 20x20cm^2 varied from 7.6-19.3%, 1.9-10.5%, and 0.9-7.0% for the locations 1cm, 5cm, and 10cm from the field edge respectively. Similar results for Clinac iX were 15.2-32.9%, 3.1-15.0%, and 1.1-8.8% for the locations 1cm, 5cm, and 10cm from the field edge respectively.

Conclusion

The O-Ring linac with a dual-layer MLC design demonstrated a lower overall out-of-field dose than the C-arm linac with a single-layer MLC. The results presented in this study can be used to optimize the out-of-field doses for special clinical situations such as pediatric cases, cardiac implants, etc.

AN IMAGE PROCESSING ECLIPSE SCRIPTING API ALGORITHM TO INSERT OR MOVE THE VARIAN COUCH TO CORRECT POSITION

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Introduction

The Varian Truebeam's carbon fiber IGRT couch can attenuate radiation beam up to 4%. To ensure accurate dose calculation and avoid couch-gantry collision, it is essential to position the couch structure correctly. However, the ECLIPSE algorithm inserts the couch structure below the lowest point of the body structure, which needs to be moved to the correct position.

Purpose

In this study, an Eclipse Scripting API algorithm was developed to insert and move the couch structure to the correct position using image processing.

Materials and Methods

The vertical line profile of the CT image of the CT scanner couch was acquired as a reference. After inserting the couch structure of medium thickness, the line profile below the top surface of the inserted couch structure was compared against the reference. A loss function was implemented to calculate the difference in the line profiles. Two iterations - a coarse and a fine tune were used to compare line profiles below the inserted couch structure to a maximum range of 15 cm. If the loss of line profile against the reference was comparable to the average loss, the shift returned was used to move the couch structure and associated couch interior.

Results

The algorithm was tested on 20 patient scans and compared against manually placed couch structure. A separate script was prepared to locate the center of the couch structure for evaluation. The standard deviation of the vertical variation between manually placed and algorithm placed couch positions was 0.56 mm, with a maximum difference observed as 2.39 mm. Minor distortion on the couch surface contour was observed due to the algorithm.

Conclusion

This study developed a simple image processing algorithm to automate the mundane task of moving the couch structure to the correct position. The distortion of the contour for the couch surface was observed, which will be investigated further.

ROLE OF PAPILLON SYSTEMS (CONTACT X-RAY BRACHYTHERAPY 50 KV) IN ONCOLOGY IN 2023

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Introduction

Radiotherapy (RT) in 90% of cases is performed using linear accelerators (≥6 MV). However, a niche exists for low energy X-ray beams (50 kV) in contact X-ray brachytherapy (CXB). CXB was developed in France in the 1970s by Papillon, currently is performed mainly in France and UK, using the Papillon systems.

Purpose

To present the results of this ambulatory treatment in small accessible tumors.

Materials and Methods

CXB is used in three main indications:

Skin cancer: basal cell and squamous cell skin cancers (T1-T2N0). Also, as adjuvant treatment after surgical excision.

Rectal cancer: lower-mid rectum with main indication T2-T3 ab N0≤4cm (organ preservation and "watch and wait", in case of clinical complete response. Endocavitary approach in the knee-chest position, always combined with chemoradiotherapy. Ideal for tumors 3 cm or less. Also prescribed as adjuvant treatment after local excision of T1N0 tumor with pejorative features on the pathological specimen.

Breast cancer (T1N0): intraoperative approach (Targit trial). A 20Gy dose (single fraction) is delivered in the tumor bed after lumpectomy (single session).

Results

Skin cancer: Local control in ~90% of the cases, with good cosmetic results. Very low toxicity rate in eyelid tumor, with no eye or lacrimal side effects.

Rectal cancer: European OPERA trial demonstrated the significant benefit of adding CXB to RT, with 81% 3-year rectal preservation for T2-T3a/b, and good bowel function in 80% of cases. The preservation rate is 95% for tumor <3 cm diameter treated first with CXB. For adjuvant strategy, 94% 5-year local control rate.

Breast cancer: Results of Papillon IORT (Centre Antoine Lacassagne) in a group of 26 patients, showed up 100% breast preservation (3-year follow-up), with good cosmetic result and no grade 3 toxicity. A complementary external beam RT was necessary in 3 patients (positive nodes).

Conclusion

CXB is associated with a very low rate of toxicity because the volume irradiated is very small (5 cm^3). The skin and breast IORT are easy for the radiation oncologist to perform. For rectal intracavitary irradiation a learning curve of 6 months/12 patients is necessary to master rigid rectoscopy and applicator tumor targeting.

SINGLE VERSUS MULTICHANNEL APPLICATOR IN VAGINAL HDR BRACHYTHERAPY

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Purpose

High dose rate brachytherapy (HDR) is a critical radiotherapy treatment that includes the insertion of radioactive sources through special type of applicator to deliver high doses of radiation directly to the cancer tumor.

Single-channel and multichannel are two types of HDR applicators which can used to deliver this type of treatment.

The aim of this study is to evaluate the dosimetric effect of using these two different applicators in intracavitary vaginal brachytherapy on organs at risk (OAR).

Materials and Methods

Retrospective endometrial carcinoma patients that were treated using cylindrical applicator are included in this study.
Two plans were created for each insertion with dose prescription is 7Gy to volume-based CTV high risk, one plan using single channel applicator while the other plan using multichannel with the same diameter size. Plans are created and performed by Varian's HDR Treatment Planning system and brachytherapy software. For each brachytherapy fraction a single and multichannel loading plans were generated with inverse treatment planning optimization.
To evaluate the effect of using different applicators on OAR, reference condition of CTV coverage D90 (dose to 90 percent of the volume) was set to be same in both plans.

Results

The study analysis data showed that the average dose for the 2 cc (D_{2cc}) in single channel applicator plans are (5.83, 6.23, 2.85, and 2.83 Gy) for bladder, rectum, sigmoid, small bowel, respectively. On the other hand, the result presents the D_{2cc} in multichannel applicator are (5.47, 5.32, 2.57, and 2.61 Gy) for bladder, rectum, sigmoid, small bowel, respectively.
Furthermore, the average variance percentage between both applicators are (6.2%, 14%, 10.6, and 9.2%) for bladder, rectum, sigmoid, small bowel, respectively.

Conclusion

High dose rate brachytherapy has different applicator modalities can be used, both applicators used in this study produce an acceptable plan but the multichannel applicator has the upper hand in decreasing the dose to normal structures.

STUDY OF CYBERKNIFE SYNCHRONY SYSTEM FOR IRRADIATING MOVING TARGET AT SULTAN QABOOS CANCER CENTER

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Introduction

In radiation therapy, treating moving targets is always a big challenge. Different methodologies have been used to overcome this problem. Among them are treating tumor with ITV, maximum intensity projection or irradiating tumor in a particular breathing phase.

CyberKnife System introduced a Synchrony method that made it possible to track and treat the tumor in a 4D real time motion while the patient is berating normally.

CIRS Dynamic Thorax phantom is used in this study.
This phantom can produce 3D complex target motion within the lung in conjunction with the Surrogate breathing platform.

Purpose

The aim of this study is to measure the accuracy of the CyberKnife Synchrony System that targets the tumor while it is in motion.

Material and Methods

CyberKnife system that includes the X-rays imaging system and the Optical Tracking system. We used CIRS Phantom for scanning and delivering the dose to the target (tumor), Gafchromic EBT^3 films were used.
The phantom was scanned as we scanned the real patient with Inhale and Exhale position (described by the Accuracy) followed by the simulation process and then planning was done by Precision TPS.
The same plan was executed 5-times with the following Phantom parameters to simulate the target motion during the treatment.
4 setups were used in this study with vertical motion ranging from 12-14 mm, lateral motion ranging 2-4mm at a cycle of 3-4/sec. The simulated depth of breathing (surrogate) ranged from 8mm to 10mm, and a phase shift of 0 and 90 degrees.
Automatic Synchrony model was used to track the tumor with breathing cycle.
After delivering the dose to the target, the film was scanned and analyzed by the E2E software provided by accuracy.

Results

Single plan was delivered 5 times with the above setups.
Results for target accuracy ranged from 0.25mm to 1.08mm

Conclusion

The moving targets can be treated with 1.08mm of accuracy.
All possible combinations of the tumor motion were produced, and the most complex motion result was in 0.29 mm target accuracy.

LOW DOSE RATE (LDR) PROSTATE PERMANENT IMPLANT ROLE AND IMPORTANCE OF MEDICAL PHYSICIST

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Purpose

To discuss the role and importance of physicist in setting up prostate permanent seed implant clinical procedures and implement the related safety polices, includes commissioning, customizing the quality checking (QA) protocols, planning evaluation &reporting and radiation safety polices.

Materials and Methods

The entire procedure is based on TRUS images, Ex-3 stepper (CIVCO-USA) assembly and mechanical grids. It is vital to check the routine quality on regular image quality and reconstruction geometry of ultrasound images. The stepper assembly with the image coordinates system and the physical grid positioning with respect to software grid alignment should be checked as a part of commissioning and reported. To perform routine and commissioning procedure, in-house QA phantom was designed and routine QA protocols are planned.

Results

Six patients have been treated and the results are as follows:

1. Activity Dosimetry

Calibration factor from single calibration seed (mean +STDEV) = 0.0092787+0.00007018 U/pc). Activity deviation for clinical seeds for four studies (Max deviation, mean deviation in %) are (-2.2,0.42%), (4.07,0.38%), (4.92,3.77%),(-2.68,-0.34%).
Our clinical data are relatively much lower to other institute for estimating the linear regression calculation. The regression factor (R^2=0.9964) and slope (a)=0.4624 and b=15.955 which is comparable with published data of another institute (a=0.52: b=10.5).

2. Dose reporting

V90% prostate &plan indices
All Initial (day-0) V90 > 100 % - V90 % dose for all plans (day-0, CT day-0, CT day30), 73 % of plans covers more than 98% prostate volume, 93.3% plans more than 90%.
Plan quality indices for all plans (v90/v150) is noted (mean ±STD) as 1.656165 ± 0.161 (> 1.4 -Our set indices).

3. Segment analysis

out of 180 segments, 86.7 % segments, prostate V90 >98%, 88.3% of segments> 90 % and 5 % segments below 80%.
Comparatively base segments are poor coverage (ant and left) than other segments and plan quality indices (V90/V150 < 1.2) fails mid and apex segment due to hot dose volume.

Conclusion

Six patients' data are undersized data for a clinical conclusion but it would help to improve our work practice. The routine quality checking is an essential step to improve our work practice.

ESTABLISHING A LOW DOSE RATE (LDR) BRACHYTHERAPY TREATMENT IN PROSTATE CANCER PROGRAM IN AN EMERGING ECONOMY

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Purpose

Prostate cancer accounts for about 5% of new cancer diagnosed in Oman. This is in absence of the prostate cancer screening program.
LDR prostate brachytherapy alone or in combination with External Beam Radiotherapy (EBRT) is a standard curative treatment option for localized prostate cancer patients. It is also used for salvage treatment option for local failure after EBRT.
Our institute successfully launched the first LDR brachytherapy program in the Middle East and Region.

Materials and Methods:

Establishing a new service in countries with minimal experience and exposure is challenging. The following requirements and steps to acquire them was identified to initiate the program:

- Equipment: VariSeed software, BK ultrasound system with trans-rectal probe, CIVCO stepper and table mount, penile clamp and other disposable items.
- Personnel: Qualified and experienced staffs with in-house training was provided by internal and external expertise.
- Regulatory requirements: obtaining the license to import radioactive from Government officials.
- Quality assurance: all equipment QA, radioactive seeds calibrations and brachytherapy plans were performed by Medical Physicists.
- Timeline: about 15 months from concept to start the program was due to the above-mentioned challenges.
- Seeds delivery: seeds were ordered and supplied from USA through protected item shipment and cleared by customs in Oman. On time seeds delivery was challenging in the first few cases due to this new process. After collaborating with stakeholders, transport and shipment is now delivered in a timely manner with minimal complications.

Results

Program function was successful after challenges were met. Five patients were treated so far including a salvage treatment case.
Regulatory services are not well established, necessitating extra work with government agencies to get approvals. Dummy seeds were ordered and dry runs were conducted to remove any potential obstacle before ordering actual radioactive seeds for treatment.
Challenges related to logistics and custom clearances of radioactive seeds were resolved by communication with airline and organizing shipment delivery during working hours.

Conclusions:

The LDR brachytherapy treatment was successfully launched in Oman. This abstract provides a glimpse of some of the challenges and how it was resolved in a country where this program was not already established.

GATE MONTE CARLO APPROACH TO HETEROGENEITY DOSE DISTRIBUTION IN SMALL FIELDS USED IN RADIATION THERAPY

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Introduction

External beam radiation therapy is a widely used technique for cancer treatment, aiming to deliver a maximum absorbed dose to the tumor while minimizing damage to healthy organs. Treatment techniques have evolved to improve dose accuracy and reduce toxicity. However, current analytical methods used in treatment planning systems (TPS) have limitations, especially in the presence of heterogeneities.

Purpose

The objective of this study is to compare the accuracy of MC dose calculations with the Acuros algorithm, a rapid calculation method employed in external radiotherapy treatments. The focus is on evaluating dose variations in heterogeneous regions of the chest, specifically in lung, bone, and heart tissues, using two different phantoms.

Materials and Methods

The study utilizes GATE simulation platform, specifically version 9.2, which offers enhanced capabilities for modeling radiotherapy systems. The simulations were performed on a supercomputer, considering a 6MV photonic energy in Flattening Filter (FF) and without Flattening Filter (FFF) modes. Two phantoms, representing the chest region, were used to verify dose calculation algorithms along the depth axis.

Results

The results of this study provide detailed insights into the comparison between GATE and Acuros in terms of percentage depth dose (PDD) calculations for different field sizes and heterogeneous regions. In the right part of the chest phantom, the comparison of PDD curves revealed significant differences between GATE and Acuros in the heterogeneous regions (upper bone, lung, and lower bone) as well as in the surrounding homogeneous regions. The discrepancy between the two algorithms was more pronounced in the smallest field size and gradually decreased as the field size increased.

Conclusion

Monte Carlo (MC) calculations demonstrated better accuracy in dose predictions compared to the Acuros algorithm, particularly in the presence of heterogeneities. The findings support the use of MC calculations for improving treatment planning accuracy and optimizing external beam radiation therapy. Further research and validation are necessary to fully integrate MC methods into clinical routine.

A CLOUD-BASED MONITOR UNITS (MU) CALCULATOR FOR CLINICAL ELECTRON BEAMS

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Purpose

The aim of this program is to establish a user-friendly web application to help clinicians and physicists to execute electron beam treatments automatically as a second check software for manual conventional MU calculations.

Materials and Methods

A python-based environment (Stream lit) was used to make a user-interface which consists of several factors used to calculate the MU of the clinical electron beams. These factors include prescribed dose, output factor, the effective SSD, cut outs and the prescribed isodose line. The program went for validation under different conditions, namely, different SSDs, different output factors (i.e. with different applicator sizes and different energies), and different prescribed doses to examine expected dose from the program with the measured one.

Results

The primary measurements were taken at 90% depth dose and 100 SSD for 100 cGy dose with different electron energies and applicator sizes. The differences between the expected dose and the measured one was within 3% - 4% for 9 MeV and 15 MeV respectively. The smallest difference was found with 20 MeV, due to its extended PDD peak. However, the most notable difference was found with the 6 MeV energy when using small applicators (e.g. 6x6 cm^2 and 6×10 cm^2) where it reached 4.4% and 4.3% difference, respectively.

Conclusion

Based on the results we conclude that this web application is valid to perform electron monitor unit calculations. Future work will be done by using integral algorithm to account the dose at several points rather than at one point.

DEVELOPMENT OF BLUETOOTH WIRELESS 1D AUTOMATIC MOTORIZED WATER PHANTOM FOR ABSOLUTE DOSE MEASUREMENT

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Purpose
Main purpose of this study was to develop indigenously Bluetooth wireless 1D automatic motorized Water Phantom for absolute dose measurement and hence to make a comparison of the result with the IAEA recommendation (TRS 398) for daily QA of Linac.

Material and Methods
Bluetooth wireless 1D automatic motorized water sensor-based water phantom has been fabricated. The X-direction chamber movement was operated by the DC stepper motor. The chamber movement was controlled by the computer software programme based microcontroller used to accurately move the chamber with 0.01mm steps. The water phantom was fabricated with 10mm tissue equivalent material 30x30x30cm^3. Bluetooth hand controller provided to make the accurate chamber movement very easily with touch screen. Once switch ON the device all the displays will be appeared and the chamber will be aligned in the preset home position. Once touch the water sensor button, the chamber assembly will start to move and stop the movement when it touches the water. Mechanical motor movement assembly was made of acrylic sheet and stainless-steel. The automatic motorization feature allows for precise movement and positioning of the water phantom, reducing human error and improving reproducibility.

Results
We have measured and compared the absorbed dose, PDD, Isodose profile for different filed sizes and Off-axis ratio data of the ID phantom with PTW beamscan RFA. This study revealed that the Bluetooth 1D water phantom is equally good positional accuracy when compared with the PTW RFA. Furthermore, we will explore the practical benefits of this technology in absolute dose measurement. The automation and wireless connectivity eliminate the need for manual adjustments and measurements, resulting in time savings and increased throughput in clinical settings.

Conclusion
The development of the Bluetooth wireless 1D automatic motorized water phantom represents a significant leap forward in the field of radiation therapy. By combining automation, wireless connectivity, and precise motorization, this technology offers a convenient and accurate solution for absolute dose measurement. It is also known that the newly developed1D water phantom is low cost, fast, accurate, simple, easy set-up, which have the provision to Scan in stepping or continuous motion and user-friendly software.

EVALUATION OF A NOVEL SOLID MRI AND CT FIDUCIAL MARKER FOR MRI FUSION IMAGING AND IMAGE REGISTRATIONS IN RADIATION THERAPY

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Introduction

The objective of this study is to introduce and highlight the innovative features and capabilities of the indigenously developed solid MRI and CT fiducial marker for MRI fusion imaging. This marker system represents a remarkable achievement in research and development, showcasing the capabilities of local expertise in medical technology innovation.

Purpose

The purpose of this work was to develop a novel biocompatible solid MRI, CT fiducial marker that prevents radiopaque imaging artifacts and maintains high imaging contrast for MRI fusion imaging and image registrations in radiation therapy.

Material and Methods

A novel solid MRI and CT fiducial marker was fabricated indigenously from the natural plants extract and used to assess the higher visibility in different types of the MRI imaging sequences and CT imaging to find the best suitability for the kilovoltage CT image registration in radiation therapy. The natural plants extract has been collected from many plants and mixed in different combinations with different percentage. All the different percentage extracts were made like 4mm solid ball and placed over the circular water phantom. Image artifacts were quantitatively assessed in terms of the metal artifact index (MAI) on kilovoltage computed tomography (CT). Marker visibility was evaluated on two types of kilovoltage planar X-ray images in terms of the contrast-to-background ratio (CBR).

Results

The basic characteristics of this marker system were investigated by assessing major sources of image contrast in all the modalities like density and T1 & T2- weighted image and CT image in comparison with commercially available markers. The natural plants extract had good contrast similar to that of the commercially available MRI and CT fiducial marker.

Conclusion

We developed biocompatible natural plants extract MRI and CT fiducial marker, artifact-robust, higher visibility and compatibility in the multimodality fusion imaging. It represents a significant advancement in the field of medical imaging, particularly in the context of MRI fusion imaging. Its unique characteristics and compatibility with both MRI and CT scanners make it a promising tool for enhancing the accuracy and precision of image registration. The natural plants extract solid fiducial markers are cost effective, non-radioactive, easy to handle and environmentally friendly.

CLINICAL EVALUATION OF IN-HOUSE HDR SURFACE APPLICATOR AND FLEXIBLE CATHETER FOR BRACHYTHERAPY

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Introduction

The present study was to clinically evaluate the indigenously fabricated human tissue equivalent HDR surface applicator and flexible catheter for brachytherapy.

Purpose

The main purpose of the study was to fabricate indigenously the human tissue equivalent HDR surface applicator and flexible catheter for HDR brachytherapy and evaluate clinically.

Materials and Methods

The HDR surface applicator has been fabricated indigenously using different combination of polymer, silicon and paraffin oil in well predetermined ratio to achieve the flexibility and tissue equivalence. Self-cutting lines were made each 1cm, this will help to customize the applicator for the individual size of the tumour. The size of the applicator fabricated in different sizes with different dimensions of $10x10cm^2$, $20x20cm^2$ and $^{30}x30cm^2$ with the thickness of 1cm and 0.8cm. HDR flexible catheters were fabricated using polyurethane Tube and placed inside the applicator at the middle. This allows the HDR remote afterloader to maintain a consistent source-to-tissue spacing of 5 mm.

Results

HDR surface applicator has the maximum of 30x30cm size and 30 possible treatment channels with a potential for 100 dwell positions per channel and a wire positioning accuracy of ±1mm. This can be cut to match the target size and ideally suited for large lesions that are difficult to cover, such as on the skull, face, chest wall. Both were used placed over the tissue equivalent phantom and connected with the HDR machine. Source transferring tubes were connected with the catheter. Gafchromic film were placed above and below to the applicator. Gafchromic film was scanned after the HDR treatment completed. The scanned film dose was compared with TPS calculated dose distribution and dwell position also compared. We found that, all the results were comparable and the percentage deviation is ±1.8.

Conclusion

Indigenously fabricated human tissue equivalent HDR surface applicators and flexible catheters are cost effective, transparent, sticky in nature, biocompatibility, dimensional stability, non-toxicity to tissue, flexibility and easily curved to match the target surface.

EVALUATION OF THE LOW DOSE FOR VMAT AND IMRT TECHNIQUES WHICH USED IN BREAST CANCER TREATMENT

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Introduction

The most common malignant tumors in women are breast cancer. The three primary treatment modalities for breast cancer are surgery, chemotherapy, and radiation therapy. External beam radiotherapy has an effective role in local recurrence control. In clinical photon beams, the dose outside the geometrical field limits is produced by photons originating from (i) head leakage, (ii)scattering at the beam collimators and the flattening filter (head scatter) and (iii) scattering from the directly irradiated region of the patient or phantom (internal scatter).

Purpose

The main aim of this work is to compare the low doses absorbed during the treatment of a breast lesion delivered using (VMAT) and (IMRT) techniques.

Materials and Methods

Twelve patients with right-sided breast cancer who underwent modified radical mastectomy were eligible for the study.

Results

DVH used to examine the dose distribution for the planning target volume, organs at risk and low dose (V2, V5). VMAT plans increase dose for PTV where 95% of prescribed dose cover 95% (V95) of Chest wall (PTV C. W) when compared with IMRT plans (P-Value 0.02476). Mean dose of heart was significantly decreased in IMRT plans when compared with VMAT plans (P – Value 0.00608). VMAT plans was equivalent or superior to IMRT plans in dose distribution, and was associated with highly advantage in sparing of the ipsilateral lung (P – Value 0.00028). VMAT plans decrease low dose (V2, V5) for normal soft tissue when compared with IMRT plans (P-Value 0.0002) (P-Value 0.0374).

Conclusion

Based on our data, VMAT present a significant advantage among the competing techniques. Oncologist should be alert of the possibility of significantly increasing the secondary cancer risk. Our results revealed that VMAT should be the first choice for patients with right-sided breast cancer.

INVESTIGATING THE USE OF OCTAVIUS 4D PHANTOM FOR PATIENT PRE-TREATMENT VERIFICATION OF MODERN RADIOTHERAPY TECHNIQUES DELIVERED BY VARIAN HALCYON ACCELERATOR

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Introduction

The individual patient quality assurance (QA) process becomes a vital step to assess the radiation dose distribution delivered to the patient during modern radiotherapy techniques such as intensity-modulated radiation therapy (IMRT) and volume modulated arc therapy (VMAT).

Purpose

This work aims to investigate the patient dose verification of IMRT and VMAT delivered by Varian Halcyon accelerator using a commercially available PTW Octavius 4D-729 system equipped with Verisoft software.

Materials and Methods

The Octavius 729 2D detector array is consisted of a matrix of 729 ionization chambers separated by a 10 mm distance from center to center, embedded in a 27×27 array. Each chamber has the cubic size of 5×5×5 mm^3 and the effective measuring point is 7.5 mm below the surface of the detector array.
Twenty complex IMRT and VMAT cases (lung (7), breast (6), head and neck (H&N) (4) and prostate (3)) were planned using Eclipse treatment planning system (TPS). Measured and calculated dose distributions were compared using both 2D and 3D global Gamma index method. The comparison was performed using 3%/3 mm and 2%/2mm as acceptance criterion. VeriSoft software package was used to perform the gamma analysis, where Gamma index was calculated for reconstructed dose distribution in all three axes, 2D, and 3D.

Results

A good correlation was observed between the measured and calculated dose distributions in most of the treatment plans. The obtained results show that the percentage of the success agreement of the Gamma index is (all 20 cases) (98.0±1.8) % for 3D compared to (95.0±4.3) % for 2D for the 3%/3mm criterion. While, for the 2%/2mm criterion, the percentage of the success agreement of the Gamma index decreased to be (90.0±5.4) % for 3D and (85.0±8.1) % for 2D Gamma index analysis.

Conclusion

The results showed that Octavius 4D phantom, with 2D-Array 729, can be an effective and efficient verification system for patient specific QA. The Octavius 4D phantom is a suitable tool in the dosimetric verification of the IMRT and VMAT delivered by Varian Halcyon accelerator. However, these results reflected the need for a deeper investigation about the criterion requested for the acceptance of the modern radiotherapy techniques.

TOWARDS EQUITABLE TREATMENT PLANNING TASKS DISTRIBUTION: KING FAHAD SPECIALIST HOSPITAL, DAMMAM EXPERIENCE

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Introduction

At our institution, treatment planning is carried out by five physicists and 2 dosimetrists. In addition to treatment planning, dosimetrists are involved in contouring of organs and in treatment planning quality assurance. Physicists, also, perform routine equipment quality assurance tests, administration, and teaching and training.

Purpose

The aim of this work is to create an application for distributing planning tasks among staff based on a points-earned system.

Materials and Methods

An inhouse web-based application was developed that randomly assigns new treatment planning requests to a planner following a "gaussian-like" sampling distribution. The application is hosted on a server within our local-area network and accessible from all other computers through a web browser. The sampling distribution is based on a points-earned system that individuals acquired from previous completed plans treatment plans and completed tasks. Each plan-type and site weigh a defined score depending on plan complexity and urgency. None-planning tasks, such as quality assurances tests and teaching/training activities are also assigned a score that is defined based on estimated times required to complete a specific task.

Results

In our department, we have been using the application for distributing treatment planning requests since Feb 2021. Currently, there are 131 tasks available that fall under 16 Groups covering quality assurance, administration, education, and development. Also, there are 176 plan types that cover 70 treatment sites. Several aspects were taken into consideration when developing our application; (1) logging of data needs to be simple and efficient (utilize dropdown menus and buttons); (2) expandable and dynamic; (3) availably at every workstation in the department; (4) logged data is transparent; and (5) creative to suit our needs. Moreover, individuals are able to obtain their "portfolio" with records of all plans and tasks done by them. The logged data also illustrates the dynamic role of medical physicists in the clinic that is usually not apparent to the hospital administration.

Conclusion

The use of our in-house developed application has considerably reduced stress and conflicts within our staff. It has also created a "gamification" environment that enhanced productivity and made work more enjoyable.

THE ROLE OF DOSE RATE AND GANTRY SPEED VARIATIONS IN PROGRESSIVE RESOLUTION OPTIMIZER (PRO) AND PHOTON OPTIMIZER (PO) ALGORITHMS FOR RAPIDARC™ VOLUMETRIC MODULATED ARC THERAPY DELIVERY

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Introduction

The study was performed to assess and compare the performance of two different RapidArc™ optimization algorithms such as PRO and PO by changing the Gantry speed and Dose Rate technical parameters. Additionally, the study aimed to assess the plan quality, agreement between plan delivery and TPS calculation, technical delivery performance using with trajectory log files.

Materials and Methods

Total five patients selected for this study from each site: Brain, Head and Neck, Hodgkin's Lymphoma, Advanced Right Lung, Ca cervix. The RapidArc™ plans were generated using Varian Eclipse TPS v15.6 PRO and PO algorithms with maximum range of Dose Rates (DR) from 100 to 600 MU/min, minimum 0.5 and maximum Gantry Speed (GS) fixed at 6.0 deg/sec. The reference plans were created for all patients by PO algorithm with GS 6.0 deg/sec and DR 600 MU/min, other plans were re-optimized using same dose constraints and objectives, for each patient 24 plans were generated and total 120 plans were created. Pretreatment gamma verification were performed using Portal dosimetry and ArcCheck to assess deliverability and accuracy. Plan quality scores were analyzed using target and OAR's values. Trajectory log files from Truebeam LINAC controllers were collected and analyzed to verify delivery performance.

Results

The result of the study shows: (i) Plan quality values both algorithms achieved similar results and no significant differences were observed; (ii) Closely similar results of dynamic range MU/deg is achieved across all dose rates with both gantry speed modulation and the values range from 2.244±0.38 and 2.027±0.35 (iii) Total mean Monitor Units (MU) for PO maximum is 14 % higher than the PRO; (iv) Reduced total beam on time is a major benefit of high DR and GS compare to constant DR and GS; (v) DR has higher priority over GS modulation and compensation mechanism adjustment between both algorithms are different for higher DRs. (vi) Pretreatment quality assurance in gamma evaluation (1 % & 1 mm) using Portal dose and ArcCheck analysis shows a maximum difference of 15 % in slow GS compare to max. GS. For both PO and PRO (vii) Trajectory log files maximum deviations observed for gantry positions, MU and DR results for PO and PRO were -0.1 deg, -0.03, 88.17 MU/min and -0.12 deg, -0.03, 83.84 MU/min respectively.

Conclusion

These results show that new PO algorithm is either clinically beneficial or neutral in terms of plan quality and efficiency in comparison to PRO. The parameters GS and DR in optimization engine might be undeviating for those variables and capable of generating plans unaided from the limits chosen. The pattern of DR variation between adjacent Control Points in PO was significantly different than PRO.

VERIFICATION OF THE ACCURACY OF DOSE CALCULATION ACCORDING TO THE DPM CODE COMPARED TO THE PENELOPE CODE USING THE PRIMO PROGRAM

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Introduction

The PRIMO program simulates the dose distribution in the field of external radiotherapy. It provides the calculation of the dose distribution in a water phantom and in a multi-layer phantom which is comprised of different materials and in computerized tomography. It also contains a set of various tools for analyzing and representing the data that was created. PRIMO has two engines PENELOPE and the Dose Planning Method (DPM). DPM represents one of Monte Carlo fast codes compared to PENELOPE.

Purpose

In this study, we evaluated the accuracy of dose calculation using the DPM compared to Penelope in the PRIMO program and assessed the impact of bin size dimensions on the accuracy of the dose distribution.

Materials and Methods

The Varian Clinac 2100 with 6 MV energy was simulated using PRIMO. The dose calculation was performed using both DPM and Penelope. The percentage depth-dose (PDD) curves in water and multi-layer phantom were compared for irradiation field sizes between (1x1 – 10x10) cm^2. The lateral dose profiles were compared using gamma index 1%, 1 mm. Also, an experiment was conducted within a water and multi-layer phantom using a field size (10x10) cm^2 to compare the effect of bin size on the accuracy of dose distribution for bin sizes (0.2 – 2) cm^3.

Results

Our results showed that there was a 99% correlation between Penelope and DPM when comparing the PDD curves in water and the multi-layer phantom. The lateral dose profiles showed a similarity of 95.45% to 100% for all field sizes and depths studied, except for the 10x10 cm^2 field size where we noticed a similarity of 92.93% and 93.94% at depths of 30 cm and 20 cm, respectively. Within the multi-layer phantom, the average difference between the two codes did not exceed 0.5% for all field sizes except for the 1x1 cm^2 field size, where the average difference was 1.49%.

Conclusion

We concluded that DPM can be used as a fast and accurate method for dose calculation compared to Penelope. However, an increase in bin size dimension resulted in an overestimation of the dose within the build-up and heterogeneous regions.

COLLECTION OF PERCENTAGE DEPTH DOSE FOR PINNACLE TREATMENT PLANNING SYSTEM FOR USE WITH VARIAN LINEAR ACCELERATOR

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Introduction

One step in the commissioning process of a linear accelerators (LINAC) is to collect and validate beam data of the LINAC with the treatment planning system (TPS). In many cancer research centres worldwide, Pinnacle TPS is the preferred products since it is a fast, accurate and interactive treatment planning tool. Percentage depth dose (PDD), profile output and output factors are the data required for commissioning Pinnacle TPS. The measurement of PDD is an essential parameter in the commissioning process of the LINAC.

Purpose

A validation measurements of beam PDD were carried out on Pinnacle TPS in a local hospital in Oman.

Materials and Methods

The PDD value was measured for a LINAC (Varian Truebeam) with 6 MV photon energy field defined by two methods: changing the jaws (3×3, 5×5, 10×10, 20×20, 30×30, and 40×40) cm^2 while fixing the multileaf collimator (MLC) retracted and by changing the MLC (3×3, 5×5, 10×10 and 15×15) cm^2 while fixing the jaws at (20×20) cm^2. The other parameters: energy = 6MV, dose rate = 600 Gy/h, source-to-surface distance = 100 cm, and highest monitor unit (maximum) were fixed. Two ionization chambers were used: field and reference ionization chambers (PTW Semiflex 3D Ion Chamber), and with using PTW water tank phantom. The analysis were carried out using PTW MEDPYSTO software. The PDD from the above-mentioned field sizes were compared with the golden beam data provided by the LINAC manufacturer.

Results

The results reported a PDD value of 66.2% at 10-cm depth for reference field size of 10×10 cm^2, which is within 0.3% of the limit (66.4%). Additionally, reported PDD for other field sizes were: 60.4% for 3×3 cm^2, 62.5% for 5×5 cm^2, 69.3% for 20×20 cm^2, 71.0% for 30×30 cm^2 and 71.7% for 40×40 cm^2.

Conclusion

All measured value were withing golden beam data limits. To conclude, the measured PDD have a good agreement with the manufacturer guideline.

HIGH RESOLUTION 3D INVIVO DOSIMETRY FOR ADAPTIVE RADIOTHERAPY

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Purpose

To enable adaptive radiotherapy high-resolution 1D/2D/3D Dosemappers recently proposed using micro-silica bead thermoluminiscent detectors (TLDs) for invivo dosimetry. Measurements made inside or on the patient's body as recommended by IAEA.

Materials and Methods

Characterization measurements performed utilizing a range of modalities and energies of clinical beams: photons, electrons, proton, neutron, carbon ions and HDR brachytherapy sources of Co-60 and Ir-192. Results encouraged investigation into their different clinical dosimetric applications including small-field dosimetry, patient specific treatment plan dosimetry verification by performing line profile dosimetry, a postal dosimetry audit program of lung SBR techniques within 20 radiotherapy departments in the UK, and 1D, 2D and 3D Dosemapperse created for high-resolution direct in vivo dosimetry for patients' treatment with kV x-ray beams and Co-60 HDR brachytherapy.

A fully automated reader also designed, prototyped and CE marked. All the bead arrangements and the reader are patented.

Results

The results in many cases offer better performance in comparison with other commonly available TL dosimeters including batch homogeneity, linear response from mGy to 100 Gy, independent response from dose rate and angle of incident beam, lower fading high precision (±3%, k=2) and high resolution (down to 1mm) dose mapping enable adaptive radiotherapy.

The speed of readout is some 10-fold greater than that of commercially available TLD readers.

Conclusion

Micro-silica beads dosimetrically characterized as TLDs. Multidimensional Dosemappers and a fully automated reader are made and CE-marked to allow for adaptive radiotherapy. Relevant patients in USA, EU, China, and India. These innovations have won a series of UK awards and grants.

COMPARISON OF BLADDER AND RECTAL DOSES USING SINGLE CHANNEL AND MIAMI MULTICHANNEL VAGINAL APPLICATOR IN HDR BRACHYTHERAPY

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Purpose

To retrospectively compare the potential dosimetric advantages of a multichannel vaginal applicator vs. a single channel one in intracavitary vaginal high-dose-rate (HDR) brachytherapy after hysterectomy, and evaluate the biological effective dose and equivalent dose 2 Gy per fraction.

Materials and Methods

We randomly selected 10 patients for single channel and 10 patients for Miami multichannel applicator with endometrial carcinoma, who received adjuvant vaginal cuff HDR brachytherapy. The diameter of both applicators was 25 mm. The treatments were planned by CT simulation in each fraction of vaginal brachytherapy. Firstly, a standard single channel treatment plan was carried out to the prescribed depth with the goal of providing maximal coverage to the tumor bed i.e. 5mm CTV typically. Doses to the bladder and rectum were also recorded by the Dose Volume Histogram (DVH). A second treatment plan was generated using a miami multichannel approach. The brachyvision brachytherapy planning system was used to generate both single and Miami multichannel inverse treatment plans. The target coverage percentage and doses to the bladder and rectum were optimized.

Results

Dose-volume-histogram (DVH) improved the dose coverage for clinical-target-volume in Miami multichannel approaches comparing to single channel applicator. For the organs-at-risk rectum and bladder, the use of multichannel applicator demonstrated a noticeable dose reduction, when compared to single channel. For D2cc of rectum, an average fractional dose of 549 ± 4.15 cGy resulted for single channel vs. 538 ± 3.09 cGy for multichannel. For D2cc of bladder, an average fractional dose of 555 ± 4.50 cGy resulted for single channel vs. 548 ± 2.60 cGy for multichannel. The dosimetric benefit of each fractional planning was demonstrated.

Conclusions

Endometrial HDR brachytherapy using a multichannel vaginal applicator and inverse planning provides dosimetric advantages over single channel cylinder, by reducing the dose to organs at risk without compromising the target volume coverage, but at the expense of an increased vaginal mucosa dose.

IMPROVING PATIENT POSITIONING ACCURACY IN IMAGE-GUIDED RADIOTHERAPY USING ALIGNRT INBORE

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Introduction

Image-guided radiotherapy (IGRT) requires precise patient positioning to ensure optimal target coverage while minimizing exposure to healthy tissues

Purpose

The absence of couch rotation correction capability in bore-based Linacs, such as Ethos, might challenge achieving accurate patient alignment. Surface-guided radiotherapy (SGRT) on closed-bore Linacs can potentially overcome this challenge. This study aimed to evaluate the effectiveness of AlignRT InBore, a novel SGRT solution, in conjunction with IGRT to improve patient positioning accuracy and consistency during treatment on Ethos.

Materials and Methods

AlignRT InBore consists of two sets of cameras, including three ceiling-mounted cameras for initial patient setup outside the bore and a ring-mounted camera system inside the bore for intra-fraction monitoring during beam delivery. The study included one rectal cancer patient with a challenging setup who underwent 28 fractions of treatment with a total dose of 50.4Gy. To assess the impact of SGRT, six fractions were administered without AlignRT InBore, utilizing standard laser-based positioning. On the other hand, AlignRT InBore was used to position the patient during six other fractions without relying on tattoos. Following the initial setup, a CBCT was performed to match the patient's position and –when using SGRT– a reference capture was taken to monitor the patient using the ring-mounted camera throughout the treatment.

Results

The results indicated that using AlignRT InBore slightly reduced the average translational magnitude of CBCT shifts and significantly reduced the residual rotation misalignment, particularly in the pitch axis by 3.7°. Additionally, the total treatment time was reduced by an average of 25%. Notably, using SGRT during patient setup eliminated the need for repeated setup or CBCT imaging in all six treatment fractions. In contrast, three out of six fractions administered without surface guidance required repeated setup and imaging due to significant patient misalignment.

Conclusion

These findings suggest that AlignRT InBore could improve patient positioning accuracy and consistency during treatment on Ethos, particularly for patients with challenging setups. In addition, the results of this study offer a proof of concept for future research involving larger patient cohorts and diverse treatment sites to improve the quality of radiation therapy treatments as a whole.

ROBOTIC SRS OF MULTIPLE BRAIN CAVERNOMAS: PERSONALIZED PATIENT SPECIFIC QA WITH A 3D PRINTED GEL DOSIMETRY PHANTOM.

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Introduction

A female patient with multiple brain cavernous malformations (CM) has been referred to NSH CyberKnife® Cancer Center, Dubai, for consultation. Four CMs were identified in T1 MRI scan with contrast. One CM located in the brainstem, two located in the right occipital lobe and one in the right temporal lobe. The hospital’s Tumor Board evaluated that all CMs were surgically unresectable, and the patient should be treated with robotic radiosurgery in CyberKnife® M6, Accuray Inc.

Purpose

The aim of the study is to implement a novel personalized PSQA method with a 3D personalized gel dosimetry phantom to verify accurate and safe radiation dose delivery in robotic SRS treatment of multiple brain cavernomas.

Materials and Methods

Treatment plans were created using fixed collimators (5mm, 7.5mm) for each of the four brain cavernomas. A personalized head phantom, manufactured from the patient’s planning CT scan using 3D printing technology and bone mimicking material (RTSafe Ltd), was used for PSQA. The replica of the patient’s head was filled with polymer gel as 3D dosimeter. The phantom was positioned on the robotic treatment couch using exactly the same immobilization devices used for the patient’s setup. PSQA plans were delivered using the 6D skull tracking method. A T2 MRI scan of the phantom was acquired (1.5T Aero SIEMENS), 24 hours post irradiation. The phantom’s MRI scan and the calculated GelDose were registered with the patient’s DICOMRT dataset. PSQA was evaluated on 3D Gamma Index analysis with passing criteria DTA(1.5mm)/DD(2%)/DT=1%.

Results

Four targets were evaluated. Mean GI passing rate was measured 97.3% (min=95.9%, max=98.6%) indicating very good agreement between the calculated RTDose and the measured GELDose datasets.

Conclusion

Based on the results of the presented study, robotic SRS of multiple brain cavernomas can be delivered accurately and safely as it was planned. The 3D printed gel dosimetry personalized phantom has been a valuable and accurate 3D dosimetry tool for pre-treatment verification in robotic SRS treatments.

DOSIMETRIC VALIDATION OF TOTAL BODY IRRADIATION (TBI) COMMISSIONED BEAM DATA

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Purpose

The purpose of this study was to validate the measured TBI beam data by comparing it with the calculated extended SSD beam parameters.

Materials and Methods

The validation was done using 10 MV at 380 cm SSD. A PTW 0.6CC farmer chamber, Markus Parallel Plate chamber, and mobile MOSFET were used in solid water phantom to measure Percentage Depth Dose (PDD), Tissue Phantom Ratio (TPR), profile, and pointe dose measurements. The following dosimetic parameters were calculated and compared with the measured values: PDD (using Mayneord formula), TPR (from the standard PDD), output. Beam Profile (10 cm depth) was measured along the gantry target direction. Monitor Unit (MU) was calculated for point doses (100 cGy) at 5, 10, and 13 cm depths at field center and two off central axis points at equal distances (30 cm). Effect of spoiler (1 cm thickness) was also investigated for transmission factor, PDD and profile to find the spoiler effect on depth doses and off axis scattering effect.

Results

PDD and TPR variations were within 2% and 1% respectively. The measured doses per MU at 10 cm depth and Dmax were 0.0672 and 0.0765 cGy/MU, respectively. The variation within the calculated and the measured outputs was 10% (0.008 cGy/MU difference). Profile flatness along patient plane for TBI condition and standard beam were found to be 110% and 110.1%, respectively. Point doses variation were within the expected doses at different depths. The deviation of farmer chamber and MOSFET measurements with the expected doses were 2.5%, and 6%, respectively. The measured point doses o off central axis deviations were 0.4% which is like the standard beam symmetry. Transmission factor was found to be 87% which matched transmission of 1 cm solid water. PDD difference with spoiler and without spoiler plus 1 cm water slab was found to be within 0.3%. The flatness of TBI condition with and without spoiler were found to be 109% and 110%, respectively. All found to be within 1%.

Conclusion

The validation of TBI beam data was carried out successfully. The measurements will be set as a baseline for future Quality Assurance of TBI.

ASSESSMENT OF DIFFERENT METHODS OF HEAD FIXATION FOR LEKSELL GAMMA KNIFE PATIENTS

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Introduction

A family of disorders known as cancer are characterized by uncontrolled cell development and have the ability to spread or metastasis throughout the body. An essential and crucial part of cancer treatment is radiation therapy. High-energy radiation is used to the cancerous tissues during radiation therapy to destroy the cancerous cells. Various intracranial targets have been treated with stereotactic radiosurgery with the Leksell Gamma Knife for many years.

Purpose

With regard to therapy, the most recent Leksell Gamma Knife (GK) generation supports both frame-based and frameless techniques. In current research the findings of retrospective research comparing thermoplastic mask fixation and 3D mask fixation for GK treatment of brain metastases.

Materials and Methods

Thirty patients with trigeminal neuralgia (TN) underwent GK radiosurgery employing the GK version 11.3.1(Icon) Elekta. In the present research, the decision for 3D mask fixation or thermoplastic mask was made on a case-by-case basis with patients' preferences taken into consideration. The 3D mask's material is checked to make sure it won't cause problems with treatment before it is put on the patients. The Elekta spherical phantom is used with an Ionization Chamber Device (PTW Semi flex 3D 31021) applied to it in order to assess the dose rate for each fixation tool.

Results

The ionization devices (PTW Semi flex 3D 31021) was used to compare dose rate for air and the materials 3D mask and thermoplastic. The dose rate for 3D and air are 0.0133, for thermoplastic and air are 0.0131, and for the 3D mask and thermoplastic are 0.0131, so that's a significant difference at level ≤ 0.05.

Conclusion

In this study, using a 3D mask during gamma knife treatment did not lead to worse results or higher rates of movement.

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BEYOND EQUIPMENT & DEVICES: MEDICAL PHYSICISTS CONTRIBUTION TOWARDS PERSON CENTERED CARE AND BUILDING SAFER RADIOTHERAPY PRACTICES.

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Introduction

Traditional Quality Assurance (QA) focuses on functional performance of equipment and is important for physical safety of patients. However, majority of incidences are not due to failure in machines but involves Man, Method and Measurements. Also, patient safety concerns do not limit to physical safety and need to consider Cultural, emotional, and psychological safety elements.

Purpose

Expanding the role of Medical Physicists in contributing towards person centered care (PCC) and overall improvement of Quality and Safety standards of the department by mitigating the major gaps identified Viz, lack of cultural competence, psychological safety, challenges with language barrier and communication.

Materials and Methods

Initiatives began with training programs on PCC, Cultural awareness, sensitivity, and competency followed by team engagement and brainstorming sessions, initiatives for enhancing internal communications, review and revision of Standard Operating Procedures adopting elements of PCC, identify methods to motivate staff and formation of committees and working groups.

Results

We could identify areas for enhancing patient safety by actively engaging Medical Physicists. We introduced Induction Buddy program and various awards including safety champion award, Voice of Customer award and Patient centric staff award. Various departmental committees and working groups were formed with active engagement of Medical Physicists including Near Miss and Incident reporting Committee and enrolled to Safety in Radiation Oncology (SAFRON) by IAEA. Failure Mode Effect Analysis is utilized for prospective risk analysis. “Connect for a purpose” is an initiative implemented, aimed at enhancing internal communication and learning cultural diversity from internal resources.

We are exploring role of Medical Physicist in transition towards PCC by Pretreatment Medical Physicist consultation and building language bank to mitigate language barrier. Tattoos are taboo in some beliefs and Medical Physicists have piloted in Surface Guided Radiotherapy for elimination of tattoos for patients who prefer tattoo less treatment.

Conclusion

Safety includes Physical, Emotional and Cultural safety and are of equal importance for healthy wellbeing. Medical Physicists, being an integral part of healthcare chain can significantly contribute to overall QA at various dimensions including person centeredness, enhance team engagement, culture of safety and prospective risk analysis besides equipment QA for safer RT practice.

PART 2:

Diagnostic Radiology

BINARY TUMOR CLASSIFICATION USING MACHINE LEARNING

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Purpose

To investigate radiomics and deep convolutional neural networks (DCNN) approaches for the classification of tumors in seven publicly available datasets.

Materials and Methods

Seven public datasets with two classes of tumors were considered: 1) low-grade glioma or high-grade glioma (369 patients, BraTS'20) 2) well-differentiated liposarcoma or lipoma (115, LIPO); 3) desmoid-type fibromatosis or extremity soft-tissue sarcomas (203, Desmoid); 4) primary solid liver tumors, either malignant or benign (186, LIVER); 5) gastrointestinal stromal tumors (GISTs) or intra-abdominal gastrointestinal tumors radiologically resembling GISTs (246, GIST); 6) colorectal liver metastases with either a 100% desmoplastic histopathological growth patterns (HGP) or 100% replacement HGP (77, CRLM); and 7) lung metastases with BRAF mutated or BRAF wild type metastatic melanoma (103, Melanoma).

Radiomic analysis was performed on 464 (2016) radiomic features for the BraTS'20 (other) datasets respectively. Random forests (RF), Extreme Gradient Boosting (XGBOOST) and a voting algorithm comprising both classifiers were tested. The parameters of the classifiers were optimized using a repeated nested stratified cross-validation process.

DCNN was performed on 2D axial and sagittal slices encompassing the tumor. A balanced database was created, when necessary, using subsampling. ResNet50, Xception, EficientNetB0, and EfficientNetB3 were transferred from the ImageNet application to the tumor classification and were fine-tuned. Five-fold stratified cross-validation was performed to evaluate the models.
The classification performance of the models was measured using multiple indices including area under the receiver operating characteristic curve (AUC).

Results

The best radiomic approach was based on XGBOOST for all datasets; AUC was 0.934 (BraTS'20), 0.86 (LIPO), 0.73 (LIVER), (0.844) Desmoid, 0.76 (GIST), 0.664 (CRLM), and 0.577 (Melanoma). The best DCNN was based on EfficientNetB0; AUC was 0.99 (BraTS'20), 0.982 (LIPO), 0.977 (LIVER), (0.961) Desmoid, 0.926 (GIST), 0.901 (CRLM), and 0.89 (Melanoma).

Conclusion

Tumor classification can be accurately performed by adapting state-of-the-art deep learning algorithms to medical contexts.

THE RADIO PROTECTIVE ROLE OF VITAMIN C IN IRRADIATED MODEL USING γH2AX MARKER FOR DNA DAMAGE IN SPLEEN TISSUE

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Introduction

The variety of lesions induced by ionizing radiation, especially γ and X-rays as a DNA damaging factor, is an intriguing feature. Biomarker for radiation-induced damage, γH2AX foci have been reported to reflect DNA double strand break (DSBs).

Purpose

To improved that the use of vitamin C was efficient in reducing cell damage by reducing free radicals and the effect of both (γ, X rays) with the same dose and variant in energy in vivo and debate to find the difference between them in statistical and practical results and to show their biological impact.

Materials and Methods

Study research 42 adult male Albino BALB/c mice randomly divided into six groups of seven mice each. Group 1 given a normal saline solution that had not been treated and exposed to radiation. Group 2 mice received intraperitoneally (i.p.) injections of vitamin C (VC) (200 mg/kg.day) for 8 days without exposed to radiation. Group 3 given radiation as a control. Group 4 exposed to X-ray radiation as a control group. Group 5 mice given the same dose of VC as group 2 mice for 8 days before being exposed to (4 Gy) of γ ray. Group 6 given a VC dose over the same time as group 1 and then exposed to 4 Gy of X-ray. All groups had been sacrificed by cervical dislocation at (1, 3, and 24 h). Post radiation mice spleen were collected.

Results

A significant difference ($P < 0.05$) between the group of VC and with a control group exposed to both (γ, X-rays) in foci forming, but there is no significant difference ($P > 0.05$) between γ and X-rays for the control and VC groups.

Conclusion

The results demonstrate that VC is a good radioprotective agent for spleen mice; the effect of (γ and X-rays) had almost the same results on the spleen with the same dose.

ESTABLISH FACILITY DRLs BASED ON CLINICAL INDICATION AND BMI CATEGORIES FOR CT SCAN

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Introduction

This study regroups most factors affecting radiation dose in CT scan examinations to establish DRLs in order to enhance the sensitivity of dose monitoring software.

Purpose

To study the effects of patient size on the CT dose indices $CTDI_{vol}$ and DLP, to develop facility dose reference values (50th percentile) based on BMI as per Qatar obesity guidelines for 5 different organ-specific Clinical Indications.

Materials and Methods

CT exams were classified into 5 different BMI categories based on Clinical Indication. The examined patient was classified as normal, overweight, obese class I, class II, and class III. The dose data were collected from the RDM (dose management software) for each Clinical indication and the image quality was confirmed as adequate for the clinical purpose. The median radiation dose indices $CTDI_{vol}$ and DLP for each BMI category, CT exam, and each CT unit were estimated.

Results

About 1743 CT exams from 2 different CT models (same vendor) in the ACC at HMC in Qatar were retrospectively collected and analyzed. 20 cases were collected per BMI, per CT unit, and per clinical indication (CT Chest, KUB, Pathology search1/G, Follow up staging, and staging), and taking normal BMI as a reference (100%), the $CTDI_{vol}$ values were increasing as the body mass index increased: overweight (∼140%), obese class I (∼180%), obese class II (∼240%), and obese class III (∼310%).In summary, overweight patients required about 40% more dose compared to normal weight patients, while obese classes I-II had about double the dose. The 50^{th}percentile values are presented for $CTDI_{vol}$, and DLP for each of the 5 CT exams, for different BMI categories and different CT scanner models.

Conclusion

A new classification scheme considering BMI, CI, and CT scan models provides a tool to perceive differences in dose metrics among patient sizes on CT body exams.

DEEP LEARNING APPROACHES FOR AUTOMATIC QUALITY ASSURANCE OF MAGNETIC RESONANCE IMAGES USING ACR PHANTOM

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Introduction

In recent years, there has been a growing trend towards utilizing Artificial Intelligence (AI) techniques in medical imaging, including for the purpose of automating quality assurance.

Purpose

In this research, we aimed to develop and evaluate various deep learning-based approaches for automatic quality assurance of Magnetic Resonance (MR) images using the American College of Radiology (ACR) standards. We trained and tested models and explored the use of pretrained models for transfer learning.

Materials and Methods

We used two-class classification models for spatial resolution and geometric distortion, and evaluated several approaches for the low contrast test, including classifying the image into 10 classes representing the number of spokes visible in the image and classifying each spoke individually as visible or not visible.
Several models, including VGG16, VGG19, Resnet50, InceptionV3, EfficientNetB0 and EfficientNetB5 were trained and tested using the corresponding slice containing the parameter measurement as input. We also explored the use of pretrained models, such as those trained on the ImageNet dataset, for transfer learning.

Results

Our results showed that deep learning-based methods can be effectively used for MR image quality assurance. Overall, for geometric distortion and spatial resolution, all of the deep learning models tested produced prediction accuracy of 80% or higher. The study also revealed that training the models from scratch performed slightly better compared to transfer learning. For the low contrast, our study found that the InceptionV3 architecture outperformed other networks in terms of accuracy, albeit by a slight margin.

Conclusion

This research contributes to the field of medical imaging by providing a promising automated solution for MR image quality assurance using deep learning.

DCE-CT PERFUSION PARAMETRIC COLOUR IMAGE USING STEEPEST GRADIENT BASED ON TIME FRAME

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Introduction

Radiologists have utilized technological advancements in medical imaging modality, including improved special and temporal resolution, to assist in the diagnosis, prognosis, and subsequently management of brain tumours.

Purpose

The goal of this research is to use the steepest gradient technique, which is based on the timing of tracer transit, to create a pixel-by-pixel perfusion map colour image of brain.

Materials and Methods

Dicom pictures were created after injecting a tracer. Several hemodynamic parameters, such as blood perfusion, used to describe the microvasculature within a specific region of interest (ROI) are evaluated using CT scanning and the steepest gradient technique.

Results

A parametric blood perfusion image that was divided based on high and low blood flow within the brain map was effectively created through the application of the steepest gradient approach.

Conclusion

According to the results of this study, the blood flow colour image may be created using the steepest gradient approach, enabling radiologists to make diagnoses, predict outcomes, and determine if a brain tumour would respond favorably to a certain type of therapy. The perfusion pixel-wise perfusion map image functions as a fingerprint of ROI irregularity inside the brains, assisting radiologists in differentiating between necrotic and neoplastic tumour locations and preventing arterial partial-volume averaging.

GENDER-BASED VARIATIONS IN SCAN LENGTH AND CENTERING FOR CHEST AND ABDOMINAL CT EXAMINATIONS IN HMC

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Introduction

In phase 1 of the project, chest and abdominal CT reviewed to record scan length (from scout/topogram) and actual scan acquisition along with patient centering. These parameters were recorded from consecutive male and female patients. Optimal practices in length and centering can help reduce dose and improve image quality.
Purpose The purpose of phase 2 is to measure if training and baseline data can help to improve centering related issues which happened in >80% of the patients in Phase 1.

Materials and Methods

For each patient, in phase 1 we recorded the following information at the time of scanning: date of CT examination, body part imaged, patient age, gender, body weight, and height. In phase 2 we will add Scout length, Scout start and end locations (anatomic locations), Scan length and Scan start and end locations (anatomic locations).

Results

In phase 1, more than three-fourths of the patients (76%; 760/ 1000) were off-centered, and 24% were centered correctly (240/1000). The median off-centering distance and interquartile range (IQR) for chest CT exams (22 mm, IQR) 19) was more significant than for abdominal CT (15 mm, IQR 13) (p = 0.003). In addition, off-centering below the gantry isocenter (55.9%; 559/1000) was more frequent than above the gantry isocenter (20.1%, 201/1000). Off-centering was slightly but statistically more common in chest CT (92/114; 80.7%) than in abdomen CT (668/886; 75.4%). In phase 2 we are expecting that the new data will not only assess the impact of training but also establish a reward system for the technologists who perform at a higher level with good patient positioning skills. Patients centered above the gantry isocenter also received higher CTDIvol, DLP, and SSDE than those scanned at low table height (centered below the gantry isocenter) (p<0.01).

Conclusion

Radiology department will be recommended to invest in upgrading the scanners with 3D mounted AI driven devices which have been reported in several studies as superior to manual patient positioning.

PATIENT RADIATION DOSE ASSESSMENT FROM DENTAL PANORAMIC RADIOLOGY: A PILOT STUDY

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Introduction

Panoramic dental x-ray is an important tool, which uses ionizing radiation to produce the entire mouth in one image. Depending on the patient size, the thyroid gland and the eyes may also become irradiated during dental panoramic imaging due to the scattered radiation. While the radiation dose received is low, the cumulative effect of small doses on sensitive tissues could lead to both gene mutations and chromosomal aberrations.

Purpose

The present study was performed to evaluate the radiation exposure from panoramic radiography.

Materials and Methods

The examinations were performed using digital dental panoramic unit (FONA ART PLUS, Slovak Republic). The organ radiation dose values were measured using an adult Alderson-Rando anthropomorphic head phantom. A set of 20 thermoluminescence dosimeters (type MTS-N (LiF: Mg, Ti)) were used to assess the organs radiation doses, 15 of them were positioned on different sites representing: Eye, internal ear, salivary gland, thyroid inside the phantom while the others were superposed on the phantom surface on the positions of thyroid, eyes, mouth and forehead. Three identical acquisitions were performed in order to obtain the mean value for each TLD. The applied exposure parameters were 76 kVp, 6.3 mA and the DAP value was 119 mGy.cm^2. The RadPro TLD Manual Reader and a TLD Furnace Type LAB-10/400 for annealing the TL elements were used. The TLD's calibration curve was plotted after irradiating the TLDs using an X-ray calibrated Beam type RQR6 in the Syrian (SSDL).

Results

The mean organ doses for Thyroid, Eye, Salivary gland, Internal ear were 425, 257, 896, 317 µSv respectively, while the mean surface doses for Thyroid, Eye, Mouth, and Forehead were 129, 127, 56, 255 µGy respectively. The organ doses are higher than surface doses for direct irradiation with low energy X-rays, which correlates with the fact that the internal scatter is more important than external one.

Conclusion

In spite of the low values of the measured organs' doses, it is recommended to strengthen the justification for the dental panoramic imaging in order to minimize the stochastic risk of radiation to the patient sensitive organs.

QUALITY CONTROL FOR DENTAL X-RAY UNITS IN HAMAD MEDICAL CORPORATION

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Introduction

In Hamad Medical Corporation (HMC) all QC tests in dental intraoral procedures are performed using our in-house designed smart electronic QC forms (eQC-forms). eQC-forms allow all measurements to be compared automatically to the performance limits, as well as to the baseline values acquired during commissioning, so that consistency of performance is also monitored.

Purpose

To review the Quality Control (QC) reports of QC tests performed in Hamad Medical Corporation (HMC) dental intraoral (DI) units and identify common problems and fail causes.

Materials and Methods

Data from the 2022 QC reports of 38 DI units, from six different manufacturers (Sirona, Planmeca, KaVo, Trident, Kodak and Philips) installed in 6 HMC hospitals, were included in this study. QC procedures and performance limits are according to the recently published book titled "Quality control procedures for diagnostic X-ray equipment", 2022, written by our medical physics team.

Results

The QC tests performed include tube potential accuracy, output repeatability/reproducibility and linearity, exposure time accuracy, HVL and image quality (IQ). The incidence air kerma for molar view is also compared to the respective limit. The IQ test is performed using the Leeds Test Objects TOR DEN digital phantom and the preset clinical protocol for the molar tooth of adults. The only test that failed to comply with the limits was the exposure time accuracy (in two old units). However, the interesting finding of this study was the occasional differences observed between the output and HVL values of QC tests and the baseline. This was attributed to differences in the position of the dosimeter within the radiation field, and it was verified by additional measurements.

Conclusion

Performance of the majority of DI units is within limits. Some differences observed were due to changes in the position of the dosimeter (heel effect) and not to changes of unit's performance. To avoid this, the dosimeter must be always positioned as closely as possible to the center of the radiation field.

DIGITAL RADIOGRAPH REJECTION ANALYSIS DURING "CORONAVIRUS DISEASE 2019 (COVID-19) PANDEMIC" IN A TERTIARY CARE PUBLIC SECTOR HOSPITAL IN KHYBER PAKHTUNKHWA PROVINCE OF PAKISTAN

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Introduction

Ionizing radiations are employed in diagnostic imaging to perform various procedures of patients to produce good quality radiographs which help in diagnosis and treatments of various diseases. The employment of reject analysis as part of overall Quality Assurance program in clinical radiography services is to produce consistent high- quality radiographs at a minimum exposure to the patient. Reject analysis not only reveals the basic causes of rejection but also highlight the technical gaps as well which can be addressed effectively by conducting skill enhancement trainings as per modern trends and techniques.

Purpose

Evaluation of X-ray reject analysis is an important quality parameter in diagnostic facility. The aim of this study was to find out the radiograph rejection and its causes during the coronavirus disease 2019 (COVID-19) pandemic as there was fear of coronavirus disease infection among the technical staff from the incoming patients in a busy, high volume public sector tertiary care hospital.

Materials and Methods

This descriptive study was conducted at Radiology Department, Lady Reading Hospital, Peshawar from August to November 2020. The rejected radiographs and their causes were analyzed.

Results

A total of 15,000 X-ray procedures were conducted during study period out of which 2550 cases were repeated making the total rejection 17%. Rejection in male and female were 74.3 and 25.7% respectively, while rejection in adults was (80.1%) and (19.9%) in pediatric age group of the total rejection. The main cause of rejection was positioning (30.5%), followed by artifacts (22.4%), motion (12.1%), improper collimation (10%), wrong labeling (8.4%), exposure errors (6.9%), detector errors (3.7%), machine faults (2.8%), re-request from referring physician (1.7%), and PACS issues (1.5%). In terms of body anatomical parts, the highest rejection was observed in extremities (44.1%), followed by chest radiography (23.3%), spine (11.4%), abdomen (6.4%), skull (5.9%), pelvis (4.7%), KUB (3.7%), and neck (0.6%), respectively.

Conclusion

Radiograph rejection is common problem in every diagnostic facility but significant increase in rejection was observed during the COVID-19 pandemics in our center due to positioning errors specifically because of the fear of coronavirus infection among the technical staff.

IMPLEMENTATION OF RADIATION PROTECTION PROGRAM (RPP) IN ACCORDANCE WITH REGULATORY REQUIREMENT IN A HIGH-VOLUME RADIOLOGY DEPARTMENT OF A PUBLIC SECTOR HOSPITAL IN PESHAWAR, PAKISTAN

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Introduction

The use of ionizing radiations hav47e revolutionized the modern era of medicine with greater degree of precision and accuracy but at the same its un-judicious uses pose certain biological threats to occupational staff, patients and public. Hence, to ensure safe culture towards radiation practice, implementation of radiation program within the facility plays a pivotal role both in protection of the patients, staff and public but also to fulfill the regulatory guidelines as well. The issues of radiation safety were identified by the Medical Physicists which were compiled collectively by the concerned authorities and their implementation was ensured through frequents audits and safety rounds.

Purpose

Basic purpose was to highlight the radiation safety measures taken in a public sector hospital towards the implementation of radiation protection program to ensure safe radiation culture both for staff, patients and public.

Materials and Methods

Descriptive analysis was carried out in the largest public sector hospital of KPK to highlight the radiation safety measures taken in order to implement the radiation protection program in developing safe culture toward radiation practice. The first step taken started with the operation of Medical Physics services by induction of Medical Physicists to look after issues related to radiation safety within the hospital, matters were discussed with higher authorities, immediate actions were taken and achieved considerable success towards the implementations of safe radiation culture in accordance with regulatory requirements.

Results

All the deficiencies were identified and safety measures were taken and addressed accordingly. Radiation safety culture is emerging in its true sense according to regulatory standards and radiation protection program (RPP) has been implemented in the Radiology department of LRH and its true enforcement is ensured by daily safety rounds by observing various operational aspects of RPP and technical training of radiation workers is being conducted to develop their skills regarding safe culture of radiation practice.

Conclusion

Radiation protection program has been implemented through team effort of all stakeholders as per regulatory guidelines, safety standards are being followed regarding safety of radiation workers, doctors, patients and public in general.

INTERVENTIONAL RADIOLOGISTS' RADIATION EXPOSURE DURING CT GUIDED PROCEDURES

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Introduction

In HMC a variety of CT guided interventional procedures (IP) is routinely performed, using CT fluoroscopy. During fluoroscopy, interventional radiologists (IR) remain within the CT room and close to the patient, to visualize in real-time the result of their manipulations, and the successful access of the IP target.

Purpose

The study's purpose was to quantify the radiation exposure of IRs.

Materials and Methods

Secondary radiation measurements were performed in the Siemens Somatom Sensation 64 room, using the designated RaySafe X2 detector. A QC phantom was used to mimic the patient and the CT table was lowered, as in clinical practice (to facilitate manipulations). Measurements were performed at the waist level, in four positions around the gantry that represent: A) the position where the waist of an 180 cm tall IR would be during manipulations [at a distance (SSD) 60cm from the isocenter], B) just outside gantry (SSD=80cm), C) to the edge of the gantry (SSD=110cm) and D) behind the gantry (SSD=125cm), using an axial scan protocol. In position A, measurements were performed at eye (SSD=80cm), chest (SSD=70cm) and lower leg (SSD=90cm) level, using the routine fluoroscopy protocol.

Results

1 min of CT fluoroscopy would result in about 0.27 mGy dose (IAK) at the level of the IR waist (without accounting for backscatter and lead apron attenuation). The respective values for eyes, chest and legs will be 0.17, 0.22 and 0.12 mGy. If the IR moves two steps back to the side of the gantry (D, C), its exposure reduces to 3-5% of that at position A, while staying within the room.

Conclusion

About two hours of CT fluoroscopy (100-200 IP procedures), will be required to exceed the dose limit for the eye, without lead glasses' protection. Moving two steps back when not performing manipulations remarkedly reduces the IR's exposure.

QUALITY CONTROL SERVICES IN DIAGNOSTIC RADIOLOGY AND MOLECULAR IMAGING DEPARTMENT AT SULTAN QABOOS UNIVERSITY HOSPITAL: EXPERIENCES AND ACHIEVEMENTS

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Introduction

The Medical Physics Unit at Sultan Qaboos University was established with the objective, among others, to control the quality of diagnostic imaging modalities in Department of Radiology and Molecular Imaging. Since then, the Quality Control (QC) service gradually developed in proportion to the department's expansion having state of the art imaging equipment including general X-ray, fluoroscopy, mammography, computed tomography, SPECT/CT and PET/CT.

Purpose

This work shares the journey of the QC services over the last decade driven by the medical physics team including their achievements, challenges and future plans.

Materials and Methods

Inventories of imaging equipment, QC test tools, QC reports and QC protocols, over the past 10 years, were reviewed. Number of medical physicists and faced challenges during this period were identified.

Results

The outcome of this review showed remarkable improvements in services provided to patients within the department. Sophisticated QC test tools were introduced and equipment were tested comprehensively according to international guidelines. Some old units were replaced and new equipment were introduced, led to an increase in the number of equipment over the years. Radiographers were trained and are currently performing daily and weekly QC tests. Protocols were updated and tailored to suit the technology advancements. The overall activities showed that medical physics support to radiology and molecular imaging department is necessary and shall raise the standards of the radiology quality management system.

Conclusion

Continuous review of QC program is required in the modern era of diagnostic radiology and molecular imaging with the introduction of new equipment and radionuclide therapies. Medical Physicists are the core and the strength of providing continuous quality control services within the department. This in return will promote the clinical services and research activities to align with Oman Vision 2040. It is our strong believe that we should strive for certified accreditation for our services to regulate the profession of Medical Physics in Oman and to maintain international standards of practice.

LOCAL CLINICAL DIAGNOSTIC REFERENCE LEVEL ESTABLISHMENT FROM ROUTING COMPUTED TOMOGRAPHY AT BLACK LION SPECIALIZED HOSPITAL

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Purpose

Medical exposure level of individuals as part of their diagnosis or treatment from routing computed tomography has been fluctuating. Thus, diagnostic reference level definition becomes a prime point to provide guidance on what is achievable in the day-to-day radiological practice to implement as low as reasonably achievable principle that is compatible with attaining the required image quality goals. The purpose of the study is to define local clinical diagnostic reference levels of four most recurrent scanning procedures of adult patients in Black Lion
Specialized Hospital.

Materials and Methods

A retrospective study was conducted on 400 adult patients posed for anatomic body region medical diagnosis. Patient related data were collected in terms of CTDIvol and DLP from the scanners dose-reporting page as of February 10 to June 10, 2020. The mean, St. Error of mean, range, standard deviation (Std), and quartiles (25th, 50th, and 75th) of the DLP for body regions: brain, chest, abdomen, and pelvis were computed and analyzed using IBM SPSS software version 20. The DRL labelled as the 75th percentile of DLP as to the suggestion of universal legal authorities and it compared to up to dated international dose reports.

Results

This study analyzes, medium sized (50-90 kg) adult patients having mean age of 53 (18-85) years. The local clinical DRLs of the body regions brain, chest, abdomen and pelvic were computed as 1487.30, 410.72, 688.26, and 867.90 respectively.

Conclusion

The local clinical DRLs computed divulges considerably higher for brain and pelvic diagnostic imaging procedure comparing to international DRLs. These can be reason of biological detriment, and needs optimization into the clinically needed level to realize as low as reasonably achievable principle.

SIZE-SPECIFIC DOSE ESTIMATION (SSDE) AND ITS RELATION WITH PATIENT BODY FAT USING BIOELECTRICAL IMPEDANCE ANALYSIS

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Introduction

Monitoring radiation exposure to patients experiencing CT is an ongoing concern to the scientific community. Using SSDE is more feasible than CTDIvol for setting reference levels for diagnostics. The negligence of volume in CTDIvol makes it challenging to check the reasonableness of its values when comparing thin or obese patients, so CTDIvol must be compared with SSDE to inspect the reasonableness of the CTDIvol value output by the scanner.

Purpose

The aim of this research is to efficiently estimate the SSDE index of a patient’s body fat (BF) in both the chest and abdominal CT scans.

Materials and Methods

The SSDE of a patient's BF% has been assessed by measuring it with Hand-to-Hand Bioelectrical Impedance Analysis for both chest (15) and abdominal (40) scans. The SSDE values identified from CTDIvol were compared with SSDEBF% and SSDE.

Results

A good agreement was found between SSDEBF% and SSDE for chest regions. A lower correlation was observed in the abdominal region.

Conclusion

The results were not very encouraging regarding SSDEBF, especially for the abdominal regions, in comparison with the other useful approach (SSDEBMI) for both the chest and abdomen regions. Accordingly, it is recommended to use (multi-frequency) bio-impedance spectroscopy instead of single-frequency bioelectrical impedance devices, which can be more accurate for measuring BF% values.

QUALITY CONTROL OF MRI SCANNERS USING ACR MRI LARGE PHANTOM.

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Introduction

Magnetic Resonance Imaging **(**MRI) Quality Control in Hamad Medical Corporation (HMC) was started in the last 5 years by medical physics section, eight important assessments of MR image quality are included: geometric accuracy, high-contrast resolution, slice thickness accuracy, slice position accuracy, image intensity uniformity, percent signal ghosting, low-contrast object detectability, and Magnetic Field Homogeneity. In addition, signal-to-noise ratio and central frequency are monitored as well, and all the Radiofrequency Coils are checked.

Purpose

To ensure appropriate MR scanner performance with high-quality diagnostic images

Materials and Methods

The MRI QC testing procedures were applied to sixteen MRI scanners in HMC, annually. In this report, the large MRI phantom from the American College of Radiology (ACR) accreditation program is used as the essential part of the MRI QC protocol. The specific procedures for the Quality Control Program are those specified in the most current ACR MRI QC Manual.

Results

All the MRI scanners has passed the annual QC tests, and this is due to two reasons, the first one that the QC tests are done on the day or the day after the vendors preventive maintenance (PPM) has been performed and the second reason is the established monthly QC program which helps in discovering any faulty issues before the annual testing schedule and any necessary correction of repair will be reported the vendor's engineers to do his part to repair and fix any issues such as the geometric accuracy and the image intensity uniformity. When evaluating the MRI performance using the ACR protocol, only the RF head coil is used for the monthly and annual QC testing procedures. The most common failing items are the radiofrequency coils because none of the coils was tested before the implementation of the MRI QC program, and the most important test is the Signal to Noise (SNR) for all receiving channels and compare it with the one measured during the acceptance testing of the RF coils base data.

Conclusion

The success of MRI depends on the production of high-quality images. These images must faithfully represent the anatomy, pathology and physiologic function of patients imaged.

DEVELOPMENT OF A MULTI-AGENT SYSTEM MODEL FOR OBJECT DETECTION FROM MRI IMAGES

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Purpose

To improve diagnosis accuracy and speed while reducing the time and cost of processing medical images, and therefore to treat patients more quickly to avoid disease progression, we conducted this work in which an artificial intelligence model was developed with the help of a multi-agent system (MAS).

Materials and Methods

We treated the set of cerebral IRM. The MAS are used to divide an IRM brain into several regions such as gray matter, white matter, ventricules, and tumors.

Results

Each agent may be induced to segment a certain visual region. Agents can be trained to recognize the unique characteristics of each area of a picture, such as texture, pixel density, shape, and size. The agents can communicate in order to integrate the segmentation results and generate the final picture segmentation. The agents can communicate in order to integrate the segmentation results and produce the final picture segmentation. SMAs are employed in the treatment of cerebral tumors. Agents can be created that look for abnormalities in medical images, such as masses or lesions. The agents can work together and communicate to combine the results of the tumor detection and provide the final diagnosis.

Conclusion

This model gave us good results in terms of detecting tumors and following up on their spread.

DETECTION OF STAGE OF LUNG CHANGES IN COVID-19 DISEASE BASED ON CT IMAGES: A RADIOMICS APPROACH

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Purpose

The aim of this study is to classify patients suspected from COVID-19 to five stages as normal, early, progressive, peak, and absorption stages using radiomics approach based on lung computed tomography images.

Materials and Methods

Lung CT scans of 683 people were evaluated. A set of statistical texture features was extracted from each CT image. The people were classified using the random forest algorithm as an ensemble method based on the decision trees outputs to five stages of COVID-19 disease.

Results

The proposed method attains the highest result with an accuracy of 93.55% (96.25% in normal, 74.39% in early, 100% in progressive, 82.19% in peak, and 96% in absorption stage) compared to the other three common classifiers.

Conclusion

Radiomics method can be used for the classification of the stage of COVID-19 disease with good accuracy to help decide the length of time required to hospitalize patients, determine the type of treatment process required for patients in each category, and reduce the cost of care and treatment for hospitalized individuals.

HOW THE PENUMBRA AFFECTS THE MEASUREMENT OF RADIATION FIELD SIZE AND KAP ACCURACY TEST?

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Introduction

Testing the accuracy of the displayed KAP values is very important. KAP is constant at any distance for the X-ray tube focus, and it is calculated as the product of radiation field size and the air kerma at any chosen distance. The problem is that when the image receptor is used to record the radiation field, due to the penumbra and the linear response of digital image receptors, its boundaries are not well-defined.

Purpose

The purpose of this study is to study the effect of the penumbra on the measurement of the radiation field size and DAP accuracy test.

Materials and Methods

Measurements were carried out in a Siemens Ysio radiographic unit with the distance between the focus and the portable image receptor (SID) set to 100 cm. The Air-kerma at the SID was measured using a calibrated RaySafe X2 dosimeter. To measure the radiation field size, two different tools: the Gammex 161-B plate and a commercial 50-cm ruler with radiopaque scale marks (1 mm step) were used. The X-ray field area was set to 18cm x 14cm (the standard field size of the Gammex 161-B plate). The radiation field sizes were visually assessed using DICOM images by seven medical physicists, and the mean values were used. Then the KAP values were calculated and compared with the displayed values. An external calibrated KAP meter (attached at the collimator) was used as a gold standard for testing the accuracy of the displayed KAP values. Various tube potential (kVp) and tube loading (mAs) settings were used.

Results

The maximum differences observed between the displayed and the measured/calculated KAP values were 3% for the external KAP meter, 32% for the Gammex 161-B plate and 19% for ruler. Deviations increased considerably with lower kVp settings and slightly with decreasing mAs. The minimum and maximum deviations were at 50 kV:11%- 32% for Gammex 161-B, and 8%-19% for the ruler. The respective differences at 80 kV were: 8%-27% and 5%-12%, and at 100 kV: 3%-23% and 0%- 8% for the ruler.

Conclusion

In absence of the gold standard, using a ruler and settings 100 kV, 10 mAs, provide accurate radiation field size measurements.

ASSESSMENT OF THIOL-CAPPED AuNPs AS CONTRAST AGENTS IN A MARS SPECTRA CT

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Introduction

Nanomaterials have become a promising diagnostics tool. They are used as contrast agents in imaging modalities such as computed tomography. High-Z nanomaterials such as Au are mostly used in CT imaging due to the advantage of K-edge imaging. In this work, we investigated the potential of gold nanoparticles (AuNPs) to generate contrast in spectra photon-counting CT in different energy windows.

Purpose

The purpose of this study is to assess the performance of AuNPs as contrast agents in a MARS Spectral CT scanner.

Materials and Methods

A chemical method was used to synthesize thiol-AuNPs by the reduction of gold salt with sodium citrate. The nanoparticles were characterized and scanned in a material phantom using a MARS CT scanner to obtain images corresponding to five energy windows.

Results

The TEM analysis shows AuNPs with an average size of 20 nm. The UV-vis spectrum gave a maximum absorbance at 527 nm while the crystal structure from XRD shows the characteristic peaks of gold. In the reconstructed CT images, AuNPs with the highest concentration show the highest contrast. The contrast however decreases with a decrease in the concentration of the nanoparticles. Hence, a linear relationship was observed between the Hounsfield unit and the concentration of AuNPs. The contrast from concentrations below 5mg /ml cannot be distinguished from that of water. Hence, 5 mg/ml is the minimum concentration that was visually perceived.

Conclusion

In conclusion, the synthesized AuNPs can enhance contrast in spectral CT at all energy windows. However, the minimum concentration of 5 mg/ml should be used to achieve a visible contrast. Further studies are necessary to optimize the use of AuNPs as contrast agents in vivo.

ESTIMATION OF METASTATIC LESION ON MRI IMAGES BASED ON MR SPECTROSCOPY

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Introduction

The goal of MRS (magnetic resonance spectroscopy) is to obtain metabolic biochemical information from normal and pathological brain parenchyma in a non-invasive and quick manner. It is one of the methods for obtaining metabolic data by determining the molecular structures of viable brain tissues.

Purpose

The purpose of the research was to see how accurate magnetic resonance spectroscopy (MRS) was at predicting Metastatic lesions.

Materials and Methods

A Popular Diagnostic Centre Limited enrolled patients with neuroepithelial tumors. Using the ^{1}H CSI MRS of the brain, changes were detected in the concentration of specific metabolites caused by metastatic lesions. These metabolites include N-acetyl-aspartate (NNA), creatine (Cr), and choline (Cho). The metabolic ratio was calculated using the division method for Cho, NAA, Cr, and Cr_2.

Results

The range of NAA for tumor cells was 0.63 and 5.65, 1.86 and 5.66 for normal cells 1, 1.84 and 10.6 for normal cells 2. In the tumor cell, Cho was in the range of 0.8 and 10.53, compared to 1.12 and 2.7 for normal cell 1 and 1.24 and 6.36 for normal cell 2, respectively. Cho/Cr2 was only marginally different from the other ratios in terms of significance. For tumor cells, the Cho/NAA, Cho/Cr_2, NAA/Cho, and NAA/Cr2 ratios were significant. Normal cell 1 had significant Cho/NAA, Cho/Cr, NAA/Cho, and NAA/Cr ratios.

Conclusion

^{1}H-MRSI can help improve the clinical outcome of metastatic lesions by guiding the extent of resection. MRS has the robustness to identify the presence of a tumor.

PART 3:

Nuclear Medicine

COMPARISON OF DIFFERENT THEORETICAL DOSE ESTIMATION WITH PRACTICAL PATIENT EFFECTIVE DOSE IN PET-CT ONCOLOGY SCANNING

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Introduction

Patients receive radiation doses from the radiopharmaceuticals and the CT scan during PET/CT exams. Radiopharmaceutical is administered to the patients via an automatic-injector.

Purpose

Our goal is to determine patients effective dose (ED) from the autoinjector (Intego) database and to compare the ED for each individual patient with ED values from software that is approved by the International Societies of Nuclear Medicine.

Materials and Methods

The study was conducted by collecting 146 PET/CT oncology patients undergoing whole body (18F-FDG and 18F-NAF) exams in Adan Hospital. Administered radiopharmaceutical, activities and effective dose were collected from (Intego) database, and the absorbed radiation dose. Radsis software and the SNMMI online calculator were used to calculate ED for comparison. The ED for CT was calculated using NCICT adopted software.

Results

There were 106 female patients and 39 male. For the comparison, we used the 3 softwares to calculate the PET/CT exams ED. Using the (Intego) database the ED for 18F-FDG and 18F-NaF exams for male patients was 9.82 ±1.64 and 11.2 ± 3.44 mSv respectively, for female patients the ED was 10.4 ± 3.64 and 11.8 ± 3.84 mSv respectively. Comparatively, using Radsis, the ED for 18F-FDG and 18F-NaF exams for male was 9.2 ± 2.8 and 8.82 ± 2.37 mSv and for female was 9.97 ± 3.14 and 10.37 ± 3.34 mSv. For the SNMMI calculator the ED was 9.32 ± 2.77 and 4.0± 0.7 mSv for male from 18F-FDG and 18F-NaF, and ED for female from 18F-FDG and 18F-NaF was 9.97 ± 3.14 and 8.91 ± 3.34 mSv.

Conclusion

For the Whole Body PET/CT the total ED for male using(Intego) database for 18F-FDG was close to the ED for the two other softwares while the ED for 18F-NaF was higher. The ED for 18F-FDG and 18F-NaF for female using Intego was higher with compare with the other softwares.

RADIATION DOSE REDUCTION STRATEGY FOR SPECT/CT BONE SCAN

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Introduction

The goal of optimizing the patient`s radiation dose in medical diagnostics is to achieve high quality image in the most efficient manner. The CT is justified or appropriated for the stated clinical indication and is, without doubt, the most important aspect of radiation dose optimization for SPECT/CT system.

Purpose

The aim of this study is to introduce the optimization method of CT parameters to reduce patient radiation exposure in bone SPECT/CT while maintaining image quality.

Materials and Methods

First part: Using Deluxe Jaszczak Phantom. The cylindrical phantom consisted of six bottles in a pie arrangement. These bottles were placed in the source tank. SPECT/CT scans were carried out with different x-ray tube current values at three different slices of thicknesses. The contrast ratio (CR) and coefficients of variation (COV) in the SPECT images as well as the signal-to-noise ratio (SNR) and
$CTDI_{vol}$ were all measured.

Second part: The study was done on patients who required a SPECT/CT bone scan of the spine area (thoracic spine (T1-T12) and lumbar spine (L1-L5)). Some patients were excluded from this study because of the image quality that was affected by several factors.

Different parameters obtained from the new reduced protocol were compared to old historical data saved in the system for patients who did the same image using the old standard protocol. The difference between the two systems was only in the current of the X-ray tube (the old 60 mA versus the new 40 mA).

Results

The optimal set of parameters for bone SPECT/CT was determined based on a phantom part that has been implemented in clinical practice. Two groups of patients were examined according to the baseline and optimized protocols, respectively.

The new SPECT/CT protocol substantially reduced patients' radiation exposure as compared to the old protocol, while also maintaining the required diagnostic quality of SPECT and CT images.

Conclusion

The newly established bone scan SPECT/CT protocol was implemented into clinical practice. It has significantly reduced patients' exposure dose as compared to the old protocol while maintaining the required diagnostic quality of SPECT and CT images.

3D PHANTOM MODELLING AND PRINTING FOR USE IN NUCLEAR MEDICINE QUALITY CONTROL

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Purpose

Quality control (QC) is a critical aspect of nuclear medicine practice ensuring that equipment and procedures used to diagnose and treat patients are accurate and reliable. This includes acceptance testing as well as regular calibrations. Acceptance and annual testing are usually based on international guidelines from National Electrical Manufacturers Association (NEMA) and use different types of phantoms acquired within clinical conditions. Some of these phantoms are available commercially but are sometimes expensive and some of them need to be fabricated in house. The goal of this study is to use 3D printing in order to create one phantom to be used in the System Alignment NEMA test (Center of Rotation).

Materials and Methods

A 3D phantom was designed based on NEMA specifications and printed using the MakerBot Replicator Z18 3D printer. The phantom, as shown in figure 1, contains 3 bars that can fit one capillary tube each. Horizontal distances between the end point of the tallest bar and the other two bars are 5 and 10 cm respectively. The vertical distance between bars were 7.5 cm. We tested the 3D printed phantom on a GE SPECT CT (870 DR) installed in the MINM department in Hamad General Hospital. 3-point sources (around 2 mCi each), with a maximum dimension of 2 mm was prepared inside three capillary tubes which were placed inside the three bars. The printed phantom was positioned in the plane of the three-point source holders parallel to the plane of the table and the central point source at the center of field of view (figure 2). A SPECT acquisition is then performed, and the Center of Rotation is calculated based on NEMA guidelines.

Results

Using the phantom, System alignment / COR results indicate a COR error of 3.22 mm, a COR deviation between heads of 5.94 mm, an axial deviation 0.43 mm and a relative axial misalignment of 0.32mm. These values fit within machine specifications.

Conclusion

Our 3D printed phantom is a valuable and cost-effective tool for measuring system alignment/COR. It represents an economical solution, and its straightforward design makes it easy to print.

OPTIMIZATION OF SCANNING TIME IN DYNAMIC ^{18}F-FDG PET IMAGES USING PRINCIPAL COMPONENT ANALYSIS

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Introduction

Dynamic PET imaging technique plays a key role in improving cancer diagnosis, assessing therapy response, and characterizing tumour lesions. However, it suffers from several limitations such as longer data acquisition time.

Purpose

This study aimed at shortening the total duration of ^{18}F-FDG scan while preserving the detectability of lesions.

Materials and Methods

The PET dynamic frames were generated using the 4D-XCAT anthropomorphic phantom combined with time activity curves calculated using a standard ^{18}F-FDG 3-compartment model and ^{18}F-FDG kinetic micro-parameters of different tissues. A 9 mm spherical liver lesion was inserted in the 4D-XACT phantom. The widely used STIR image reconstruction software was utilized. The principal component analysis method was applied to the simulated dynamic ^{18}F-FDG-PET images generated at different scanning times (11, 13, 15, 20, 25, 35, 40, 45, 50, and 55 min). The estimated Principal Component Images (PCIs) were visually assessed and compared to the SUMmed images (from t=35-55min). The Tumor-to-Background-Ratio (TBR) was considered in the quantitative assessment.

Results

The visual assessment of the 3 estimated PCIs and SUM images shows that PCI3 has better detectability of the tumour lesion regardless of scanning time. PCI2 shows good lesion detectability at all timing expect at 11 and 13 min, whereas PCI1 shows lower lesion detectability for all times. Quantitatively, TBR estimated on PCI3 is similar to the SUM images (TBR on PCI3 is 2.49±0.72 and 3,08±0.49 on the SUM images) but higher than on PCI1 and PCI2 from timing 11 to 35 min. TBR on PCI1 decreases with the increase in scanning time. On PCI2, TBR increases with scanning time (maximum of 3.87±1.11 at 55min).

Conclusion

The above findings suggest using PCI3 to optimize scanning time in dynamic ^{18}F-FDG PET while preserving lesion detectability. This study demonstrates that PCA allow reduction of scanning time, hence increasing patient comfort, and minimizing motion effects.

DIAGNOSTIC ADVANTAGE OF SESTAMIBI SPECT/CT OVER DUAL-PHASE PLANAR SCINTIGRAPHY IN PATIENTS WITH PRIMARY HYPERPARATHYROIDISM

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Purpose

Primary hyperparathyroidism is the 3rd most common neuroendocrine disorder. Parathyroid adenoma is the most common pathology for hyperparathyroidism. The goal of this study is to find the potential advantage of SPECT CT imaging in detecting parathyroid adenoma over planar imaging.

Materials and Methods

109 patients with suspected parathyroid adenoma underwent Tc99m Sestamibi scintigraphy during the period between Aug 2021 to Aug 2022. 9 patients were excluded from the study as SPECT CT was not done due to patient related reasons (claustrophobia, refusal) and only planar imaging was available.
Department clinical **imaging** protocol was used including neck and chest planar imaging acquired at 20 min and 2h and one SPECT CT acquired at 1 h. The reporting was done based on all information including planar and SPECT CT images. However, a separate Physician was asked to do a blinded review for planar imaging only to indicate the presence of parathyroid adenoma and then to compare that with the inclusion of SPECT CT. At a second step, he was asked to mark the advantage of SPECT CT in localizing parathyroid adenoma.

Results

Planar imaging was sufficient in detecting parathyroid adenoma in all the 100 study cases. 63 cases were positive, and 37 cases were negative. However, SPECT CT helped in a better localization in 92.08% (58/63) of the cases.

Conclusion

Although planar imaging may be sufficient in centers where they have no access on SPECT CT imaging, SPECT CT is still a valuable tool for increasing confidence in accurate localization of Parathyroid adenoma in patients with primary hyperparathyroidism. It facilitates surgical planning for minimally invasive parathyroid surgery.

CAN RADIOMICS HELP IN CHARACTERIZING METASTATIC LESIONS IN THE SPINE USING F-18 FDG PET/CT IMAGING?

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Introduction

PET/CT imaging is widely used for the diagnosis, staging, and follow-up of cancer, cardiac diseases and brain disorders. The deployment of radiomics and artificial intelligence (AI) in the medical field has grown exponentially since the year 2016. The combination of extracting radiomic features with machine learning algorithms could reveal pathological and metabolic characteristics of tumor lesions.

Purpose

The purpose of this study was to investigate the potential of radiomics to characterize metastatic lesions in the spine using F-18 FDG PET/CT imaging.

Materials and Methods

Ten breast cancer patients with multiple metastatic lesions in the spine were included in this study. Patients have undergone whole body F-18 FDG PET/CT scanning (baseline and follow-up scans). All scans were performed on the Siemens Biograph mCT 128 slice scanner. Image series were reconstructed using the iterative 'Ordered Subsets Expectation Maximization Time-of-Flight Point-Spread-Function' (OSEM-TOF-PSF) reconstruction, available on the scanner. For the extraction and selection of radiomic features, the 3D slicer tool was used to segment the vertebrae and outline the spine region on the CT images in order to extract and select the features. The segmented regions from the CT scan were projected onto the PET images. Radiomic features were extracted using the standardized 'Pyradiomics' tool. Principal Component Analysis (PCA) was used for features selection.

Results

A total of 107 radiomic features were extracted from image series; falling into six categories: shape features, first order features, gray-level co-occurrence matrix (GLCM), gray level-run-length matrix (GLRLM), gray level-size-zone matrix (GLSZM), gray level-dependence matrix (GLDM), and neighboring gray-tone-difference matrix (NGTDM). The number of features was reduced to 39 features using PCA: 14 shape, 13 GLDM, 10 GLRLM, and 2 first order features. The PCA method showed that the selected features account for 63.9% of the overall variation within patients.

Conclusion

The preliminary findings of this study suggest that the selected 39 features are the most pertinent features that characterize the F-18 FDG PET bone lesions. These findings are compelling enough support to assess this methodology on a large patient population.

BLOOD MICRO-SAMPLING: AN ALTERNATIVE BLOOD COLLECTION METHOD FOR BLOOD AND BONE MARROW DOSIMETRY FOR THYROID CANCER PATIENTS

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Introduction

I-131 is used for remnant ablation of differentiated thyroid cancer (DTC). Personalising I-131 treatment is therapeutically advantageous, however, when pretherapeutic dosimetry measurements are not possible, during-therapy dosimetry can be performed to retrospectively assess critical organs' absorbed doses, and can be used as a basis for planning future treatment. The European Association of Nuclear Medicine (EANM) dosimetry protocol, which ensures that a safe limit to the critical organs is not exceeded, mandate collecting blood sample and whole-body measurement at various time points post I-131 administration, where the blood provides a more accurate and reliable assessment. While centres employed remote monitoring for the whole-body measurements post-therapeutic administration of I-131, collecting the blood samples requires close proximity to the patient and carries the risk of high radiation exposure to staff collecting blood, especially in busy centres. Capillary blood collection is less invasive and less stressful alternative to venous or arterial blood collection, while also reducing collection time, increasing repeatability, not requiring post-collection processing, facilitating easier transport and storage, and lowering biohazard risks.

Purpose

This work proposed to establish whether venous blood withdrawal, as suggested by the EANM dosimetry protocol, may be replaced by a finger-prick blood sampling method, while maintaining the 5% acceptable uncertainty of counts required by the protocol.

Materials and Methods

Sixteen DTC patients were recruited in this study, all patients were referred to St James's hospital, Ireland, for I-131 therapeutic ablation, or thyroid cancer surveillance scanning. Thirty blood samples (finger prick and standard venepuncture) were taken post-administration of I-131.

Results

The findings show no significant difference found either between the count-rate of venous vs capillary blood types (-0.98±4.31%, p=0.223), or between 1.0-ml-blood versus blood-droplet geometries (-3.42±9.97%, p=0.070), or between their combination (-1.76±8.86%, p=0.286). The 1-ml venous-blood count-rate required by the EANM protocol can be estimated using the finger-prick blood count-rate with 94.5% predictability.

Conclusion

This study validated the use of finger-tip sampling as an alternative method of blood collection when blood radioactivity quantification is required for DTC patients. It is a faster, safer and more convenient method and, once validated, could be performed by the patient themselves.

PREDICTIVE PRETHERAPY IN BLOOD AND BONE MARROW DOSIMETRY FOR THYROID CANCER PATIENTS PREPARED WITH RHTSH INJECTION

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Introduction

Radioactive iodine (I-131) is used for remnant ablation in differentiated thyroid cancer post thyroidectomy. Tumour biokinetics have been demonstrated to alter with repeated treatments, leading to target cells becoming radio-resistant. Hence, maximising the administered activity for the first treatment is advantageous. The European Association of Nuclear Medicine (EANM) published a dosimetry procedure for differentiated thyroid cancer (DTC) patients, which allows maximising the remnant dose while ensuring that the dose received to critical organs is not exceeded, hence, reducing the risk of inducing toxicity. The administration of I-131 occurs after high Thyroid Stimulating Hormone (TSH) levels are achieved either by hormone withdrawal or by intramuscular injection of recombinant human TSH (rhTSH). Both have been shown to have equivalent results with the rhTSH approach reported to reduce morbidity and hypothyroidism symptoms. There is limited number of centres that use rhTSH as hormone withdrawal is widely implemented. Hence, there is scant literature on implementing dosimetry in patients prepared with rhTSH and the predictive power of pretherapy dosimetry has not been fully demonstrated

Purpose

This study developed an adapted version of EANM dosimetry-based treatment planning to investigate the predictive power of pre-therapy dosimetry in patients prepared with rhTSH injection

Materials and Methods

A clinical cohort study was carried out at St James's Hospital, Ireland. Maximum therapeutic activity (MTA) was estimated by whole-body counting and blood sampling at various time points post-administration of pre-therapeutic (PT) I-131 tracers (6.1±2.5 MBq). The measurements were repeated during-therapeutic (DT) post-administration of 3.9±0.2 GBq and compared. Thirteen thyroid cancer patients were recruited in this study.

Results

The findings show that the PT whole-body residence-time overestimated the DT with a -7.7±8.1% difference ($p=0.007$) while no significant difference is reported in PT vs DT blood residence-time (1.13±6.49%, $p=0.559$). There was no significant difference in the MTA between PT and DT with a reported difference of 1.7±4.8% ($p=0.241$).

Conclusion

In conclusion, pretherapy dosimetry using the EANM protocol was predictive of DT dosimetry in the cohort of this study. A larger sample is needed to increase the power of the results. The study suggests that dosimetry is feasible for all patients, irrespective of therapy preparation method.

PHANTOM BASED COMPARISON BETWEEN 18F-PSMA AND 68GA-PSMA PET/CT

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Purpose

Prostate cancer is one of the most common types of cancer in men. In order to diagnose/follow up prostate cancer patients, Positron emission tomography/Computed tomography (PET/CT) imaging is used. **Prostate-specific membrane antigen** (PSMA) is highly expressed on most prostate cancer cells. There are several isotopes that can be labelled with PSMA, for instance, 68-Ga or 18-F. In this study we will investigate the potential quantitative difference between PET/CT images acquired using either 68-Ga or 18-F.

Materials and Methods

The NEMA IEC body phantom containing 6 spheres of different sizes (ranging from 37mm diameter to 10 mm diameter) was either injected with 68-Ga or 18-F using a sphere to background ratio of around 4:1. The phantom was placed on the patient couch and imaged on the Siemens Biograph Vision 600 for 5 min (1 bed). 12 regions of interest (ROIs) and 1 ROI per sphere (covering 95% of the sphere) were drawn on the background and the 6 spheres respectively. Two parameters were then evaluated for both 68-Ga and 18-F based images. The first is the percent contrast for each sphere and the second is the background variability.

Results

For 18-F the percent contrast range was between 94.3% for the largest sphere and 86.6% for the smallest one. Regarding 68-Ga the percent contrast was between 70.4% and 37.6% respectively. For the background variability, the mean percentage was 3.9% and 2.1% for 18-F and 68-Ga respectively.

Conclusion

This study demonstrates that in 18-F PET based images, the recovered contrast was better than in 68-Ga based images. However, 18-F PET has the worst background variability. Future work will concentrate on a more complete comparison between 18-F and 68-Ga by measuring both sensitivity and spatial resolution. Moreover, patients 18-F and 68-Ga PET based images will be compared and evaluated to either have a patient specific decision on the choice between 18-F and 68-Ga or to prove the superiority of any of them.

A NEW GEANT4-BASED TOOL FOR INTERNAL DOSIMETRY CALCULATIONS: DOSECALCS

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Purpose

Specific absorbed fractions (SAF) and S-values (S), which are related to internal dosimetry, can currently be estimated using a variety of Monte Carlo tools, including MCNP and GATE, in order to prevent biological damage from being done to tissues and organs after they have been exposed to ionizing radiation. For physicists with coding skills, such tools make physics easier. However, programming and/or simulation inputs continue to be labor-intensive and time-consuming tasks.

Materials and Methods

In this study, we introduce a newly created Geant4-based code called "DoseCalcs" for internal dosimetry calculations. This code offers a variety of geometrical methods (STL, GDML, TEXT, STL, C++, voxelized, DICOM, and tetrahedral) that can be used to build the simulation geometry, as well as computational capabilities such as running with MPI or multi-threading mode.

Results

The SAFs for eight discrete mono-energetic protons which energies ranging from 0.01 to 2 MeV were estimated using the stylized ORNL female and voxelized ICRP adult female phantoms, and S-values for 18F were determined using DoseCalcs.

Conclusion

The accuracy is shown by the two phantoms' good agreement with both references, which shows its suitability for application in the estimation of internal dosimetry quantities using a variety of geometrical methods.

INVESTIGATING THE EFFECTS OF VOXEL SIZE ON RADIATION DOSE DISTRIBUTION IN ^{131}I INTERNAL DOSIMETRY USING MONTE CARLO SIMULATION

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Introduction

Iodine-131 has been a successfully and widely used treatment regimen for thyroid diseases. While conventional empirical dose calculation methods are currently used for treatment planning, they are limited in accuracy. As a result, Monte Carlo (MC)-based treatment planning systems have gained momentum.

Purpose

Due to 131I post therapy imaging being performed on a wide range of scanners from different manufacturers, a plethora of "best" voxel sizes are possible. This study primarily explores using MC simulations of a computational phantom to investigate the effects of voxel size on the radiation dose distribution in the thyroid, pancreas, kidney, heart, lung, and liver post-administration of ^{131}I in an adult female XCAT phantom.

Materials and Methods

Simulations were performed using the GATE software. Voxel dimensions in the range of 1-7 mm in the x and y directions are investigated with a matrix array size of 400 x 400 x 1600, reflective of the range of current clinical and preclinical SPECT systems. The number of events simulated was kept consistent, ($1x10^6$) for each simulation and the absorbed dose per voxel scored.

Results

The results demonstrate the dose per voxel for all organs studied decreases with increasing voxel size at voxel sizes of up to 2 mm. However, at voxel sizes larger than 2 mm this pattern becomes less evident and a convergence in the dose per voxel is observed in all the organs studied with the exception of the thyroid. At smaller voxel sizes the computation time was greater, with 358 s for the 1x1x1 mm^3 voxel dimensions and a lower 208 s for voxel dimensions 7x7x4 mm^3. Similarly, at smaller voxel sizes larger uncertainties were found illustrating the importance of the choice of voxel size in internal dosimetry.

Conclusion

Voxel dimensions have a clear influence on the calculation of absorbed radiation dose in small organs such as the thyroid. Small voxel sizes are required for imaging dosimetry studies in order to accurately calculate self dose to the thyroid. Harmonization attempts should be made in order to enable comparison of doses calculated from clinical SPECT systems.

EVALUATION OF THE PERFORMANCE PARAMETERS ON THE BIOGRAPH VISION PET/CT SCANNER USING THE NU2- 2012

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Introduction

The introduction of fast lutetium oxyorthosilicate crystals allowed for shorter coincidence timing windows for time-of-flight (TOF) imaging, and an enlarged axial field of view (FOV) increased volume sensitivity.

Evaluation of PET systems' physical performance using NEMA NU 2-2012 provides for reliable and acceptable comparisons.

Siemens Healthineers' digital Biograph Vision PET/CT system uses silicon photomultiplier (SiPM)–based detectors with 3.2-mm lutetium oxyorthosilicate crystals and complete coverage between the crystal and SiPMs.

Purpose

The Vision's performance was assessed using NEMA NU 2-2012 standards including spatial resolution, sensitivity, scatter percentage, noise-equivalent count-rate (NECR), image quality, and attenuation and scatter correction accuracy.

Materials and Methods

Silicon photomultiplier detectors with 3.2-mm lutetium oxyorthosilicate crystals complete the scintillator region in the new digital PET/CT system. PET components include 8 rings of 38 detector blocks, each with 4 × 2 small blocks. Each mini block has an axial field of vision of 26.1 cm due to a 5 × 5 lutetium oxyorthosilicate array of 3.2 × 3.2 × 20 mm crystals connected to a 16 × 16 silicon photomultiplier array. The study evaluated PET/CT system performance according to the NEMA NU 2-2012 standard. We measured spatial resolution, sensitivity, count-rate performance, attenuation and scatter correction accuracy, image quality, co-registration accuracy, and time-of-flight performance. Measurements and their manufacturer's findings were directly compared.

Results

The Biograph Vision shows a NEMA sensitivity of 15.1 kcps/ MBq, an axial spatial resolution at Full Width Half Maximum (FWHM) of 3.5 mm at 1 cm offset of the center of the FOV, a NEMA peak NECR of 259 kcps at 32 kBq/mL and TOF timing resolution was 213.7 ps. The overall image contrast seen with the NEMA image quality phantom ranged from 80.79% to 90.86%.

Conclusion

The Biograph Vision is able to meet NEMA standards and manufacturer values.

EFFECT OF PSF+TOF (UHD) AND TOF ON FDG UPTAKE MEASUREMENTS IN CANCER PATIENTS' LESIONS USING OSEM

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Introduction

In cancer 18F-2-Fluoro-2-Deoxyglucose Positron Emission Tomography scans (F18-FDG PET), the maximum standardized uptake value (SUVmax), Metabolic Tumor Volume (MTV), and Total Lesion Glycolysis (TLG) are frequently used for further diagnosis and lesions staging. For centers with established protocols for lesion categorization based on SUVmax thresholds, point spread function (PSF) modelling and time-of-flight (TOF) reconstructions have a considerable impact on SUVmax & MTV. This may be the reason why these reconstructions have been adopted slowly.

Purpose

In this study, the effects of two alternative post-filtering strategies on SUVmax, MTV, and TLG were assessed.

Materials and Methods

With the help of Siemens Biograph Vision 600 and the two post-filter sets, images from 20 cancer patients were reconstructed using PSF+TOF (UHD) and TOF with OSEM. Lesions for each reconstruction were used to quantify SUVmax, MTV, and TLG. Measures of uptake were compared relative to one another, and any alterations were evaluated for their potential clinical effects.

Results

While MTV reduced by 21% for UHD in contrast to TOF, SUVmax & TLG increased significantly when voxel variance was matched, increasing by 21% and 8.4% respectively for UHD in contrast to TOF. This could have an effect on the majority of patients' outcomes.

Conclusion

Matching image voxel variance with UHD and/or TOF reconstructions led to significant increases in SUVmax & decrease in MTV, particularly with UHD modelling, which prevented the application of established techniques for lesion categorization based on SUVmax & MTV. The ability to detect lesions may, however, be improved by diminished partial volume effects for UHD in contrast to TOF. Last but not least, compared to SUVmax & MTV, TLG might be less sensitive to reconstruction techniques.

SyrMan MODEL FOR INTERNAL DOSIMETRY CALCULATIONS

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Introduction

The MIRD Phantom was based on data of the ‘‘Reference Man’’ created by ICRP for radiation protection purposes. The reference man was originally defined as being 20–30-year-old Caucasian, weighing 70 kg and 170 cm height. The “voxel models”, representing the diversity of human anatomy, were built using tomographic images for real humans. Later, many ethnic voxel models were constructed and simulated by Monte Carlo codes for radiation dosimetry calculations.

Purpose

Reconstruction of human voxel model from CT images for a person from the Middle East region to calculate the radiation dose using Monte Carlo code. The model was used for internal dosimetry.

Materials and Methods

The CT images of a volunteer (33-year-old male, 172 cm height, and 75 kg weight) were used to reconstruct a head-to-knee voxel model, named SyrMan. The volunteer represents the average, in weight and height, of a group of 262 males aged between 25 and 50 years. The SyrMan model was used for internal dosimetry calculations using two Monte Carlo codes: MCNP4C2 and GATE. The deposited energy and Specific Absorbed Fractions (SAFs) were calculated in target organs from source organs containing monoenergetic photons or electrons. The SAFs of SyrMan model were compared with those of previous published models.

Results

The comparison of organ masses between ‘‘SyrMan’’ model versus those of ICRP23, VIP-man, GOLEM, and Visible Human models showed that separate organ masses were considerably different in many cases. Even though with phantoms whose weight and height are close to that of SyrMan such like Zubal phantom, the relative differences ranged from -36% for pancreas to +37% for kidneys. Due to the differences in masses and anatomy, the values of self SAFs and cross SAFs were different. For example, for photons of 100 keV, SAF (Liver ‹- Liver) differs -16% and SAF(Pancreas ‹- Kidneys) differs +25% between SyrMan and Zubal models.
The differences in SAFs between both Monte Carlo codes were less than 3% in most cases.

Conclusion

SyrMan model represents a real middle-east human body. It was used for internal dosimetry and can be used for various radiation dosimetry applications.

ROYAL HOSPITAL EXPERIENCE OF LIQUID RADIOACTIVE WASTE MANAGEMENT

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Introduction

Various radioactive nuclides are used in Nuclear Medicine for both diagnostic and therapeutic procedures. Safe disposal of the generated radioactive waste is a critical element of the hospital waste management. The liquid wastes are generated from the iodine isolation therapy toilets and from general nuclear medicine department which is collected in the two delay tanks. In Royal Hospital, the liquid radioactive waste is managed according to delay and decay concept. Iodine-131 is an essential example of a radioactive nuclide has been used since 2006. According to radiotoxic classification, I-131 is one of the group 2 element and decay with gamma and beta. Hence, a liquid radioactive waste management regime is required to guarantee that the radiation exposure does not exceed safe limits which is 22.2 MBq /m^3. The effluent of the tank was released into public sewage about six times per year.

Purpose

This study aimed to review Royal Hospital experience of liquid radioactive waste management, to ensure that the radiation exposure to an individual (Public, Radiation worker, Patient) and the environment does not exceed the prescribed safe limits and address the challenges to review the current guidelines.

Materials and Methods

Data from 2006 to 2023 of liquid waste management at Royal Hospital was collected, reviewed and analyzed.

Results

All measurements are within the acceptable limit 22.2 MBq/m^3. Some challenges are appeared from this reviewed study like: after the COVID-19 pandemic the number of treated patients was doubled, the disposed liquid waste treated in local water planet and the absence of National Radiation Authority. Special recommendations were taken to approach the acceptable limit once the challenges were faced.

Conclusion

Medical Physicists at nuclear medicine and engineers play a key role in the waste disposal operations at Royal Hospital. All challenges were discussed to review the situation and to update the local guidelines.

CORRELATION OF EXTERNAL EXPOSURE AND BMI IN RADIOIODINE(I-131) THERAPY

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Introduction

Radioiodine (I-131) therapy is used since mid of last decade for treatment of patients who had undergone total thyroidectomy for differentiated thyroid carcinoma. Benefits to patients treated with radioiodine–131 must be balanced beside external radiation exposure to the surrounded persons.

Purpose

This study planned to investigate the correlation of external radiation exposure at one meter with the BMI (Body Mass Index) in thyroid cancer patients treated with radio-iodine I-131 capsule.

Materials and Methods

The present study carried out 70 patients treated with I-131 at Royal Hospital, Oman. The involved patients were enrolled randomly and separated based to their administrated activity into three groups which are 3.7 GBq, 5.5 GBq and 7.4 GBq. BMI (weight divided by square of height) was calculated for each patient at the day of I-131 capsule administration. The external radiation exposure from the patients was measured using calibrated survey meter, CoMo-170, from a distance of one meter parallel to the patient's thyroid gland directly after Iodine-131 administration.

Results

The relation of external radiation exposure values with BMI were analyzed statically. The external radiation exposure was inversely correlated with the BMI.

Conclusion

The BMI values is an important factor that help to expect the external radiation exposure before radio-iodine therapy, predicting the time of discharge and control the isolation room. Moreover, the BMI values of patient treated by I-131 can help for optimization of radiation hazard.

ASSESSMENT OF RADIOACTIVE CONTAMINATION IN NUCLEAR MEDICINE, ROYAL HOSPITAL, SULTANATE OF OMAN

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Introduction

The most common adverse event that can occur in nuclear medicine is radioactive contamination due to the use of unsealed radioactive materials. Radioactive contamination checks should be performed frequently among nuclear medicine facilities for good radiation safety practice. Wipe test is an important test that helps for assessment of radioactive contamination.

Purpose

Assessment of radioactive contamination in different places at nuclear medicine facility

Materials and Methods

Wipe- test was performed for different locations in the nuclear medicine department and Molecular Imaging Center (MIC) including controlled areas, supervised areas and public areas. The selection of the wipe tests locations were based on the high chance availability of radioactive contamination. Area of (10×10) cm^2 wipes were used for the wipe-test samples. All wipe samples were placed on test tubes and were measured in well-counter (Capintec CR 25) for one minute. The Background (BG) levels were measured before each wipe measurement. After that, the mean counts were calculated and counting activities in Bq/ cm^2 were recorded. The curve of counting-activity was plotted to specify measured counts equaled to activities.

Results

The Study shows that 10 of 300 locations in the Nuclear Medicine department and Molecular imaging center exceed the surface contamination limit. This assessment shows that the most contaminated area is the Hot Lab especially the preparation area in the bio-safety cabinet, door knob and the pen that used in the Hot Lab.

Conclusion

The occurrence of radioactive contamination is very minimal in the nuclear medicine department and Molecular Imaging Center based on the assessment findings of this study. Sometimes some items in the Hot Lab are found contaminated due to preparation and dispensing of radiopharmaceuticals.

OPTIMIZING PET SCANNER DESIGNS FOR PEDIATRIC APPLICATIONS: SMALLER BORE DIAMETERS AND CRYSTAL SELECTION

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Introduction

Positron emission tomography (PET) imaging has been widely used for diagnosing, staging, and monitoring various diseases due to its ability to detect molecular changes in vivo. The clinical use of PET imaging in pediatric patients has always been a concern due to their smaller body size and lower tolerance to radiation exposure. However, it's worth noting that the pediatric population has an advantage compared to adults because their attenuation levels are significantly lower. As a result, per injected dose (MBq/kg), relatively fewer scattered events and more trues can be measured due to reduced attenuation.

Purpose

This study proposes and simulates PET designs based on the Biograph Vision 600 PET/CT scanner with smaller bore diameters for pediatric applications. Different crystals are also studied to optimize the cost of such a design without losing spatial resolution and image quality.

Materials and Methods

The Biograph Vision 600 scanner incorporates a PET device that includes a detector with Optiso Ultra Dynamic Range (UDR) technology, which is fitted with lutetium oxyorthosilicate (LSO) crystals and digital silicon photomultiplier (SiPM) sensors. The scanner is modeled in GATE, and the NEMA sensitivity of the different designs is e valuated with BGO and LSO crystals.

Results

Generally, BGO yielded higher sensitivity than LSO, and reducing the bore diameter increased the system sensitivity for both crystals. The findings of this study have implications for making more effective PET scanners after lowering the administered activity of the radioactive tracer to the patient, which leads to a safer procedure for pediatric applications.

Conclusion

The next step is evaluating the proposed designs' spatial resolution and image quality to optimize the scanner parameters such as bore/crystal size and type of crystal. A further step is extending the axial field of view (aFOV) of the designs to propose a cost-efficient Total Body – PET (TB-PET) design for pediatric applications, which would allow for comprehensive whole-body imaging, reducing the scan time and the administered dose and improving patient comfort.

THE CLASSIFICATION OF BREAST CANCER USING 18-FDG PET/CT BASED ON AN ARTIFICIAL NEURAL NETWORK

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Introduction

PET/CT is a routine procedure for the measurement of breast cancer, but it does not classify histological subtypes automatically.

Purpose

This research aims to evaluate the clinical classification of breast cancer based on the value of tumor marker using an artificial neural network.

Materials and Methods

One hundred forty-two breast cancer patients (Training, Testing) who underwent ^{18}F-FDG PET/CT to diagnose the classification of breast cancer in our nuclear medical center. Before the scanning procedure, the patients were given ^{18}F-FDG-18 injections. We followed the routine procedure for the scan. The softmax function with cross-entropy loss is used in the output layer of the artificial neural network to diagnose subtypes of breast cancer based on the value of the tumor marker.

Results

The result demonstrates the ANN model for k-fold cross validation including accuracy of 95.77%. The average sensitivity and specificity were 0.958 and 0.955 respectively. The average AUC was 0.985.

Conclusion

The proposed model can classify breast cancer subtypes. Following the clinical implementation of the proposed model, the PET/CT may be upgraded to diagnose breast cancer classification using the appropriate tumor maker value.

PART 2:
Health Physics

INVESTIGATION OF MEDICAL DIAGNOSTIC X-RAY SHIELDING BY PPLYMER COMPOSITE

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Introduction

Radiation shields protect patients and workers from unintentional exposure. The properties of shielding materials depend on the type and energy of radiation. Nowadays, researchers are studying various polymers for radiation protection.

Purpose

Studying the shielding properties of polymer composites against the diagnostic X- rays emitted with a voltage range (80-135) kV.

Materials and Methods

The composite samples were prepared with different thicknesses from Epoxy Resin EUXIT 50, polyurethane EUXIT TG10, Polyurethane EUXIT 101 and Lead of a ratio (40, 50, 60 ,70) %wt for different sizes lead particles (Nano, powder and shot/ball). Samples were characterized according to the blend code, lead weight percentage and size as (N-Y, P-Y, K-Y, H-Y, Z-Y, F-Y, and D-Y). Shielding properties of samples have been determined using narrow beam transmission method. The exposure was set at 10 mA in 0.1 sec, and the X-ray beam was collimated relative to the center of detector as (3x3) cm according to samples' size. The exposure to the primary and transmitted X-ray beams were measured with and without the samples. Lightness of each sample was evaluated in comparison to lead heaviness which is considered as a standard.

Results

The average attenuation for the lead composite was (90.25% to 99.17%). The (P-Y) composite of the thickness 10mm, and 70% lead powder showed the most effective shielding for the voltage range (80 to 135) kV, very low transmission with attenuation percent of (99.17%, r=0.95). A higher X-ray transmission was with the (P-B) composite which was loaded by 70% lead powder, where the average attenuation percentage was (98.3%, r= 0.9856). The excellent attenuation (99.15% , r=0.90453) was with (H-G) composite (4mm thickness,70% Nano lead particles), it had a density effect of 3.105 g/cm^3. The lightest composite was (F-Y) of 40% lead particles.

Conclusion

Polymer composite is preference attenuation than pure polymer blend.

EFFECTS OF PORE-FORMING PEPTIDES (MELITTIN AND MAGAININ 2) ON THE PHOSPHOLIPID BILAYER INTERIOR

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Introduction

In this research, we investigated the interaction of melittin and magainin 2 with three models of cell membranes: 80% POPC 20% POPG, 40%POPC 40% POPE and 20% POPG, and 80%POPC 20%POPG plus 30% mole fraction of cholesterol. Time-resolved fluorescence anisotropy of 1,6-diphenyl-1,3,5-hexatriene (DPH) was employed to investigate the dynamics and acyl chain ensemble order in the core of the membrane bilayers. The results of anisotropy decay provide information about the orientational order and motion of DPH. These physical parameters information of DPH provide an accurate picture of the ensemble of acyl chains throughout the depth of the phospholipid bilayer interior which is not well known from previous studies.

Purpose

The objective of this research is to study the effect of headgroup and the interior bilayer composition on peptides-lipid bilayer interactions.

Materials and Methods

Samples for all fluorescence measurements were prepared at a concentration of 150 µM phospholipid. Samples were prepared in 1.5 ml quartz spectrophotometer cuvettes with magnetic stir bars. For samples containing 0.5 µM of DPH stock solution was added to each cuvette to yield a final DPH to phospholipid molar ratio of 1:300.

Results

Melittin more active than Mag2 with respect to disrupting the bilayer in the range of the peptide to lipids studied in this research. Melittin has about twice the number of cationic residues as Mag2, therefore the electrostatic interaction between the cationic residues of peptides and zwitterionic lipid bilayers is stronger in the case of melittin.

Conclusion

The effects were found to vary widely across the two peptides examined and the three bilayer compositions. The cholesterol in the bilayer hydrophobic core has measurable and distinct effects on the ways peptides alter processes generally associated with the bilayer headgroup region. However, the addition of PE to the bilayer headgroup has distinct effects on the ability of peptides to alter aspects of the bilayer interior such as ensemble acyl chain order.

BIOLOGICAL DOSIMETRY RETROSPECTIVELY IN SCENARIOS OF OVER-EXPOSURE TO IONIZING RADIATION OCCUPATIONALLY/ACCIDENTALLY

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Introduction

Biological and physical dosimetry are recognised as key techniques to provide individual estimates of dose following unplanned exposures to ionizing radiation. Biological dosimetry directs and offers assessment provision for screening (scenarios of mass casualties), therapeutic management, and long-term risk assessment. Consequently, it is being considered as an essential parameter for the radiation -protection and -emergency programs. The radiation-induced changes in human lymphocytes can be studied using different cytogenetic assays. Among these translocations as stable type aberrations have shown the potential to be applied for assessing the dose retrospectively. This presentation summarises the existing data on estimating the dose on different cohorts exposed to ionizing radiation accidentally/occupationally.

Purpose

To apply Fluorescence in situ hybridization (FISH)-based translocation assay to detect translocations in different cohorts exposed in the past to radiation of different qualities. This is of a great importance to improve the quality of life based on risk assessment.

Materials and Methods

Multi-colour FISH for different chromosomes and a pancentromeric probe were applied to detect translocations for assessing the dose retrospectively at several scenarios of exposure (occupationally/accidentally) to ionizing radiation (such as gamma-rays, X-rays, 89Sr, 90Sr and 239Pu), at different intervals in different cohorts such as, Goiania- Gomel-, Techa river-, Mayakand Fukushima- populations.

Results

Calibration data based on exposing human lymphocytes (in vitro) to X- or gamma-rays were generated and used for determining the dose. It was also found that translocation frequency is increasing with age. In all cohorts under these studies, it is found that the FISH translocation assay can be usefully applied for detecting internal and combined external radiation and internal doses albeit with fairly large uncertainties.

Conclusion

For retrospective dosimetry, FISH-based translocation assay is the most reliable biological assay that can be applied. However, it became also evident that more studies are needed in order to elucidate the influence of several factors, such as the dose, interindividual sensitivity, chronic and acute exposure as well as whole- and partial- body exposure on the stability of translocations.

COMPARISON OF INSTITUTIONAL DIAGNOSTIC REFERENCE LEVELS FOR CERVICAL SPINE X-RAY EXAMINATIONS IN ADULT PATIENTS IN SRI LANKA

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Introduction

Cervical spine X-rays are routinely performed to diagnose spinal complaints, tumors, fractures, and degenerative pathologies. These examinations are well known to utilize varying radiation doses for patients. To improve patient protection, it is imperative to optimize radiation doses in cervical spine X-ray examinations by implementing Diagnostic Reference Levels (DRLs).

Purpose

To compare institutional DRLs (IDRLs) in adult patients referred for cervical spine anteroposterior (AP) and lateral (LAT) X-ray examinations in five public hospitals in Sri Lanka.

Materials and Methods

The hospitals selected for this study were labeled as I, II, III, IV, and V. Data on patient demographics (age, sex, weight, and BMI), exposure parameters (kVp and mAs), and kerma-area product (KAP) measurements were collected from 275 adult patients (58±20 kg). The normality of the KAP distributions was assessed using the Shapiro-Wilk test ($p<0.05$).

Results

The median values of the KAP distributions for each hospital were proposed as the IDRLs. The mean BMI in $kg.m^{-2}$ of patients was comparable between hospitals, ranging from 22.9 to 24.8 for cervical spine AP and 23.1 to 25.1 for LAT examinations. The IDRLs of hospitals I, II, III, IV, and V were 0.44, 0.21, 0.26, 0.24, and 0.22 $Gy.cm^2$ for cervical spine AP and 0.35, 0.32, 0.21, 0.16, and 0.31 $Gy.cm^2$ for LAT examinations, respectively. The highest IDRLs for cervical spine AP and LAT examinations were reported in hospital I due to high mAs values. The median kVp used for cervical spine AP examinations ranged from 60 (hospital III) to 70 (hospital IV), while for LAT examinations, it ranged from 64 (hospital III) to 70 (hospital I, IV). The median mAs for cervical spine AP examinations varied from 12.5 (hospital II) to 18.0 (hospitals I, III, V), while for LAT examinations, it varied from 14.0 (hospital II) to 20.0 (hospitals I, III, V).

Conclusion

The IDRLs reported in this study can serve as a baseline for establishing national DRLs for cervical spine X-ray examinations in Sri Lanka. Owing to the large variations observed in KAP values and exposure parameters, this study recommends reviewing current practices, including the selection of exposure parameters and collimation.

MONTE CARLO SIMULATION OF ORGAN DOSES AND RELATED RISK FOR CANCER IN ALGERIA FROM SECONDARY RADIATION IN PROSTATE TREATMENT INVOLVING 3D-CRT

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Purpose

The present study aimed to evaluate organ doses and related risk for cancer from secondary radiation involving 3D Conformational Radiotherapy (3D-CRT) for patients with prostate cancer in Algeria base

Materials and Methods

A detailed geometric Monte Carlo (MC) modeling of the LINAC benchmarked against experimentally measured depth dose data, combined with a hybrid whole-body phantom XCAT phantom was carried out. The secondary radiation doses were calculated out of field of patient's organs. The obtained doses were used to estimate the Lifetime Attributable Risks (LARs) for cancer incidence out of field organs. LARs was evaluated assuming Biological Effects of Ionizing Radiation VII (BEIR VII) risk model for exposure age in the range 35-70 years, according to the interval's age of treated patients in Algeria. The baselines cancer risks and survival data were associated with the statistical data for the Algerian population.

Results

The results showed that secondary radiation equivalent doses per prescribed dose (Photon Dose) mostly depend on the distance of organs from the treated volume. The highest and lowest equivalent doses of 5.77 mSv/Gy and 0.24 mSv/Gy were recorded in the small intestine and ocular lens, respectively. The highest estimated lifetime attributable risk per 100,000 populations was found for 35 yrs' exposure age in colon 19.66, intestine 15.14 and lung 13.60. The lowest risks were found for 70 yrs' age, in spine 0.06 and thyroid 0.14. The results showed that LARs values decrease with the increase of the exposure age and cancer incidence risk is lower than the baseline cancer risk incidence for all organs.

Conclusion

The present study may help in providing a database on the impact of radiotherapy-induced secondary cancer incidence during 3D-CRT for prostate cancer in Algeria and other developing countries.

DISTRIBUTION OF OCCUPATIONAL DOSES AMONG NUCLEAR MEDICINE PROFESSIONALS IN OMAN

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Introduction

The introduction of hybrid imaging systems and new radionuclide therapies has led to increase of radiation doses both to patients and radiology healthcare professionals. Several studies have reported significant increase in radiation doses to nuclear medicine professionals due to day-to-day handling of radiopharmaceuticals used for diagnosis and treatments.

Purpose

The aim of this study was to investigate the distribution of occupational radiation doses for nuclear medicine radiation workers at Sultan Qaboos University Hospital (SQUH).

Materials and Methods

Dose records (whole body Hp(10), and extremities Hp(0.07)) from 19 radiation workers were collected from the local dosimetry service over period of 7 years (2015-2021). Four staff categories (technologists, medical physicists, NM physicians, and nurses) were considered. Doses were measured using calibrated thermo-luminescence dosimeters (TLD-100 (LiF:Mg,Ti)). Two Thermo Scientific Harshaw TLD Automated Readers (Model 6600 and Model 6000 Plus) were used with a computer program (WinRems) and a personalized dose management software (Dosibase; Sia Enterprise) to measure the TLD readings. The minimum, maximum, and average cumulative doses were estimated and compared with the annual whole body and extremities dose limits (20 mSv and 500 mSv per year, respectively) and the local dose investigation level (6 mSv per year).

Results

Personal whole body Hp(10) doses are given as (minimum:maximum:average) for technologists, medical physicists, NM physicians, and nurses, and found to be 0.3:7.8:1.8, 0.3:0.4:0.3, 0.1:0.2:0.1, and 0.1:0.2:0.1 mSv, respectively. For the three occupational categories (technologists, medical physicists, and NM physicians) personal doses measured using fingers ring dosimeters Hp(0.07) for the left and right hands [Right-hand min-dose, Right-hand max-dose, Right-hand average-dose; Left-hand min-dose, Left-hand max-dose, Left-hand average-dose] were [1.4, 17.5, 7.7; 1.4, 18.1, 8.7] for technologists, [2.5, 3.0, 2.7; 2.0, 2.3, 2.1] for medical physicists, and [1.7, 3.7, 2.4; 1.2, 3.8, 2.3] for nurses.

Conclusion

Personal radiation doses distribution for whole body and extremity doses were well below the ICRP recommended limits and dose investigation level, at the exception of technologists. Technologists recorded the highest occupational dose followed by medical physicists, nurses, whilst NM physicians showed the lowest dose. This study suggests lowering dose investigation level for all professional categories except for technologists.

RADIATION AWARENESS AMONGST RADIATION WORKERS WORKING IN DIAGNOSTIC RADIOLOGY OF A PUBLIC SECTOR HOSPITAL IN KHYBERPAKHTUNKHA

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Introduction

As radiation workers are working in close proximity with ionizing radiations, so they prone to the detrimental effect of radiations. In order to ensure their and patient safety, they should be well trained in their field of work through frequent training sessions and awareness sessions to groom their skills regarding radiation safety. This will not only boost their skills but also will a sense of responsibility towards radiation protection.

Purpose

To determine the level of improvement amongst radiation workers regarding knowledge of ionizing radiations and principles of radiation protection while performing routine diagnostic procedures after attending a dedicated refresher course of one month on radiation awareness and protection.

Materials and Methods

Forty-six (46) radiation workers (38 males and 08 female) out a total sixty radiation workers participated in this refresher course and filled the pre and post performa comprising twenty questions on basics aspects of ionizing radiations, cellular interaction, biological effects and radiation protection to check their existing knowledge and improvement respectively.

Results

Mean scores of all radiation workers in pre-sessions assessment was 39.35% which improved to 61.95% after attending the dedicated course designed with a mean difference of 22.6% ($p< 0.0000001$). The female radiation worker's awareness level improved a bit high (pre: 36.25%, post: 59.38%) than male workers (pre: 40.0%, post: 62.5%). The workers having inter and higher qualification did better (pre: 38.42%, post: 61.45%) than the ones who have only metric (pre: 43.75%, post: 64.38%) and workers having relevant diploma in radiology scored (pre: 42.86%, post: 65.48%) than the workers who haven't got diploma (pre: 37.0%, post: 59.0%).

Conclusion

The knowledge about basics of ionizing radiations and protection of both staff & patients before the sessions was not satisfactory as it should be. An improvement was found amongst the radiation workers about their knowledge and understanding after attending the dedicated course on radiation awareness designed according to their needs and it can be achieved through concurrent efforts and streamlined coordination between licensee and regulatory body.

INVESTIGATION INTO DISTRIBUTION OF PATIENT DOSES IN SPECT/CT AND PET/CT SCANS IN OMAN

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Introduction

Optimization of radiation exposures of patients and healthcare workers is a one of the pilar of radiation protection. The assessment of the distribution and radiation doses delivered to patients and the establishment of Diagnostic Reference Levels (DRLs) is an effective way towards optimizing exposures.

Purpose

The purpose of this study was to estimate patient dose distributions and DRLs for the most frequent SPECT/CT and PET/CT imaging examinations performed at our institution.

Materials and Methods

Radiation doses from 961 adults patients who have undergone SPECT/CT and PET/CT imaging examinations over a period of 4 years (2018 – 2021), were included. Patients' scans consisted of: 227 whole body PET/CT scans, 130 brain PET/CT scans, 44 cardiac PET/CT scans, 160 SPECT/CT bonestatic, 300 myocardial perfusion imaging SPECT/CT, 118 thyroid post-ablation scans, 81 thyroid uptake scans and 69 parathyroid SPECT/CT scans. The low-dose CT dosimetry data (CT dose index (CTDIvol), dose length product (DLP)) and radiopharmaceutical activity, were collected. The minimum, maximum and third quartile were calculated for CTDIvol (mGy), DLP (mGy.cm) and administrated activity for each examination category. The effective doses (mSv) of all examinations were also estimated.

Results

The estimated DRLs are given as follows (third quartile CTDIvol (mGy), minimum:maximum:third quartile DLP (mGy.cm), minimum:maximum:third quartile administrative activity (MBq)): whole body PET/CT: 2.37, 52.6:499:219.5, 177:452:298; brain PET/CT: 12.86, 301.7:301.7:301.7 (same doses for all patients), 128:392:270; cardiac PET/CT: 1.79, 17.2:68.3:42.5, 206:600:383; bone SPECT/CT: 3.18, 54:225:135.3, 500:989:814; MPI SPECT/CT (stress-rest): 1.8, 28:90:60, 602:987:821-1.8, 28:104:60, 365:901:809; parathyroid SPECT/CT: 3.52, 56:200:140, 180:968:815; thyroid uptake (with I-131) SPECT/CT: 4.36, 81:268:189.5, 100:266:207; thyroid post-ablation 4.7, 63:256:190. The estimated total ED (mSv) (male:female) was: 7.5:7.8, 7.9:7.9, 6.9:7.2 , 5.2:5.2, 7.4:7.8-7.3:7.7, 7.6:7.9, 4555:4555, 1.5:1.9 for whole body PET/CT, Cardiac PET/CT, Brain PET/CT, bone SPECT/CT, MPI SPECT/CT (stress-rest), parathyroid SPECT/CT, thyroid-uptake (with I-131) SPECT/CT, and thyroid post ablation SPECT/CT, respectively.

Conclusion

The estimated patients' doses distribution and established local DRLs are comparable to published DRLs. The derived DRLs has facilitated monitoring of doses and will result in reduction of patients' doses distribution.

DISTRIBUTION OF PATIENTS' DOSES IN COMPUTED TOMOGRAPHY IMAGING AT THE TWO LARGEST HOSPITALS IN OMAN

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Introduction

Computed Tomography (CT) is currently considered as the workhorse in diagnostic radiology. However, it delivers high radiation dose to patients compared to other imaging modalities.

Purpose

The aim of this study was to investigate the distribution of patients' radiation doses in the most frequent CT imaging examinations and estimate Diagnostic Reference Levels (DRLs) and effective doses in each examination category in order to monitor and have better control of radiation doses delivered to patients.

Materials and Methods

The study included the seven most frequent CT examinations that are performed over a period of 12 months. This included, CT Head, CT Chest, CT Chest High Resolution, CT Abdomen Pelvis, CT Chest Abdomen Pelvis, CT kidneys Ureters Bladder and CT Cardiac. Patients' scans were performed either on the Siemens Sensation 64 slice or Dual CT SOMATOM Force 256 slice. CT dosimetric quantities (DLP, exposure settings (kVp and mAs)) and patient demographics (age, gender and weight) were collected from the PACS/RIS radiology systems. The minimum and maximum and 3rd quartile doses were calculated for DLP (mGy.cm). The Effective doses (in mSv) were also estimated.

Results

The dose distributions and DRLs are given as follows (minimum:maximum (mGy), third quartile DLP (mGy.cm)): CT Head: 357:986 715; CT Chest: 19:1212, 570; CT Chest High Resolution: 19:807, 313; CT Abdomen Pelvis: 76:1539, 708; CT Chest Abdomen Pelvis: 331:2412, 1134; CT Kidneys Ureters Bladder: 75: 1040, 473; and CT Cardiac: 2.8:123, 39. The estimated effective doses for CT Head, Chest, Chest High Resolution, Abdomen Pelvis, Chest Abdomen Pelvis, Kidneys Ureters Bladder and Cardiac were 1.4, 6.1, 3.2, 9.4, 12.8, 4.8, and 0.5 mSv, respectively. The estimated local DRLs are lower than UK DRLs for CT Head, CT Abdomen Pelvis, CT Chest Abdomen Pelvis and CT Kidneys Ureters Bladder while CT Chest and CT Chest High Resolution have higher values.

Conclusion

The findings of our study show that the estimated patients' doses distributions and estimated local DRLs are comparable to published DRLs. The established local DRLs for the most frequent CT examinations will act as guidance doses and trigger investigations to prevent systematic excess of patient doses.

SEMICONDUCTOR LASER INHABIT CANCER CELLS

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Introduction

The biological responses of cells to visible and near infrared IR laser radiation, occur due to physical and/or chemical changes in photo acceptor molecules, component of respiratory chains in mitochondria.

Purpose

To evaluate the effect of low level laser therapy (LLLT) on increasing the response of immune system by stimulating the lymph nodules action in case of diseased mice in order to inhabit cancer cells activity which leads to decrease the tumor size without using drugs by using different duration times on the same area in each irradiation with the same power densities.

Material and method

Thirty mice were randomly assigned to two groups A, B each of fifteen mice, female, 60 days age, 100gm main weight subjects transplanted with mammary gland carcinoma in the Iraqi center of Cancer Research and Medical Genetic.

Results

The reason behind using wave length of 905nm was that it is suitable for stimulating the mitochondria (the energy source of the cells) in order to stimulate the immune cells activity t-cell and macrophage to attack the cancer cells, this was first step, the other step was to release energy from the cell that come out from the mitochondria (ATP) this energy stimulate the cell to release heat according to the law of energy of conservation that states that the outcome energy must equal the inters one, which is the main cause of cancer cells killing.

Conclusion

The increasing of the immune response resulting in the decreasing or limiting the size of the tumor that measured before and after laser irradiation. The results of this study suggest that soft laser therapy has a significant role in promoting faster healing, particularly in the early stages of cancer at multiple sites, and in stimulating the immune system to damage or limit the growth of tumors by activating immune blast cells discovered in lymph nodes near the cancer sites.

STATUS OF RADIATION SAFETY TRAINING IN HAMAD MEDICAL CORPORATION

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Introduction

The radiation safety program at HMC (SA1066), Article 3.4 “Education and training requirements for radiation workers” states that radiation workers shall follow the HMC accredited radiation protection training course. This training course is beneficial not only for renewing the participant’s personal radiation license but also to use the accredited CPD points to renew their professional medical license.

Purpose

To provide information about status of radiation safety training in HMC, Qatar.

Materials and Methods

Radiation safety training in Hamad Medical Corporation(HMC) started on 2002 and has been developed from small lecture into full training program in addition to training for different speciality. Data were collected from 2019 up to 1st quarter of 2023, the total number of participants were 2541. Attendees were of different disciplines which includes Radiology and Non Radiology Doctors, medical physicist, technologists, technicians, nurses, therapist including dental and admin staff. Department of Healthcare Professions (DHP) has standard form, this form includes many requirements to get the accreditation approval such as educational standards (need assessment, learning objectives and interactivity and evaluation), and ethical standards.

Results

The total number of participants was decreased by almost 83 % from year of 2019 up to year 2021 due to the Covid 19 outbreak and restrictions on face-to-face trainings. The number of participants were increased by almost 41 % from 196 in the year of 2021 to 477 in 2022 due to that the situation was improved due to COVID-19 pandemic.

MPS-OHS in partnership with the HMC Corporate Communications Web Team, launched an online Certification and Verification System for all the training courses given by MPS-OHS and this includes the Radiation Safety Training. The participants can download their certificates after they completed the training. Early 2023, the certificates will be verified of its authenticity through verification site by scanning the QR code embedded on each certificate. This will help on the approval process of the Ministry of Environment (MoE); which is the regulatory body of personal radiation license application.

Conclusion

Radiation protection courses should includes specific session for other health professionals such as, referring doctors, administrators, and managers within HMC.

LASER SAFETY MANAGEMENT AT HAMAD MEDICAL CORPORATION - QATAR RISKS, CONTROL MEASURES, AND REGULATIONS

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Introduction

Medical lasers are used for numerous applications: in surgery, dermatology, for promoting wound healing and many others. Despite the important role that laser plays in the medical field, lasers can pose a risk to both the user and the patient due to the large and intense energy laser rays carry, that may cause damage to the eyes and burns to the skin in addition to the risk of fires when directed at flammable materials. This makes it necessary to implement protection measures in accordance with international standards. Hamad Medical Corporation (HMC) is one of the largest medical institutions in the world in terms of the use of lasers in different medical specialties, with fifteen hospitals and more than hundred high-power laser devices, including dermatology, urology, ophthalmology, physiotherapy, and surgery.

Purpose

This work presents the development of the laser safety management at HMC in the last few years, starting from establishing laser safety program to implementing control procedures, namely administrative and engineering controls, and ending with conducting a risk assessment as well as an annual audit.

Materials and Methods

A comprehensive laser safety program is established in line with the Joint Commission International (JCI) requirements and based on the American National Standards Institute (ANSI), British Medicines and Healthcare products Regulatory Agency (MHRA).

Results

Laser risk assessment for 98 machines in 11 hospitals have been conducted (80 high power lasers - class 4, 14 medium power lasers - class 3B, and 4 intense pulsed light - IPL machines). This included assessment of the risk associated with the equipment safety, environment, personal protection equipment, administrative arrangements, and training. In addition, 5 laser safety training courses were organized during which 301 workers were trained (68% in 2021-22 and 38% in 2023).

Conclusion

To fully characterize laser related risks, risk assessment must be done regularly to quantify the risks in order to protect patients and users from the harmful effects of the medical lasers.

SYNCHRONOUS FLUORESCENCE SPECTROSCOPY FOR DIAGNOSIS OF ORAL SUBMUCOUS FIBROSIS

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Introduction

Most of the invasive oral cancers arise from pre-cancerous lesions such as leukoplakia, erythroplakia, and Oral Submucous Fibrosis (OSF). The conventional clinical OSF diagnostic methods, namely, maximum mouth opening (MMO), tongue protrusion (TP) and quantitative evaluation of burning sensation, are quite indirect and do not provide information about the histological condition of the oral mucosa. Among various fluorescence spectroscopic techniques, Synchronous Fluorescence Spectroscopy (SFS), also referred as stokes shift spectroscopy (SSS) technique provides highly resolved spectra of the endogenous fluorophores even in complex systems.

Purpose

Synchronous Fluorescence Spectroscopy (SFS) was studied for diagnosis of Oral Submucous Fibrosis (OSF).

Materials and Methods

20 patients having a premalignant lesion condition of Oral Submucous Fibrosis (OSF) from the Tamilnadu Government Dental College and Meenakshi Ammal Dental College in Chennai, India, were included in this study. The in vivo SF spectra were recorded using a Fluoromax-2 (ISA Jobin Yvon-Spex, Edison, New Jersey) spectrofluorometer coupled with optical fiber.

Results

The average SF spectrum of normal subjects shows three major peaks around 300, 350 and 397 nm which attributed to tryptophan, collagen and NADH respectively. Still the exact biochemical and structural changes responsible for altered spectral signatures at different sites in the oral cavity as well as under different tissue transformation conditions, especially under different premalignant conditions are not known. However, it is reported that the structural protein, collagen, and the coenzymes NADH and FAD are responsible for altered fluorescence when normal tissues are transformed into neoplastic. The increase in fluorescence of tryptophan from OSF cases compared with that of normal may be attributed to this HSP. It is further reported that emission due to NADH from cancerous oral tissues is higher than that of collagen, and vice versa for normal.

Conclusion

The results demonstrate that spectral changes due to tryptophan, collagen and NADH. Statistical analysis reveals that normal subjects are discriminated from OSF with 100% sensitivity and 95% specificity. Further, more studies of different oral pathological conditions are needed to optimize the parameters for SFS before using it as a real- time in vivo clinical diagnosis of cancer.