The Encyclopaedia of Medical Physics II Edition: Radiotherapy Update

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Abstract: **The paper briefly outlines the Radiotherapy update of the Encyclopaedia of Medical Physics II Edition (published 2021).**

Keywords *– Medical Physics Encyclopaedia, Medical Physics Education, Medical Physics resources, Radiotherapy.*

I. Introduction

The Encyclopaedia of Medical Physics aimed to collect, in our opinion for the first time, terms that contribute to a very extensive (if not total) knowledge of the most important applications of Physics in Medicine. The articles were originally based on a Medical Physics Thesaurus of terms, developed in 2003 and updated in 2008 and 2011. Thus, Edition I of the Encyclopaedia included over 2800 articles explaining the foundation terms in medical physics. These were published by CRC Press (in paper, in 2013 [1]) as a two-volume set and uploaded (together with the Scientific Dictionary of Medical Physics Terms in 32 languages) on the dedicated website www.emitel2.eu as a free reference and educational resource.

Over the period 2019-2020 our editorial sub-group made a major update of radiotherapy entries within both the Thesaurus and Encyclopaedia. This update included almost 200 new or substantially modified radiotherapy articles.

II. Radiotherapy update

Over the past decade, in particular, advances in: proton and ion therapy, radiobiology, dosimetry, dose-calculation, imaging / image registration, and equipment design have shaped our field. We felt it essential to add articles on these topics, expanding the Encyclopaedia's bank of radiotherapy knowledge.

We paid special attention to proton and ion therapy, including over 30 new articles in this area. These articles include: 'Pencil Beam Scanning (PBS)', 'Spot spacing' (see Figure 1), 'Multi-field optimisation' (see Figure 2), 'Proton Arc Therapy' and 'Single room particle therapy systems', 'Proton radiography' and 'Proton CT (pCT)'.

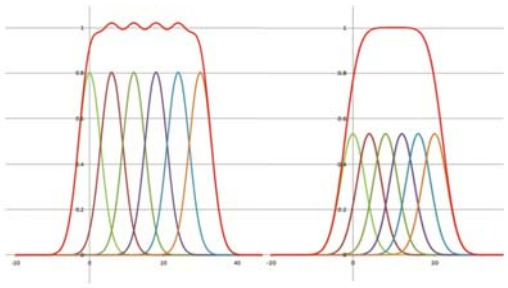

Fig.1 In scanned proton therapy, in order to produce a homogenous dose distribution, individual spots are delivered at a given distance from each other. The distance between each spot and the spot size will affect the homogeneity. If the spots are too far apart, the distribution becomes wavy. If spots are placed closer together, the weighting of each spot gets smaller. There is a limit to how low the weight of each spot can be, and below a certain limit they are undeliverable so the spacing must balance these two factors – *extracted from the 'Spot spacing' article*

The Encyclopaedia's radiobiology provision was expanded with new articles such as 'Track-structure' (see Figure 3), 'Double Strand Breaks', the 'Nonhomologous end-joining Repair Pathway', 'Hypoxia' and 'FLASH'.

For dosimetry, we added articles on topics such as 'Dose-to-medium calculations', 'Dose-to-water calculations',

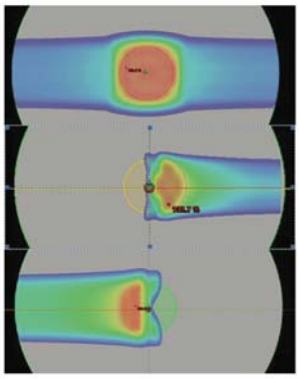

Fig.2 Multi-field optimisation is an optimisation technique which allows different scanned proton beams to cover different sections of the target. This technique is especially useful for a situation where the treatment volume is partially obstructed by an Organ at Risk (OAR) – *extracted from the 'Multi-field Optimisation' article*

Fig 3 The track structure along the path of a charged particle can be split into two regions, the infra-track and ultra-track (as shown above). The infra-track region encompasses the region where the electric field of the charged particle is sufficient to directly cause ionisations. The ultra-track region encompasses the infra-track and constitutes the region in which ionisations are caused by secondary electrons from the infra-track ionisations. The size of the ultra-track depends on the maximum energy of the secondary electrons produced by the charged particle – *extracted from the 'Track Structure' article*

'Faraday Cup', 'Alanine' and 'Metal oxide semiconductor field-effect (MOSFET) transistors'.

Considering imaging and registration, the encyclopaedia was updated to reflect advances in MR-guided radiotherapy with new articles such as: 'MR-linac', 'MRI-guided radiotherapy (MRIgRT)', 'MR-only treatment planning', 'Pseudo CT' and 'Deformable Image Registration (DIR)' (see Figure 4).

We also took care to reflect advances in treatment planning with articles such as 'Dose Painting', 'Multi-criteria Optimisation (MCO)' and 'Pareto Surface'.

Finally, we expanded the encyclopaedia to cover clinical terms relevant to radiotherapy, such as: 'Clinical Trial Endpoints', 'Patient Reported Outcome Measures

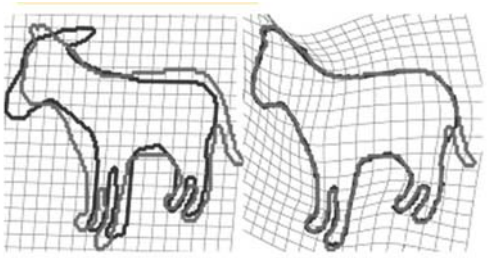

Fig 4 Deformable image registration (DIR) is the process of registering an image data set to a reference image data set by applying an elastic deformation to minimise the difference between the two. This allows comparison or integration of data which is obtained from two different measurements – *from the 'Deformable Image Registration (DIR)' article*

(PROMs)', 'Acute Morbidity', 'Long Term Morbidity' and 'Quality-adjusted life years (QALYs)' (see Figure 5).

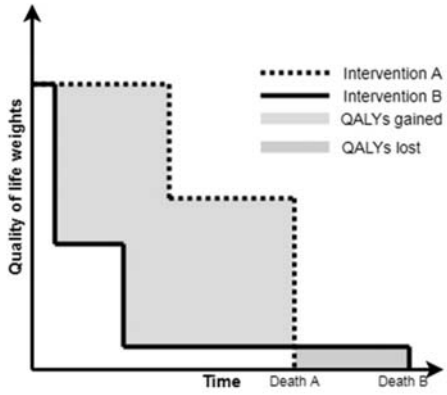

Fig 5 In order to have a systematic way to appraise the benefit of treatment options, many health organisations use quality-adjusted life years (QALYs) as the comparison metric. In contrast to metrics of quantity of life (e.g. overall survival), a QALY is a measure of the state of health of a person or group which incorporates quality of life. One QALY is equal to one year of life in perfect health. The condition of perfect health is measured in terms of the person's ability to carry out normal daily activities, freedom of physical pain and mental disturbance. This is calculated by estimating the years of life remaining for a patient after treatment or intervention and weighting each year on a scale of 0 to 1 (0 = death, 1 = best possible health state). – *extracted from the 'Quality-adjusted life years (QALYs)' article.*

III. CONCLUSION

The update of the radiotherapy field included almost 200 new articles. These were managed by the Coordinators of the Working Group on Radiotherapy – Franco Milano, Eva Bezak and Tracy Underwood.

The update covered exciting new developments in radiotherapy and expanded the bank of terms related to clinical practice. The Editorial Board would welcome suggestions from colleagues regarding new radiotherapy methods and equipment that should be included in the III Edition of the Encyclopaedia (possibly around 2031).

ACKNOWLEDGEMENTS

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