An Investigation of Radiation Dose to Patient's Eye Lens and Skin During Neuro-Interventional Radiology Procedures

Mohammad Javad Safari[1,2],

[1]University of Malaya, Kuala Lumpur, Malaysia.

Abstract— X-ray guided interventional procedure is a common diagnostic and/or treatment modality for various vascular, and cardiac diseases. Advanced technology has enabled interventional radiologists in performing more complex neuro-radiology procedures, resulting in concomitant increase in radiation dose to the patients. The main contributions of this thesis were firstly, characterization of the MOSkin detector in kilovoltage photon beams, and testing its suitability for in-vivo patient's dose measurements during interventional radiology procedures. Secondly, a comprehensive evaluation of the exposure parameters contributions on patient's dose during neuro-interventional procedures was performed. It was found that the lateral x-ray tube contributed considerably high radiation dose to the patient's eye lens. This led to the design and fabrication of a novel type of eye lens protector for those procedures that the patient's eye is repeatedly positioned within the lateral tube exposure field, where the applying of collimation on lateral beam is not possible. An eye lens protector was particularly designed in order to be placed within the x-ray field of view, attenuating the direct beam from the lateral x-ray tube while being sufficiently radiolucent not to perturb the radiological image and the interventional procedure. Finally, a new type of an anthropomorphic head phantom was fabricated with more options for dosimeter placement and more similar tissue substitute materials to the actual human eye to evaluate the dose delivered to the patient's eye lens during a clinical neuro-interventional procedure.

The MOSkin detector has been proven to be a reliable and suitable dosimetry system for the measurement of the radiation dose in kilovoltage photon beams and has been successfully utilized during 35 clinical neuro-interventional procedures to evaluate the radiation dose received by the patients' eye lenses. This study revealed that among the 35 patients, the left outer canthus regions of 8 patients and left eyelid region of one patient were found to receive higher dose than the recommended threshold dose for cataract formation (500 mGy). Based on the study of the contribution of exposure parameters on patient's dose, it is recommended that the judicial use of acquisition imaging techniques, and the use of the lateral x-ray tube particularly in the anterior-oblique orientation to reduce the patient's eye lens dose during neuro-interventional procedures. In the situation where the application of physical collimation on lateral tube beam is not possible, the novel eye protector layer may be used to attenuate the direct radiation beam to the patient's eye lens. This work showed that for a simulated aneurysm procedure, this protector reduced the maximum radiation dose received by the eye lens and eyelid up to 67.0%, and 23.3%, respectively. The eye protector also had negligible effects on the exposure parameters by a maximum of 8% for the tube current-time product of the DSA (2 frame per second) imaging mode, and image quality (increases the fluoroscopy image pixel value up to 4.7% ± 0.6%). Lastly, the fabricated anthropomorphic phantom has been proved to be a suitable tissue-mimicking medium for the evaluation of the radiation dose received by the patient's eye lens during clinical diagnostic procedures.

References

1.Safari, M.J., Wong, J.H.D., Ng, K.H., Jong, W.L., Cutajar, D.L., Rosenfeld, A.B. (2015): Characterization of MOSkin detector for in vivo skin dose measurement during interventional radiology procedures. Medical Physics. 42(5): 2550-8

2.Safari, M.J., Wong, J.H.D., Ng, K.H., Kadir, K.A.A., Thorpe, N., Cutajar, D.L., Petasecca, M., Lerch, M., Rosenfeld. A.B. (2016): Real-time eye lens dose monitoring during cerebral angiography procedures. European Radiology. 26(1): 79-86

3.Safari, M.J., Wong, J.H.D., Kadir, K.A.A., Sani, F. A., Ng, K.H. (2016): A method to reduce patient's eye lens dose in neuro-intervention radiological procedures: A Phantom Study. Radiation Physics and Chemistry. 125, 75-81

4.Safari, M. J., Wong, J. H. D., Jong, W. L., Thorpe, N., Cutajar, D., Rosenfeld, A., & Ng, K. H. (2017). Influence of exposure and geometric parameters on absorbed doses associated with common neuro-interventional procedures. Physica Medica, 35, 66-72

Contacts of the corresponding author:
Author: Mohammad Javad Safari
Email: M.Safari@physik.uni-muenchen.de
Institution: University of Malaya, Malaysia
Field of research: Medical Physics
Supervisors: Prof. Dr. Kwan-Hoong Ng, Dr. Jeannie Hsiu Ding Wong
Graduation date: August 28, 2016
.