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Skin-Dose Mapping for Patients Undergoing Interventional Radiology Procedures: Clinical Experimentations versus a Mathematical Model

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Abstract : Introduction: During an 'Interventional Radiology (IR)' procedure, the patient's skin-dose may become very high for a burn, necrosis and ulceration to appear. In order to prevent these deterministic effects, an accurate calculation of the patient skin-dose mapping is essential. For most machines, the 'Dose Area Product (DAP)' and fluoroscopy time are the only information available for the operator. These two parameters are a very poor indicator of the peak skin dose. We developed a mathematical model that reconstructs the magnitude (delivered dose), shape, and localization of each irradiation field on the patient skin. In case of critical dose exceeding, the system generates warning alerts. We present the results of its comparison with clinical studies. Materials and methods: Two series of comparison of the skin-dose mapping of our mathematical model with clinical studies were performed: 1. At a first time, clinical tests were performed on patient phantoms. Gafchromic films were placed on the table of the IR machine under of PMMA plates (thickness = 20 cm) that simulate the patient. After irradiation, the film darkening is proportional to the radiation dose received by the patient's back and reflects the shape of the X-ray field. After film scanning and analysis, the exact dose value can be obtained at each point of the mapping. Four experimentation were performed, constituting a total of 34 acquisition incidences including all possible exposure configurations. 2. At a second time, clinical trials were launched on real patients during real 'Chronic Total Occlusion (CTO)' procedures for a total of 80 cases. Gafchromic films were placed at the back of patients. We performed comparisons on the dose values, as well as the distribution, and the shape of irradiation fields between the skin dose mapping of our mathematical model and Gafchromic films. Results: The comparison between the dose values shows a difference less than 15%. Moreover, our model shows a very good geometric accuracy: all fields have the same shape, size and location (uncertainty < 5%). Conclusion: This study shows that our model is a reliable tool to warn physicians when a high radiation dose is reached. Thus, deterministic effects can be avoided.

Keywords : clinical experimentation, interventional radiology, mathematical model, patient's skin-dose mapping.
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