Assessment of out-of-field doses in radiotherapy treatments of paediatric patients using Monte Carlo methods and measurements

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Foreword

Dear colleagues,

Radiation oncology is a standard known treatment for paediatric cancer patients. However, late side effects, second cancers, growth disturbances, cosmesis and decreased functional outcomes continue to be relevant and of concern to the radiation oncology professional community.

As radiotherapists, our teams have to be as precise as possible, regarding the patient and machine characteristics, and it`s very important to seek the best approach for children's treatments in our departments.

We present an interview with the first author of this paper, Ana Cravo Sá, a radiotherapist and PhD student, in Faculdade de Ciências Nova University, in Lisbon, Portugal.

Isabel Pereira Lobato

Interview with Ana Cravo Sá

What was your motivation for initiating this study?

Developments in medical technologies have increased the life expectancy of cancer patients. However, after radiotherapy, there is a concern in terms of radio-induced tumours. Currently, techniques that employ high doses are used in the target volumes; however, unwanted doses are supplied to healthy tissues, which may allow the development of second tumours. Evaluation of these doses is fundamental, since they are not evaluated under the treatment planning systems (TPSs) used in clinical practice. The need for a new approach to the assessment of doses outside the treatment field has stood out in recent years as a research priority in radiological protection, particularly in paediatric patients.

What were the main challenges during the work?

I found three major challenges during development of this work: (1) to perform the geometry of the linear accelerator (linac) and to obtain detailed information regarding all materials from the manufacturer; (2) to create the voxelised phantom from the existing physical phantom; and (3) management of the computational power versus time spent with all simulations.

(1) It is a challenge to contact the manufacturer of the accelerator and try to discover which materials are used in each part of the linac. To validate the Monte Carlo (MC) model, it is necessary to know not only the materials themselves but also the density of the respective materials.
(2) Manipulation of data regarding millions of voxels gained from computed tomography (CT) images and assignment of the density of the organ in question to each voxel is very laborious.
(3) The computational effort to perform the required calculations is very great and it is necessary to find the best variance reduction technique to obtain the best results.

What are the most important findings of your study?

First and foremost, it adds knowledge regarding out-of-field organ doses in paediatric patients. This knowledge is rare in the literature. A detailed model of the Linac 2100CD with the MillenniumTM 120-leaf multileaf collimator (MLC) has been implemented and validated against measurements for the first time in the Monte Carlo N-Particle code 6 (MCNP6). In addition, in an unprecedented way this study combines measurements from thermoluminescence dosimeters with calculations from TPSs and MC models in a paediatric computational phantom manually voxelised from CT images. Moreover, the same phantom was used for both measurements and TPS and MC calculations, so providing an unprecedented thorough, comprehensive and accurate methodology to assess the reliability of the computed organ doses presented in this work.

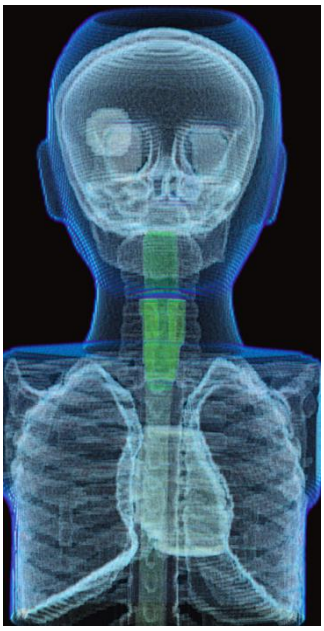

Figure 1 - Paediatric voxelised phantom.

What is the implication of this research?

Our study provides a linac and ancillary equipment model that has never before been implemented in MCNP6 and which could be used in clinical research for dose evaluation outside the treatment fields, which is sparse in the literature. This validated model is particularly relevant, especially in paediatric patients, for the study of new radiotherapy treatment techniques, since it can be used to estimate the development of secondary cancers through the supply of dosimetric data to state-of-the-art cancer incidence and risk models. In an unparalleled way, this study provides dosimetry measurements, and TPS and MC calculations of a manually voxelised paediatric computational phantom. In future work, we intend to apply this model to intensity modulated radiotherapy treatments. An appropriate risk model can then be used to estimate the development of secondary cancers.

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