Validation of a Monte Carlo model for peripheral dosimetry and dose calculations in a full-body voxelised phantom with regards to secondary cancers

A. Joosten[1], F. Levi[2], S. Baechler[1], O. Matzinger[3], W. Jeanneret-Sozzi[3], R.-O. Mirimanoff[3], F. Bochud[1], R. Moeckli[1]
[1] University Institute for Radiation Physics, CHUV and University of Lausanne
[2] Cancer Epidemiology Unit and Cancer Registries of Vaud and Neuchâtel, Institute of Social and Preventive Medecine, CHUV, Lausanne
[3] Department of Radiation Oncology, CHUV, Lausanne
mail: andreas.joosten@chuv.ch

Introduction

Secondary cancers after successful treatment of the initial cancer is becoming of increasing concern in the radiation oncology community due to longer survival times and new treatment techniques spreading low doses over larger volumes of healthy tissue. The comparison of risks associated with different treatment techniques (conventional, steep-and-shoot IMRT, arc therapy) with regards to secondary cancer induction is controversial due to uncertainties in risk estimations [1]. Current models for low doses (< 2 Gy) are based on atomic bomb survivors and data for higher doses (> 2 Gy) is sparse [2]. There is a clear need to collect more data from long-term cancer survivors and stratify the risk as a function of dose. Since doses ranging from 100 mGy up to > 50 Gy are susceptible to induce cancer [3], an accurate dosimetry in the full body of the patient is required to ascertain radiation risks. This can be achieved with Monte Carlo (MC) methods.

Material and Methods

The linear accelerator Siemens Primus was modelled for 6MV beams with BEAMnrc MC code. The MC simulations were compared with measurements of the Primus in a water tank with special emphasis on out-of-beam doses up to 25 cm from the field edge. Peripheral dose measurements were also performed on 3 other linear accelerators operating at 6MV in order to validate the MC model as a generic model to be used in epidemiological studies. A four-field breast cancer treatment was simulated with MC in a full body voxelised phantom.

Results

Comparison of MC simulations with different measured linacs shows that the MC out-of-field doses are within the variability of measured linear accelerators up to 25 cm from the beam edge. The variability between machines was 15% for a 20x20 field and increased up to 100% for a 5x5 field. These discrepancies are acceptable considering the large range of doses (3 orders of magnitude) and uncertainties involved in second cancer risk assessment.
A single MC model for 6MV linacs has thus been validated for peripheral dosimetry with regards to secondary cancer induction. This validation allowed us to perform dose calculations in a full-body voxelised phantom. Dose-Volume Histograms were extracted for several organs.

Discussion

A Monte Carlo model has been validated for full-body dose calculations. Such a model allows accurate calculation of low doses (< 2 Gy) and associated risks with these low doses which is not possible with a commercial treatment planning system.

References

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