Influence of dose calculation accuracy on model predictions of radiotherapy-induced esophagitis

Arefeh Sheikholeslami 1, Elahe Fathipour 1, Mansour Ansari 2, Mohammad Mohammadianpanah 2, Sareh Karbasi 2, Seyed Hassan

Hamedi 2, Nozhat Khanjani 2, Mohammad Reza Sasani 4,5, Peyman Jafari 6, Reza Fardid 1,3, Mohammad Amin Mosleh-Shirazi 2,3\*  
  
1 Department of Radiology, School of Paramedical Sciences, Shiraz University of Medical Sciences, Shiraz, Iran

2 Department of Radio-oncology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran

3 Ionizing and Non-Ionizing Radiation Protection Research Center (INIRPRC), School of Paremedical Sciences, Shiraz University of Medical Sciences, Shiraz, Iran

4 Medical Imaging Research Center, Shiraz University of Medical Sciences, Shiraz, Iran

5 Department of Radiology, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran

6 Department of Biostatistics, School of Medicine, Shiraz University of Medical Sciences, Shiraz, Iran

mosleh\_amin@hotmail.com

*Abstract*

Background: Treatment planning systems (TPSs) are used in cancer radiotherapy to design acceptable radiation beam configurations for each patient’s treatment. They use dose-calculation algorithms which model the physical characteristics of the accelerator radiation beam as well as how radiation interacts with the patient’s anatomy (represented by CT scan images), to calculate the resulting dose distribution in the body. Normal-tissue complication probability (NTCP) models can then use the calculated dose distribution to predict various radiation-induced side effects from each plan and, thereby, help clinical decision making. Dose-calculation algorithms differ in accuracy and speed. TPSs often have multiple algorithms, so choosing the most appropriate one is important to ensure a correct decision in the shortest time. Aim: To quantify the influence of photon dose-calculation algorithm selection on the cervical esophagus (CE) dose indices and the derived equivalent uniform dose (EUD) and NTCP for acute esophagitis in patients treated for head-and-neck cancer (HNC). Materials and Methods: The Fast Photon Effective Path (FPEP) and Collapsed-Cone Convolution Superposition (CCCS) algorithms (Prowess Panther TPS) were compared for 30 patients (six tumor sites). The Lyman-Kutcher-Burmann (LKB) model was used to calculate the EUDs and NTCPs. Results: On average, the faster but simpler FPEP algorithm overestimated the mean dose to CE planning organ-at-risk volumes by 2.0% (p = 0.003). The average absolute difference in mean dose was 2.7% and the maximum difference was 9.3%. The V5Gy, V10Gy, V15Gy, V20Gy, V25Gy and V30Gy values were significantly higher with FPEP, while the point-dose and D2cc hot spots were similar. In turn, the dose differences led to an underestimation of the LKB-model prediction of the EUD by 1.4% (p = 0.297). The mean absolute difference in EUD was 4.5% and the maximum difference was 15.3%. In the 14-50 Gy mean dose range, the resulting NTCPs with FPEP were lower on average by 2.6% than CCCS (p = 0.041). Conclusions: For these HNC patients, the EUD and NTCP for acute esophagitis were moderately sensitive to the choice of dose-calculation algorithm. Despite an overestimated mean dose by the faster algorithm, the NTCP underestimation, which can be large in some patients, requires attention.

Keywords— Dose calculation model, NTCP, EUD, Head-and-neck cancer, Acute esophagitis

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