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Photon Dose Calculation Algorithms in the Presence of Low-Density Heterogeneity-a Mini Literature Review

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Abstract Dose prediction accuracy in photon dose calculation algorithms is important to ensure accurate delivery of prescribed dose to the tumor during radiation therapy. The main objective of this article is to provide a brief review on most recent dose calculation algorithm called Acuros XB, which is used to calculate the cancer treatment plans in external beam radiation therapy.

Keywords: *Acuros XB, dose Calculation, AAA*

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1. Introduction

The primary goal in radiotherapy is to maximize the tumor control while minimizing the dose to the organs at risk (OARs). Dose calculation algorithms employed in treatment planning systems (TPS) play an important role in predicting the radiation dose to the tumor. Hence, inaccurate dose prediction by the dose calculation algorithms may lead to unwanted radiation dose to the normal tissues or reduced dose to the tumor. This will ultimately lead to unfavorable clinical results.

Currently, there are several photon dose calculation algorithms available in the commercial TPS. The most commonly used dose calculation algorithms are collapsed cone convolution superposition (CCCS) and analytical anisotropic algorithm (AAA). Recently, a new dose calculation algorithm called Acuros XB has been implemented in the Eclipse TPS, and several researchers have shown the superiority of Acuros XB over CCCS and AAA, especially when a heterogeneity is involved. The purpose of this study is to review the dosimetric results of dose calculation algorithms in the presence of low-density heterogeneity, with a focus on Acuros XB. Both the AAA and Acuros XB are available in the Eclipse TPS, whereas the CCCS is implemented in the Pinnacle TPS.

2. Methods

A literature search was conducted in Google Scholar using search terms "collapsed cone convolution superposition", "analytical anisotropic algorithm", and "Acuros". Relevant articles were reviewed, and the summary of major findings among selected studies is presented.

3. Results

Several investigators [1-9] have studied the accuracy of Acuros XB, and compared its results with the AAA and CCCS calculations. The research group of Bush et al. [2] showed that Acuros XB was more accurate than the AAA when compared to the Monte Carlo (MC) results, with a difference up to 4.5% for the Acuros XB and up to 17.5% for the AAA. Han *et al.* [3] showed the larger difference for the AAA (2.5%-6.4%) and smaller difference for the Acuros XB (0.4%-4.4%) when compared to the measurements. Kan et al. [4] showed that the Acuros XB had a smaller deviation (3%) than the AAA (10%) from the measurements.

From the research group of Rana et al. [5,6], the results demonstrated that the Acuros XB was more accurate with a difference up to 3.8%, whereas the AAA showed larger deviation (up to 10.6%) when compared to the measurements. Stathakis et al. [7] showed an agreement between the CCCS and Acuros XB was within 2%, whereas the AAA calculations showed higher deviation (5%). In a recent study involving CCCS, Oyewale [10] showed that the CCCS could have dose prediction errors by up to 6.7% after the photon beam traversing the air gap.

4. Discussion

Although Acuros XB has been found to be more accurate than the AAA and CCCS, the dosimetric differences between the Acuros XB and other dose calculation algorithms may be less distinct for the clinical cases. However, the accuracy of Acuros XB will be important when a tumor site involves a low-density tissue such as the lung. The variation in discrepancies among dose calculation algorithms is mainly due to the difference in beam modeling approach as well as the method used to account the tissue heterogeneity corrections. The involvement of smaller photon fields and low-density medium will typically cause the electronic disequilibrium, and the dose calculation algorithm must be able to account such conditions. Additionally, the inaccurate estimation of primary beam attenuation, beam hardening effect, and lateral scatter will lead to dose prediction errors, especially when photon fields pass through high and low-density heterogeneities such as the bone and lung tissues.

5. Conclusion

The current literature suggests that Acuros XB is more accurate than AAA and CCCS. The improved dose prediction accuracy in Acuros XB may be beneficial in the treatment of lung tumors.

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