

## Interpreting Radiation Treatment Planning Study Results: A Note of Caution

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Prostate cancer is the most commonly diagnosed cancer among males in the United States.<sup>1</sup> The treatment of prostate cancer has several options, including external beam radiation therapy. The primary goal of radiation therapy is to control the tumor by delivering a maximum dose to the tumor site, yet minimizing the radiation dose to normal tissues. The development of advanced delivery techniques such as intensity modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT) as well as more accurate treatment planning systems have improved tumor control in radiation therapy. Intensity modulated radiation therapy is a treatment technique that delivers the radiation beam in a static mode, whereas VMAT is considered to be a rotational IMRT that allows the beam to be delivered with the gantry of the machine rotating around the patient.<sup>2</sup> Sophisticated treatment planning systems have also increased the accuracy of dose calculation and improved the work flow in the clinic. The results from different complex delivery techniques, however, may vary from one institution to another. The main purpose of this article is to provide a brief summary of the reasons that may have caused discrepancies among different treatment planning studies on prostate cancer.

This study reviewed the most recent literature on prostate cancer treatment planning. The literature search was conducted using the terms “prostate cancer”, “IMRT”, and “VMAT” on Google Scholar. According to the review, the common agreement among different studies was the decreased treatment time and less number of monitor units (MUs) associated with VMAT when compared to IMRT.<sup>3-14</sup> There were discrepancies in dosimetric results for organs at risk (OARs) among different authors.<sup>3-14</sup> For example, Kjaer-Kristoffersen et al.<sup>3</sup> reported that VMAT had the capability to produce better or equal sparing of OARs than IMRT. In contrast, Yoo et al.<sup>4</sup> reported that IMRT was better in sparing OARs than VMAT. Zhang et al.<sup>5</sup> showed that VMAT was better than IMRT in sparing the rectal wall. In a study by Tsai et al.,<sup>6</sup> there

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was no clear dosimetric advantage of one technique over the other.

The VMAT planning for prostate cancer is generally performed using either a single or double arc. The double arc has more controlled points than the single arc which can give a higher modulation. However, this high modulation is associated with longer planning time due to complex optimization processes for highly modulating beams. The major advantage using a single arc is treatment efficiency; however, researchers have reported a higher rectal dose if a single arc is utilized in VMAT planning.<sup>7</sup> Guckenberger et al.<sup>8</sup> have reported that the single arc technique produced a lower rectal dose than the double arc. One of the most recent studies by Rana et al.<sup>9</sup> has shown that a partial-single arc can be better than the standard single arc technique in VMAT planning. These researchers have stated that a beam set up with avoidance sectors in locations directed posterior and anterior to the prostate could push the dose away from the rectum and bladder.<sup>9</sup>

Treatment planning systems from different vendors can produce different dosimetric results even when treatment planning is done with the same computed tomography (CT) dataset from the patient. The optimization technique and dose calculation algorithm are two major components in treatment planning systems. The optimization technique can influence dosimetric results since the treatment planner can adjust the upper and lower objectives of the structures during plan optimization. Furthermore, the experience of the treatment planner involved in optimization process is crucial since the familiarity of the optimization interface is essential in obtaining the optimum treatment plan in a timely manner. Treatment planning time is particularly important for busy clinics.

Dose calculation algorithms implemented in commercial treatment planning systems can affect the dose distributions of the treatment plans.<sup>15-17</sup> The treatment of prostate cancer also involves tissue heterogeneities, and it is essential for the dose calculation algorithms to account for the heterogeneity correction more accurately during

computation of the treatment plans. However, the difference in beam modeling among various dose calculation algorithms can result in discrepancies in prostate cancer treatment plans. For example, the anisotropic analytical algorithm (AAA) is convolution-superposition based and differs from the pencil beam convolution (PBC) and collapsed cone convolution superposition (CCCS). Since these three algorithms (AAA, PBC, and CCCS) have different ways of handling tissue heterogeneity corrections, it is possible to obtain different results using different algorithms. Hence, an IMRT plan that has been calculated with AAA may not give a similar result to that of an IMRT plan calculated with CCCS or PBC.

The OARs are typically situated away from the target volume. Although the primary intent is to maximize the dose to the planning target volume, there is always a possibility that OARs will receive this dose. One of the factors that can affect the OAR dose is the head of the treatment machine, which is responsible for the scatter radiation. It is important to note that different vendors have treatment machines (or linear accelerators) with different head designs; this can lead to variations in secondary collimator transmission and scatter radiation depending on the vendor configuration. The difference in beam energy used for the treatment planning can also impact prostate cancer treatment planning results.<sup>18,19</sup>

The variability in commissioning data used by the treatment planning system can also produce different dosimetric results. The commissioning data are typically obtained from the measurements performed in the water medium. However, some centers prefer to use golden beam data such as for Varian machines. The commissioning data are fed into the treatment planning system, which then facilitates the dose calculation algorithms to compute the dose for the treatment plans. Hence, the impact of commissioning data on the dosimetric results also cannot be ignored.

It is essential to study the clinical outcome of patients treated with VMAT and IMRT. Although the toxicity outcomes of patients treated with IMRT have been reported,<sup>20</sup> the clinical impact of VMAT has yet to be reported. In an attempt to

reduce rectal and bladder toxicities, recommendations include minimizing rectal and bladder exposure to the high dose.<sup>20</sup>

Despite the discrepancies among different treatment planning studies, the use of VMAT technique for prostate cancer seems appealing, particularly for the clinics with high numbers of patients. However, clinicians must be careful in choosing one technique over the other based on the treatment planning results that have been reported by various studies. Treatment plan evaluation using radiobiological response models can provide important information regarding the treatment outcome of the patients.<sup>21</sup> It has been suggested that proton therapy can be an attractive option for cancer treatment due to its finite range in tissue and sharp lateral penumbra.<sup>22</sup>

### Conflict of Interest

No conflict of interest is declared.

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