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Short Communication

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Stereotactic Body Radiation Therapy Treatment for Prostate Cancer: From Setup to Delivery Strategies

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INTRODUCTION

Stereotactic Body Radiation Therapy (SBRT) of prostate cancer has garnered increasing attention owing to its proposed low a/b value, which is close to 1.5 Gy.[1] Recent clinical data support the low value for a/b ratio as predicted by radiobiological models; hence, large doses per fraction should result in a higher probability of tumor control together with a reduced probability of complications for healthy tissue. In this paper, we focused on the technical parameters and treatment strategies adopted in the hypofractionation (HF) studies published in literature.

SETUP AND PREPARATION STRATEGIES

The effect of geometric uncertainties is known to be one of the major concerns in radiation dose delivery in prostate cancer.[2] These uncertainties are mostly due to patient setup errors and extensive motion of the rectum and bladder that is dependent on organ filling. In this regard, an augmented impact of geometric uncertainties is expected when high doses per fractions are adopted. This could occur because in HF treatments, any single targeting error causes a greater biologic impact by consistently underdosing the target organ at greater expense of the organs at risks (OARs).[3] Several technological innovations have boosted the high-precision localization of the prostate during treatment, allowing the delivery of highly conformed dose fractions to a well-defined target with sharp dose fall-off towards the bladder and rectum.[4] However, multiple technical parameters and operational variables can affect the correct localization of the prostate and the reproducibility of the procedures.[5]

Changes in patient posture were also of importance (e.g., relaxation of pelvic muscles). To reduce motion, specific patient positioning, immobilization strategies, controlled diet, and rectum/bladder filling have been practiced by different groups.[6-8] The most commonly used patient treatment position was the supine. However, the optimal treatment position for the prostate remains controversial and inconclusive because several studies[5] have reported advantages and disadvantages for both supine and prone approaches. An advantage of the prone position is that the irradiation dose to the rectum is reduced because the seminal vescicles (SV) are pulled away from the rectum.[9] Moreover, the geometric relationship between the prostate and the pelvic bony anatomy is more consistent in the prone position and seems to be very important for centers using bony structure based positioning.[10] Conversely, a disadvantage of the prone position is greater prostate motion compared with the supine position.[11] Additionally, the supine position is more comfortable for patients and more convenient for therapists than the prone position. Immobilization frames were routinely used to reduce the degree of spatial uncertainty secondary to positioning error. Pelvic vacuum cushions, thermoplastic sheets, foam agents, and/or leg, knee, ankle and foot supports were generally used in the reviewed studies. Despite reports that a whole-body cushion ensures more reproducibility,[6] the usefulness of specific supports must be substantiated. For example, the use of a knee support during prostate irradiation, which prevents dorsal rectum shifts and prostate rotation at the apex around the left-right axis, decreases the dose delivered to the rectal wall.[12]

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Displacements of the prostate relative to the radiation beams occur not only as a result of patient positioning but also owing to different filling levels and pressures from the bladder and rectum. Graf et al[13] reported reduced prostate motion when patients were appropriately instructed regarding constant bladder and rectum filling. In most of the selected HF studies, the bladder volume was kept constant by having the patient empty the bladder and drinks a known amount of water before the simulation and treatment. Different strategies were adopted for the rectum, for which filling is more difficult to control. Frequently, a rectal enema was performed in patients treated with extremely high frequency (EHF) regimes. In fact, several studies showed a decrease in the interfraction prostate displacement with a consequent reduction in the target margin when an enema was used.[14,15] None of the drugs or compounds delivered was shown in the current literature to be useful in preventing or mitigating acute damage to healthy tissues. The use of a rectal balloon, which positively influences intrafraction prostate stability, was sporadic. The use of tissue spacers in the region between the prostate and the anterior rectal wall has never been referenced. However, a reduced variability in the data regarding bladder toxicity, especially late toxicity, was observed in patients who received preparation, this indicates a more accurate prediction of the expected toxicity when assessed for a lower anatomical inter patient variability.

IMAGING STRATEGIES

The use of computed tomography/magnetic resonance imaging (CT/MRI) image fusion for more precise target volume identification in prostate cancer patients was reported. Hentschel et al[16] reported that CT scans overestimate prostate volume by 35% compared with MRI. In particular, they found that the mean area defined by CT imaging was larger than the area defined by MRI, mainly at the base and the apex of the prostate. However, in the segmentation process, it is necessary to take into account the prostate swelling that occurs during treatment.[17] In a recent study performed by Gunnlaugsson et al,[18] the adoption of an EHF regimen showed a significant increase in prostate shape and size of 14% at the middle of treatment (Equivalent dose in 2 Gy fractions Z 33 Gy) and 9% at the end of treatment (Equivalent dose in 2 Gy fractions Z 67 Gy). This trend differs from the conventional fractionation trend.[19]

IMAGE GATED RADIOTHERAPY STRATEGIES

The daily or random prostate localization timing were done using several different technologies, including transabdominal US, x-ray portal imaging, and kilo-voltage and mega-voltage cone-beam computed tomography (CBCT). With these technologies, patient localization uses bony anatomy, implanted fiducials (seeds or electromagnetic transponders), or soft-tissue images. EHF studies reported mostly a prostate alignment performed with implanted fiducial markers. Intermodality shifts between the different technologies seem comparable, as reported by Mayyas et al.[20] Among the methods, localization using markers results in the least interuser disagreement compared with using anatomy or soft tissues.[14,21] Different authors have reported that the choice of imaging frequency and timing are key components in delivering the desired dose while reducing the associated overhead, such as imaging dose, preparation, and processing time.[22]

ADAPTIVE STRATEGIES

No adaptive strategy was adopted in the published EHF studies. Several groups have conducted research in the pelvic region with different adaptive approaches.[23,24] One notable method that could be applied to HF regimens is the so called "*plan of the day*" approach.[25] In this strategy, a multiple-plan library was generated before the treatment course from weekly serial 6-8 CT datasets from 4 patients. During each fraction, a daily plan was manually chosen from the library according to the patient's daily anatomy. Chen et al[25] reported an excellent target coverage using a similar approach, with the dose delivered to the OARs being only slightly increased.

CONCLUSIONS

Recent clinical data support a low value for a/b ratio as predicted by radiobiological models; hence, large doses per fraction should result in a higher probability of tumor control together with a reduced probability of complications for healthy tissue. The evaluation of the cost-effectiveness of the treatment, it is mandatory to also consider the associated morbidity. This paper is an overview on technical parameters and delivery strategies to be taken as a guideline for HF radiotherapy treatments.

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