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Interobserver variability in rectum contouring in high-dose-rate brachytherapy for prostate cancer: A multi-institutional prospective analysis

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ABSTRACT

PURPOSE: The aim of this study was to evaluate the interobserver variability (IOV) of rectum contouring, and its dosimetric consequences, for high-dose-rate brachytherapy in patients with prostate cancer across multiple institutions.

METHODS AND MATERIALS: Five radiation oncologists contoured rectums in 10 patients on transperineal ultrasound image sets after establishing a delineation consensus. The $D_{0.1cc}$, D_{1cc}, and D_{2cc} rectum volume parameters were determined. The mean, standard deviation, and range of each dose—volume histogram parameter were evaluated for each patient. The IOV was determined using the coefficient of variation, and the dosimetric impacts on the total dose were analyzed by estimating the biologically equivalent dose ($EQD_{2\alpha/\beta\,=\,3}$).

RESULTS: The interobserver coefficients of variation (±standard deviation) for the reported $D_{0.1cc}$, D_{1cc}, and D_{2cc} were 5 ± 1.84%, 4 ± 1.26%, and 4 ± 1.33%, respectively. As for the impact on the total dose, the mean dose differences for $D_{0.1cc}$, D_{1cc}, and D_{2cc} were 10 Gy, 7.3 Gy, and 6.6 Gy, respectively.

CONCLUSIONS: The D_{2cc} is robust as evident by the low IOV (<5%). However, some variability ranges almost overlap with the clinical threshold level, which may present dosimetric and clinical complications. General rectal contouring guidelines for prostate high-dose-rate brachytherapy are desirable to reduce discrepancies in delineation. © 2017 American Brachytherapy Society. Published by Elsevier Inc. All rights reserved.

Keywords: Contouring; High-dose-rate brachytherapy; Interobserver variability; Prostate cancer

Introduction

The latest studies on the treatment of high-risk prostate cancer suggest that high-dose-rate brachytherapy (HDRBT) as a boost to external beam radiotherapy (EBRT) reduces the risk of relapse and increases survival (1—7). In 2016, Kishan *et al.* (8) published a multi-institutional comparative analysis on the treatment of high-risk prostate cancer with radiotherapy (RT) or radical prostatectomy, in which they reported better systemic control with the use of EBRT and brachytherapy (BT). The American Brachytherapy

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Society has reported similar outcomes in its latest task group report of 2016 (9).

HDRBT is a technique that permits the selective treatment of the prostate through the use of radioactive sources; it delivers high doses of radiation to the tumor while avoiding organs-at-risk (OARs) such as the urethra, bladder, and rectum (10). This makes it a promising alternative dose-escalating technique in patients with this disease.

In the RT/BT planning process, a number of uncertainties exist when devising the most optimal treatment plan. These include the variation in volume delineation of the target tumor and OARs, which can be attributed to (or influenced by) the observers (11). Such interobserver variability (IOV) may have a direct impact on dosimetry and clinical results. Some studies on delineation have been performed to minimize the IOV, and guidelines have been published. However, such variation continues to exist despite the technological advances in RT.

At this time, there is no consensus guideline for rectum contouring for HDRBT for prostate cancer. In their latest recommendations for HDRBT, the Group Européen de Curiethérapie (GEC) and European Society for Radiotherapy and Oncology (ESTRO) suggested that rectum contouring should include the outer wall as a minimum (12), whereas the American Brachytherapy Society recommends that the rectum be defined by contouring the external and mucosal surface (13). The GEC/ESTRO have proposed that the minimum dose received by the most exposed 2.0 cm^3 volume (D_{2cc}) be constrained to a $\leq$75 Gy biologically equivalent dose (EQD_2) in their latest guidelines (12).

To evaluate the robustness of the aforementioned dose constraint to the rectum, we previously performed an IOV pilot study on rectal delineation and found the IOV to be <5% for D_{2cc}, but with a strong dosimetric impact up to 5.8 Gy as the worst-case scenario. This study was performed after a consensus for rectum contouring that was achieved between radiation oncologists, radiologists, and urologists at the same RT center (14). Several studies have analyzed the IOV in RT volume contouring; most of that investigated volume delineation uncertainties in RT focused on targets (15). Only three of 31 published studies have evaluated OAR delineation variability on BT. Recently, a significant relationship between the dose–volume histogram (DVH) parameter (D_{2cc}) of the rectum and the occurrence of late rectal toxicity (LRT) in HDRBT-treated patients with prostate cancer was discovered (16). Given the aforementioned factors, the purpose of this study was to evaluate the IOV of rectum contouring for HDRBT to treat prostate cancer, determine the dosimetric consequences, and analyze the robustness of the GEC/ESTRO recommendations regarding D_{2cc} constraint in a multi-institutional study.

Methods and materials

This was a multi-institutional prospective transrectal ultrasonography (TRUS) planning study, based on a clinical HDRBT and EBRT combined protocol for patients with high-risk prostate cancer. Five academic radiation oncologists (observers) experienced in prostate HDRBT from four institutions participated in the study; each observer contoured the rectum on the TRUS images of 10 patients.

Study cases

Ten patients with high-risk prostate cancer who underwent HDBRT and EBRT at our department were enrolled. All patients were classified as high risk according to the National Comprehensive Cancer Network guidelines (17) based on serum prostate-specific antigen level, Gleason score, and clinical tumor stage. Tumor and HDRBT treatment characteristics are listed in Table 1. Selected cases included a range of different prostate sizes or clinical target volumes (CTVs) representing common situations in HDRBT prostate contouring. The Institutional Ethics Review Board approved this study.

Image acquisition and treatment planning

Planning TRUS image sets were obtained for each patient using the Primus 6.5 MHz ultrasound device (Hitachi, Ltd, Tokyo, Japan). As part of the HDRBT treatment, the ultrasound scan was uploaded to the Oncentra Prostate planning device (version 4.2; Nucletron, Veenendaal, Netherlands) to reconstruct the three-dimensional prostate and OAR volumes. Each patient was placed in the lithotomy position under anesthesia. The ultrasonography probe was inserted into the rectum, and two prostate stabilizing needles were inserted before image acquisition. The planning system recorded *in vivo* axial images captured at 1-mm slice intervals. Axial images of the prostate were captured from the base through the apex after the needles were positioned.

HDRBT was considered an intraoperative procedure, in which a single 15 Gy dose was delivered while the TRUS

Table 1
Patient characteristics

Patient	Tumor stage			PSA (ng/mL)	Gleason score	Prostate volume (cm^3)
1	T3a	N0	M0	5.2	6	35.7
2	T3a	N0	M0	20.4	7	28.1
3	T1	N0	M0	27.4	7	44.8
4	T2b	N0	M0	30.0	6	39.5
5	T2b	N0	M0	9.2	7	53.7
6	T2b	N0	M0	16.6	7	66.5
7	T2c	N0	M0	22.1	7	43.3
8	T3a	N0	M0	14.6	8	26.4
9	T1c	N0	M0	12.5	7	57.6
10	T1c	N0	M0	16.3	7	47.5

PSA = prostate-specific antigen.

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