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Sector analysis provides additional spatial information on the permanent prostate brachytherapy learning curve

Ahamed Badusha Mohamed Yoosuf[1,*], Darren M. Mitchell[2], Geraldine Workman[1], Sai Jonnada[2], Eoin Napier[3], Suneil Jain[2]

[1]*Department of Radiotherapy Medical Physics, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Antrim, Northern Ireland, UK*
[2]*Department of Clinical Oncology, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Antrim, Northern Ireland, UK*
[3]*Department of Radiology, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Antrim, Northern Ireland, UK*

ABSTRACT

PURPOSE: To evaluate the permanent prostate brachytherapy (PPB) learning curve using postimplant multisector dosimetric analysis and to assess the correlation between sector -specific dosimetry and patient-reported outcome measures (PROMs).

METHODS AND METHODS: First 200 patients treated with ^{125}I PPB monotherapy (145 Gy) at a single institution were assessed. Postimplant dosimetry (PID) using CT was evaluated for whole prostate (global) and 12 sectors, assessing minimum dose to 90% of prostate (D_{90}) and dose to 0.1 cm^3 of rectum ($D_{0.1cc}$). Global and sector PID results were evaluated to investigate changes in D_{90} with case number. Urinary and bowel PROMs were assessed using the International Prostate Symptom Score and the Expanded Prostate Cancer Index Composite questionnaire. The correlation between global and individual sector PID and urinary/bowel PROMs was also evaluated.

RESULTS: Linear regression confirmed a significant improvement in global D_{90} with case number ($r^2 = 0.20$; $p = 0.001$) at a rate of 0.11 Gy/case. Postimplant D_{90} of base sectors increased at a rate of 0.11−0.15 Gy/case ($p = 0.0001$) and matched global improvement. The regression lines of midgland and apex sectors were significantly different from global D_{90} ($p = 0.01$). Posterior midgland sectors showed a significant reduction in D_{90} with case number at a rate of 0.13−0.19 Gy/case ($p = 0.01$). Dose to posterior midgland sectors correlated with rectal $D_{0.1cc}$ dose but not bowel PROMs. Dose to posterior midgland sectors correlated with urinary International Prostate Symptom Score change, which was not apparent when global D_{90} alone was considered.

CONCLUSIONS: Sector analysis provided increased spatial information regarding the PPB learning curve. Furthermore, sector analysis correlated with urinary PROMs and rectal dose.

Keywords: Permanent prostate brachytherapy; Learning curve; Global and sector analysis; Spatial dose distribution

Introduction

Permanent prostate brachytherapy (PPB) is a well-established, effective radical treatment for low- and intermediate-risk prostate cancer (1, 2). The biochemical outcomes from PPB are related to implant quality (3, 4), hence the evidence-based guidelines for postimplant dosimetric assessment and audit (1,5−7).

A global dosimetric learning curve has been widely reported for PPB and is characterized by improving postimplant dosimetry (PID) indices such as the D_{90} (dose delivered to 90% of the prostate volume) (8, 9) and improving patient-reported outcome measures (PROMs) (10, 11). Feedback from global PID is a valuable learning tool, particularly for new centers, allowing the implanting team to identify trends and adjust both their planning and implant techniques (12). However, global dosimetry is limited by a lack of spatial information thereby failing to identify, which part of the prostate has received a higher or lower than intended dose.

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* Corresponding author. Radiotherapy Medical Physics Section, Northern Ireland Cancer Centre, Belfast City Hospital, Lisburn Road, Belfast BT9 7AB. Tel.: +44-28-95047817; fax: +44-28-90637763.

E-mail address: ahamed.badusha@belfasttrust.hscni.net (A.B. Mohamed Yoosuf).

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Spatial dose mapping with sector analysis software can help to address this limitation by dividing the prostate into several reproducible regions that allow comparison of the planned vs. delivered dose to smaller subsegments of the prostate, allowing trends of underdosing or overdosing to be identified in these segments (13, 14).

Several publications have used sector analysis to show that the anterior base and posterior midgland are regions that are frequently underdosed and overdosed, respectively (13,15−17), with multivariate analysis demonstrating that the dose to the anterior inferior quadrants is predictive for subsequent biochemical relapse (18).

We hypothesized that sector analysis would give more information than global dosimetry in assessing the PPB learning curve information, which could be of benefit to both new and established centers in evaluating and refining their implant program. We also wished to investigate whether the dosimetric parameters of individual sectors were predictive of urethral and bowel PROMs.

Methods and materials

From December 2009 to October 2014, the first 200 consecutive patients who underwent permanent prostate ^{125}I brachytherapy as monotherapy at a single institution were evaluated. The Seattle preplan technique was used for all patients (19). Patients were divided into four groups of 50 consecutive patients to assess clinical and global dosimetric differences over time.

Preimplant and postimplant dosimetry

The minimum prescription dose was 145 Gy for all patients. The preplan technique has previously been reported (5−7). All implants were planned with ^{125}I stranded radioactive seeds (model 6711 RAPID Strand, Oncura, a Unit of GE Healthcare, Chalfont St. Giles, UK) with a reference air kerma strength of 0.458 U (U - μGyh^{-1} m^2) for the first 110 patients and 0.496 U for the last 90 patients. As our program evolved, we moved from axial to sagittal imaging for seed deposition after 110 patients. All plans were created using Variseed 8.0 (Varian Medical Systems, Inc., Palo Alto, CA) treatment planning system. The American Association of Physicists in Medicine Task Group 43 (TG-43 Update) formalism was used in the planning and calculation of the dosimetry (20). All implant procedures were performed by two radiation oncologists, supported by a radiologist. All preimplant treatment plans were generated to meet the

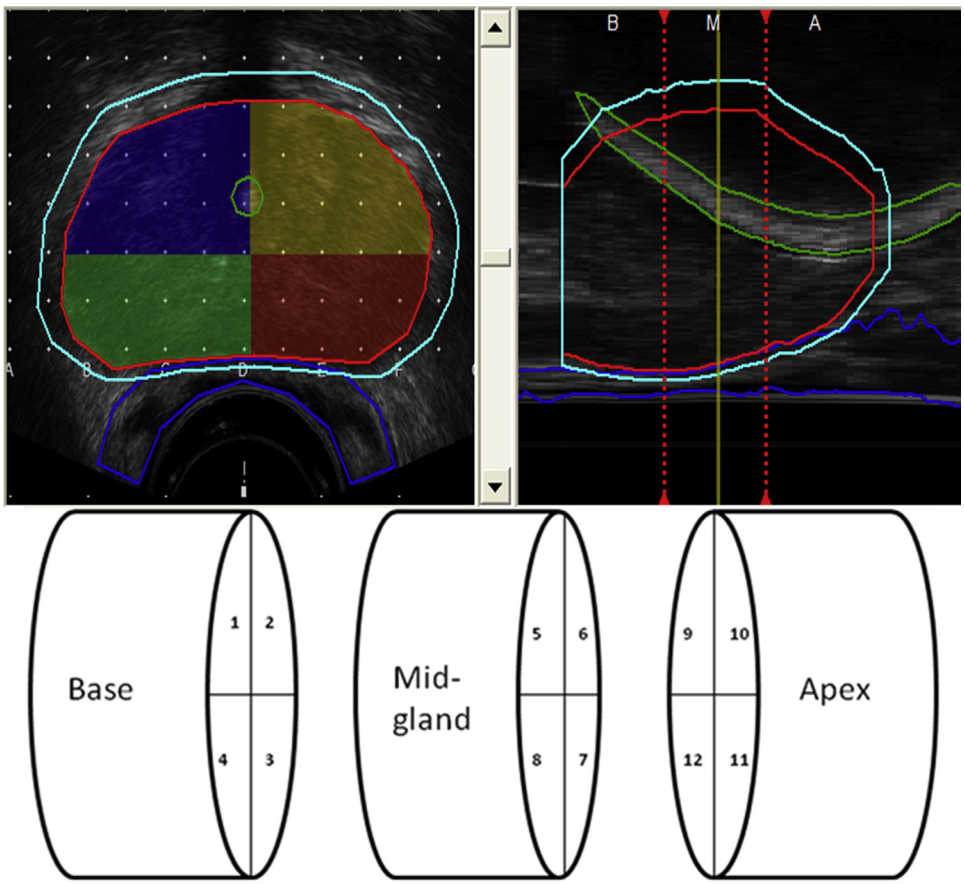

Fig. 1. Twelve-sector analysis created by dividing the prostate into three equal lengths along the craniocaudal axis to form base, midgland, and apex and then subdivided with a vertical plane and a horizontal plane generating right/left anterior and right/left posterior sectors.