Medical Dosimetry ■■ (2017) ■■–■■

Medical Dosimetry

journal homepage: www.meddos.org

Dosimetry Contribution:

The impact of intensity-modulated radiation therapy plan normalization in the postprostatectomy setting—does it matter?

Mary Anne Stritch, B.Sc. (Hons), Elizabeth Forde, M.Sc., and Michelle Leech, M.Sc.

Applied Radiation Therapy Trinity, Discipline of Radiation Therapy, School of Medicine, Trinity College Dublin, Ireland

ARTICLE INFO

Article history:
Received 6 June 2017
Accepted 24 July 2017

Keywords:
IMRT
Normalization
Dose prescription
Post-prostatectomy

ABSTRACT

The International Commission on Radiation Units & Measurements -83 recommends prescribing intensity-modulated radiation therapy (IMRT) in a dose-volume manner. Despite this, clinical variation still exists in how prostate IMRT plans are prescribed. This study aims to investigate the impact of different plan normalization methods for postprostatectomy IMRT.

IMRT treatment plans were created retrospectively for 20 postprostatectomy patients. These were normalized such that the dose received by 98% (D98) of the planning target volume (PTV) was equal to 100% of the prescribed dose. All plans were individually optimized to achieve target coverage and organ at risk (OAR) dose constraints. Each patient's plan was then copied and normalized such that the mean dose (Dmean) received by the PTV was equal to 100% of the prescribed dose. The International Commission on Radiation Units & Measurements -83 recommended dosimetric end points were extracted for targets and Quantitative Analyses of Normal Tissue Effects in the Clinic or Radiation Therapy Oncology Group 0534 end points extracted for OARs. Statistical analysis using the Wilcoxon signed-rank test to measure the difference between data from plans normalized to D98 and Dmean was conducted.

Extracted dosimetric end points of the targets and OARs were significantly higher in plans normalized to D98 than Dmean ($p < 0.05$) with the exceptions of D2 of the rectum and right femoral head.

Normalization impacts on dosimetric end points of a plan. Hence, reporting the normalization method used is necessary to allow for meaningful interpretation of IMRT dosimetric studies.

Introduction

The International Commission on Radiation Units & Measurements (ICRU) develops internationally acceptable recommendations regarding prescribing and reporting radiotherapy treatment plans.[1] ICRU reports are under continual review and contain the most recent data in the rapidly growing field of radiation oncology.[1,2] Intensity-modulated radiation therapy (IMRT) differs greatly from 3-dimensional conformal radiation therapy (3DCRT) and so to provide accurate and relevant recommendations, ICRU published Report 83 in 2010.[1,2] It reports that the median dose, the dose received by 50% of the volume (D50), may be a reasonable measure of typical dose across a 3D volume and is similar

Reprint requests to Elizabeth Forde, M.Sc., Discipline of Radiation Therapy, School of Medicine, Trinity College Dublin, Ireland.
E-mail: eforde@tcd.ie

http://dx.doi.org/10.1016/j.meddos.2017.07.010
0958-3947/Copyright © 2017 American Association of Medical Dosimetrists

to the dose recorded by the ICRU reference point, recommended for 3DCRT treatment plan reporting.[1-4] In effect, when planning using IMRT this means normalizing with a dose-volume approach. In clinical practice plans are commonly normalized to the mean dose (Dmean) and in these cases ICRU recommendations are not strictly being followed. Das *et al.* investigated dose prescription, recording, and delivery.[5] In this multi-institutional study, large dosimetric variation in prescribed and delivered doses was reported.[5] This study was carried out before ICRU-83 was published. It called for international guidelines in these areas to allow for comparable and meaningful clinical trials in IMRT,[5] a concept reiterated in multiple publications.[6,7] A more recent publication by Das *et al.* in 2017 demonstrate that unfortunately, despite ICRU-83 guidelines becoming available, standardization in IMRT prescription methods has not improved.[8]

This research aims to investigate the impact different normalization methods can have on the dosimetric outcomes for patients treated with IMRT following radical prostatectomy.

Methods and Materials

Patient selection

Following institutional ethical approval, irrevocably anonymized computed tomography (CT) data sets from a convenience sample of 25 postprostatectomy radiotherapy patients were obtained for this retrospective planning study. Patients were excluded due to hip prostheses ($n = 3$), bladder contour inconsistent with protocol ($n = 1$), and failure to import into the treatment planning system used for research ($n = 1$). The final sample size was 20 patients.

Simulation and preplanning

Simulation details for this patient group followed standard local practice, as previously described.[9] Patients were simulated and CT scanned supine, with a head sponge, arms on chest, and a SimMed knee block and ankle stocks. A GE Lightspeed RT CT scanner captured the scan in 2.5-mm slices from the superior aspect of the fifth lumbar spine vertebra to 5 cm inferior of the ischial tuberosities. Intravenous contrast with a 10-minute delay time was used to improve visualization of the urethral anastomosis.[10]

Target volume: delineation and prescription

The clinical target volume (CTV) was delineated by a genitourinary specialist radiation oncologist in accordance with consensus guidelines.[10] The CTV was expanded from 0.8 cm to 1.5 cm in all dimensions to create the planning target volume (PTV) as described by Forde *et al.*[11] Patients in this study were planned to the postprostatectomy salvage radiotherapy dose of 68 Gy in 2 Gy fractions.[12]

Table 1
Dose volume constraints adhered to for organs at risk

Structure	DVCs	Source
Bladder	V65 < 50%	QUANTEC
	V70 < 35%	QUANTEC
	V75 < 25%	QUANTEC
	V80 < 15%	QUANTEC
Bladder—CTV	V65 < 50%	RTOG 0534
	V40 < 70%	RTOG 0534
Rectum	V40 < 55%	RTOG 0534
	V50 < 50%	QUANTEC
	V60 < 35%	QUANTEC
	V65 < 25%	QUANTEC
	V65 < 35%	RTOG 0534
	V70 < 20%	QUANTEC
	V75 < 15%	QUANTEC
Femoral heads	V50 < 10%	RTOG 0534

CTV, clinical target volume; DVC, dose volume constraint; QUANTEC, Quantitative Analyses of Normal Tissue Effects in the Clinic; RTOG, Radiation Therapy Oncology Group; V40, volume receiving 40 Gy; V50, volume receiving 50 Gy; V60, volume receiving 60 Gy; V65, volume receiving 65 Gy; V70, volume receiving 70 Gy; V75, volume receiving 75 Gy; V80, volume receiving 80 Gy.

Organs at risk (OARs): delineation and dose constraints

Experienced radiation therapists delineated OARs according to Gay *et al.*,[13] and these contours were peer reviewed by a second radiation therapist.

When QUANTEC (Quantitative Analyses of Normal Tissue Effects in the Clinic) plans were created, dose volume constraints (DVCs) were adhered to as well as the Radiation Therapy Oncology Group (RTOG) 0534 trial DVCs as summarized in Table 1.[14-16]

Planning

IMRT treatment plans were created on the Eclipse TPS (version 8.6.15) and dose calculated using the anisotropic analytical algorithm with a calculation grid of 0.25 cm. Tissue heterogeneity was used with a bulk density correction applied for the bladder contour to correct for the presence of contrast within this structure. Each plan was initially normalized so that 100% of the prescription was delivered to 98% of the PTV (D98). Each of these plans was then copied and re-normalized so that 100% of the prescription was the mean dose received by the PTV (Dmean).

Data collection

For both the PTV and CTV, the dose to 2% of the volume (D2), D98, mean, median, dose to 99% of the volume (D99), and volume receiving 95% of the prescription (V95%) were