International Journal of Advances in Medicine
Philip M et al. Int J Adv Med. 2023 Aug;10(8):622-625
http://www.ijmedicine.com
pISSN 2349-3925 | eISSN 2349-3933

DOI: https://dx.doi.org/10.18203/2349-3933.ijam20232210

Case Series

Dosimetric comparison of irradiated small bowel volume with intensity modulated radiotherapy and volumetric modulated arc therapy in adjuvant pelvic radiation therapy for endometrial carcinoma

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Received: 29 May 2023
Revised: 01 July 2023
Accepted: 03 July 2023

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ABSTRACT

Newer treatment techniques help in reducing dose to small bowel (SB) which is an organ at risk (OAR) for pelvic radiotherapy (RT). However, instead of SB, bowel bag is contoured routinely and constraints are given. In this retrospective case series, we compared the dose received by SB while using intensity modulated radiation therapy (IMRT) and volumetric-modulated arc therapy (VMAT) techniques in patients receiving adjuvant pelvic RT for endometrial carcinoma. 10 patients with stage II EC who received VMAT were included in this single institution study. SB was contoured retrospectively in the planning computed tomography scan of these patients. An IMRT plan was also generated with a similar planning target volume coverage and organ at risk (OAR) constraints of the previously approved VMAT plan. Volume receiving 10 Gy, 20 Gy, 30 Gy, 40 Gy and 45 Gy of SB was analysed and a dosimetric comparison was made among the two plans. Anaylysis of variance (ANOVA) and unpaired t tests were used for dosimetric comparison. Mean SB volume receiving 10 Gy (V10 Gy) was 85.3% and 83.7% with IMRT and VMAT respectively. Mean SB volume receiving 45 Gy (V45 Gy) was 4.1% and 5% with IMRT and VMAT respectively. No statistically significant difference was noted in the low dose or high dose irradiated volume of SB using both techniques; however, the volume of SB getting irradiated in the absence of optimisation was found to be high in both the groups which can translate in to acute and late bowel toxicity. Further prospective studies have to be conducted to know the clinical significance of this dose-volume relationship to SB.

Keywords: IMRT, VMAT, Small bowel, Endometrial carcinoma

INTRODUCTION

Total hysterectomy and bilateral salpingo-oophorectomy with lymph node dissection is the standard surgical treatment for endometrial carcinoma (EC). External beam radiation therapy (EBRT) is strongly recommended for patients with International Federation of Gynaecology and Obstetrics (FIGO) stage IB grade 3, stage II EC and conditionally recommended for FIGO stage IB grade 1 or 2 or muscle invasive stage IA grade 3 EC with high risk features like substantial lymph vascular space invasion.[1] Concurrent chemoradiation therapy is recommended for FIGO stages IB, II endometrial cancers with high risk histology and FIGO stages III, IVA with any histology.[1]

Radiation enteritis is a term traditionally used to define injury to the small bowel (SB) and is one of the commonest acute toxicities encountered with standard doses of pelvic radiotherapy (RT). The volume and dose of irradiated SB as well as treatment technique has been linked to grade of toxicity in pelvic RT.[2] Intensity modulated radiotherapy (IMRT) has been shown to reduce acute grade II bowel toxicity by 30% and reduce the need for anti-diarrheal prescriptions by up to 30%.[3] As TIME-C trial reported less bowel toxicity with IMRT, currently the standard of care in post-operative gynaecological malignancies is IMRT.[4] When compared to IMRT, volumetric modulated arc therapy (VMAT) can reduce treatment delivery time by 54% and thus improves patient comfort and treatment compliance; most centres routinely use IMRT or VMAT in these patients.[5]

Though SB is considered to be an organ at risk (OAR) for pelvic radiation therapy (RT); most of the centres and even clinical trials recommend on contouring the entire peritoneal cavity and constraints are given for bowel bag (BB).[6,7] Due to lack of substantial data, there is no clear guidelines on the dose constraints for SB with regard to acute bowel toxicity. As no optimisation is given for SB, there is high chance for increased dose to SB loops and can also result in higher integral dose to SB. Hence in this retrospective case series we compared the dose received by SB while using IMRT and VMAT techniques in patients receiving adjuvant pelvic RT for EC. We hypothesized that dose received by SB will be higher in IMRT than VMAT.

CASE SERIES

10 patients who received adjuvant external beam RT for FIGO stage II EC at our institute during 2022 were analysed in this retrospective study. All these patients had undergone computed tomography (CT) simulation with oral and intra venous contrast as a part of our institutional protocol. Planning target volume (PTV coverage) and OAR dose constraints were given as per TIME-C protocol. These patients received external beam radiotherapy with VMAT technique, total prescribed dose of 45 Gy delivered in 25 fractions (1.8 Gy per fraction) followed by HDR brachytherapy of 18 Gy delivered in 3 fractions prescribed to 0.5 cm depth of vaginal mucosa.

We contoured SB in the previously obtained planning CT scan of these 10 patients. SB was outlined as the loops containing contrast, similar to the recommendation by NRG group. Volume receiving 10 Gy (V10 Gy), V20 Gy, V30 Gy, V40 Gy and V45 Gy to SB was obtained from dose volume histogram (DVH) using previously approved VMAT plan. An IMRT plan was also generated with a similar PTV and OAR dose constraints of the previously approved VMAT plan and V10 Gy, V20 Gy, V30 Gy, V40 Gy and V45 Gy to SB was also obtained from IMRT plan. Dose-volumetric data obtained from the dose-volume histogram (DVH) of both the plans were compared using ANOVA and unpaired t tests. Mean SB volume receiving 10 Gy (V10 Gy) was 85.3% and 83.7% with IMRT and VMAT respectively. Mean SB volume receiving 20 Gy (V20 Gy) was 65.1% and 64.8% with IMRT and VMAT respectively. Mean SB volume receiving 30 Gy (V30 Gy) was 28.1% and 29.3% with IMRT and VMAT respectively. Mean SB volume receiving 40 Gy (V40 Gy) was 14.5% and 14.2% with IMRT and VMAT respectively. Mean SB volume receiving 45 Gy (V45 Gy) was 4.1% and 5% with IMRT and VMAT respectively. While comparing IMRT and VMAT, dose reduction was noted in V10, V20, V40 Gy of small bowel with use of VMAT, but was not found to be statistically significant (p=0.40, p=0.95, p=0.93). While comparing IMRT and VMAT, dose reduction was noted in V30, V45 Gy of small bowel with use of IMRT, but was not found to be statistically significant (p=0.403, p=0.959) (Table 1).

Table 1: Irradiated volume of small bowel using IMRT and VMAT.

Group	Mean	Standard deviation	P value (unpaired t test)
SBV 10 (%)			
IMRT	85.30	4.057	0.403
VMAT	83.70	4.296	
SBV 20 (%)			
IMRT	65.10	12.351	0.959
VMAT	64.80	13.105	
SBV 30 (%)			
IMRT	28.10	12.432	0.844
VMAT	29.30	14.407	
SBV 40 (%)			
IMRT	14.50	8.031	0.936
VMAT	14.20	8.430	
SBV 45 (%)			
IMRT	4.130	3.5359	0.582
VMAT	5.000	3.3993	

DISCUSSION

Gastrointestinal toxicity is the most commonly encountered side effect with pelvic radiation therapy.[2] The change in treatment technique from two dimensional radiotherapy (2DRT) to three dimensional conventional radiotherapy (3DCRT) to IMRT and VMAT have led to reduction in acute and late small bowel toxicities.[7-9] In majority of the studies which used inverse planning, instead of individual SB loops, entire peritoneal cavity which includes SB and surrounding peritoneal space was contoured and constraints were given to BB which resulted in reducing acute and late bowel toxicity.[6-8] Though QUANTEC recommended SB V15 Gy <120 cc for <10% of acute grade 3 toxicity, most of the centres and clinical trials used to contour BB and gave QUANTEC recommendation of BB V45 Gy <195 cc.[10] Rationale of contouring BB than SB is that, during the 5-6 weeks long RT, the SB position varies on a day today basis and it is not possible to predict the exact position and dose delivered to SB during each fraction. TIME-C trial which assessed the benefit of IMRT over 3DCRT in post-operative gynaecological malignancies has also contoured the BB than SB.[4] IMRT and VMAT is able to limit the dose to an organ only if that structure is contoured and constraints are given for optimisation. Moreover, the structures that are not contoured and optimised have a high chance of getting more dose, due to the use of multiple fields or arc for planning.[11] Hence we tried to compare the dose received by SB using these techniques.

Our study shown that, in the low dose region (V10, V20 Gy) irradiated SB volume was marginally more in IMRT than VMAT whereas in the high dose region (V45 Gy) irradiated SB volume was marginally more in VMAT than IMRT (Table 1).

However, no statistically significant difference was noted. Our results also showed that, in the absence of proper optimisation, the volume of SB getting irradiated was found to be high in both the groups which can potentially translate in to acute and late bowel toxicity (mean SB V10 Gy=85.3% and 83.7%, mean SB V45 Gy=4.1% and 5% with IMRT and VMAT respectively). Although we haven't measured, optimisation for other contoured structures and PTV may also result in higher integral dose to SB.

Though this was a retrospective dosimetric comparison study, our results showed that irradiated SB volume was higher in the absence of a proper optimisation while using conformal techniques. To confirm our dosimetric analysis we are also planning for a prospective cohort study on dose-volume relationship and acute bowel toxicity. We have done a similar study in bone marrow dose-volume relationship and acute haematological toxicity in gynaecological malignancies which has already been published.[12]

We strongly believe that in the era of daily image guidance using cone beam CT, magnetic resonance imaging guided linear accelerator and adaptative radiotherapy, contouring SB and giving constraints to SB will definitely help in reducing the acute and late bowel toxicity.[13,14] Based on our results we also recommend contouring individual SB loops and giving dose constraints for optimisation.

CONCLUSION

This retrospective dosimetric study showed the importance of small bowel contouring and proper optimisation while using modern RT techniques for adjuvant pelvic RT for EC. Further prospective studies are warranted to validate the clinical significance of this observed higher irradiated mean SB volume.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Philip M, Antony F, Chalissery JR, Boban M. Dosimetric comparison of irradiated small bowel volume with intensity modulated radiotherapy and volumetric modulated arc therapy in adjuvant pelvic radiation therapy for endometrial carcinoma. Int J Adv Med 2023;10:622-5.