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A Dosimetric Comparison of ICRU Point Based Doses with 2CC Volume Doses of Bladder and Rectum in CT Based Planning of Intracavitary HDR Brachytherapy in Carcinoma Cervix

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Abstract
Aim: *Main purpose of this study is to compare traditional ICRU bladder and rectum point doses with Doses received to 2cc volume of bladder and rectum in CT based planning of HDR brachytherapy in carcinoma cervix.*
Materials & Methods: *Collected data of thirty five patients for whom intracavitary High Dose rate(HDR) brachytherapy planning done with a dose of 7Gy per fraction of total 3 fractions per patient on basis of ICRU bladder and rectal points. Then contoured complete bladder and rectum and then using DVH(Dose Volume Histogram) curves calculated D2cc, dose received by 2cm3 volume of the bladder and rectum separately according to GEC- ESTRO guidelines. Then compared point doses with D2cc doses of bladder and rectum using Pearson correlation test.*
Results: *Mean dose of bladder point and rectal point is 4.40Gy and 3.31Gy per fraction respectively. The mean D2cc of Bladder and rectum is 6.63 and 4.70 respectively. Hence it found that mean D2cc of bladder and rectum is 1.50 and 1.41 times the bladder and rectum point doses respectively.*
Conclusion: *Therefore this study suggests ICRU bladder and rectum points underestimates the particular dosage received by bladder and rectum. There is a correlation between both point doses and rectum doses. However bladder doses correlation is clinically significant while rectum doses are not clinically significant.*

Introduction

Cervical cancer is the fourth most common cancer in women worldwide(1). Intracavitary brachytherapy plays an important role in the treatment of cervical carcinoma. It is possible to achieve a high therapeutic index with brachytherapy by delivering a high dose to the tumor and by sparing adjacent organs like the bladder and the rectum. It is usually done at the end of a course of external beam radiotherapy (EBRT). There are two types of brachytherapy – Interstitial and Intracavitory brachytherapy. Intracavitory brachytherapy is widely available and used in many cases. Intracavitory

brachytherapy is delivered bya central intrauterine tandem and two lateral ovoids placed in the lateral vaginal fornices. Traditionally, treatment planning was based on point dose prescriptions (point A) and doses to organs at risk (OAR) were quantified by bladder and rectal reference points set by the\International Committee on Radiation. and Measurements (ICRU) in Report No. 38[(2)].

Nowadays with the New advancements, use of volumetric imaging and 3-dimensional (3D) planning in intracavitary brachytherapy, doses to the organs at risk (OARs), namely, the bladder and the rectum are quantified using dose-volume histograms. The recommendations for dose reporting for 3-dimensional image-based brachytherapy have been published by the GEC ESTRO (Groupe Europeen de Curietherapie and the European Society for Radiotherapy and Oncology) group[(3,4)].

Traditionally, ICRU bladder point is located on a radiograph by inserting a Foley's catheter and the Foley's balloon is filled with a 7-cm3 radiopaque fluid. The catheter is pulled down to bring the balloon against the urethra. The bladder reference point is at the center of the balloon on an antero-posterior radiograph. On the lateral radiograph, the bladder reference point is located on an antero-posterior line drawn through the center of the balloon, at the posterior surface. The ICRU rectal reference point is located at the lower end of intrauterine source or the middle of the intravaginal source on an antero-posterior radiograph. On a lateral radiograph, an antero-posterior lineis drawn through from the lower end of intrauterine source and the rectal reference point is located 5 mm behind the posterior vaginal wall on this line.

Although ICRU point based OAR (Organ's at Risk) dose reporting is widely used in intracavitary brachytherapy, the inherent weakness in predicting late toxicity cannot be denied[(6,7)]. Point-based dose reporting does not accurately describe the heterogeneity of absorbed dose within organ walls. Therefore, it is recommended to report dose-volume values in the high dose range. The minimum doses for the highest dosed 0.1, 1.0, and 2.0 cubic meter OAR volumes are shown as D0.1cc, D1cc, and D2cc, respectively. Several studies have previously reported differences between volumetric doses and point-based doses to the bladder and rectum[(10,11,12)]. D2cc, the dose delivered to an organ volume of 2 cm3, is now the most commonly used parameter to estimate rectal and bladder dose with 3D CT-based ICBT (3). In most studies side effects –late toxicities correlate with the dose of D2cc to the organs at risk[(13,14)]. However, regarding the old ICRU rectal and bladder point doses, it remains unclear whether these doses can continue to be used as surrogates for D2cc. There have been reports that suggest a good correlation of the D2cc and point doses for the bladder and rectum[(5)].In the present study, we compared the 2cc dose to the bladder and the rectum with the corresponding ICRU point doses using CT-based planning.

Materials and Methods

I) Data collection

We collected data of 35 patients of carcinoma cervix, who underwent External beam radiotherapy with photons to whole pelvis of total dose 50Gy in 25 fractions (2 Gy per fraction) with or without weekly cisplatin followed by Intracavitary HDR Brachytherapy with iridium 192 of total dose 21Gy in 3 fractions (7 Gy per fraction). In all these patients ICRU Point based panning was done.

II) Treatment Procedure

In all these patients following treatment technique was done in our institute:

A) Intracavitary application

A soap and water enema was given before the procedure for all patients for adequate rectal preparation.

After adequate sedation, started procedure. A Foley's catheter was inserted into the bladder, and Foley's bulb was filled with 2ml of

iodinated Contrast and 5ml of normal saline and catheter is pulled down to bring the balloon against the urethra to localize the bladder neck. A thorough gynaecological examination was performed and tumour factors assessed. The length of the uterine cavity was determined using a uterine sound. Gamma-med plus Fletchers or Henskeys applicators with tandem and ovoids are used for application. Radiopaque 2 inch gauze soaked in betadine was used to pack the vagina and to fix the applicators in place and to push the bladder and rectum away. Then Radioopaque rectal probe placed till 5cm from anal verge.

B) CT Simulation

After the applicator placement, the patients were shifted to the CT simulator. CT scans of the pelvis were taken with 3mm slice thickness with the patient in the supine position and acquired images were digitally exported to the varian treatment planning system.

C) Treatment planning

A dose of 7 Gy was prescribed to point A. Point A was located at 2 cm above and 2 cm lateral to the flange on either side of the intrauterine tube at the external os. Bladder and rectal reference points were placed in treatment plans to calculate ICRU bladder and rectal reference doses according to ICRU-38 guidelines. The ICRU rectal reference point was identified at the level of the flange on the tandem, on an antero-posterior line drawn through the tandem, 5 mm behind the posterior vaginal wall. The ICRU bladder point was identified at the most posterior part of the Foley catheter balloon. Manual optimization of the plan was done starting with standard loading pattern and dwell times; adjustments were made until an optimal plan result was reached. As much as possible, the bladder and rectum dose was kept less than 80%.

III) Image segmentation or Contouring:

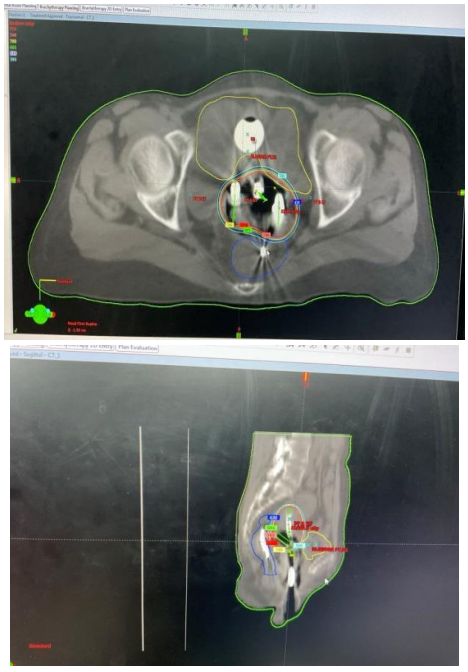
After collecting data on all patients who underwent the above procedure, the bladder and rectum were now delineated with consecutive CT sections according to GEC ESTRO recommendations[3].

a) Segmentation of Bladder (Contouring): The outer wall of the urinary bladder was contoured from the base of the contrast-filled Foley catheter ballon to the tip of the bladder. Coronal and sagittal views were also carefully analyzed to properly delineate these structures.

b) Segmentation of Rectum (Contouring): The outer wall of the rectum was contoured inferiorly from the 5cm above anal verge or the lowest level of the ischial tuberositi and ends superiorly before it connects anteriorly with the sigmoid. Coronal and sagittal views were also carefully analyzed to properly delineate these structures.

IV) D2cc Dose determination

The Dose volume histograms (DVH) were generated using Brachyvision brachytherapy planning system. The dose per fraction from brachytherapy is given in terms of the physical dose. Then dose received to the 2 cc volume of bladder and rectum (D2cc) was noted. Then compared D2cc of bladder and rectum with previously calculated ICRU bladder and rectum point doses.

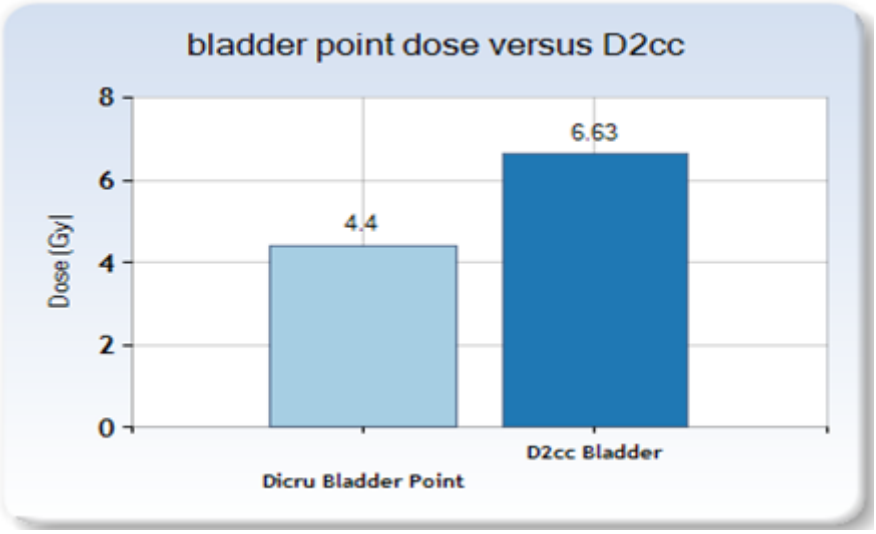


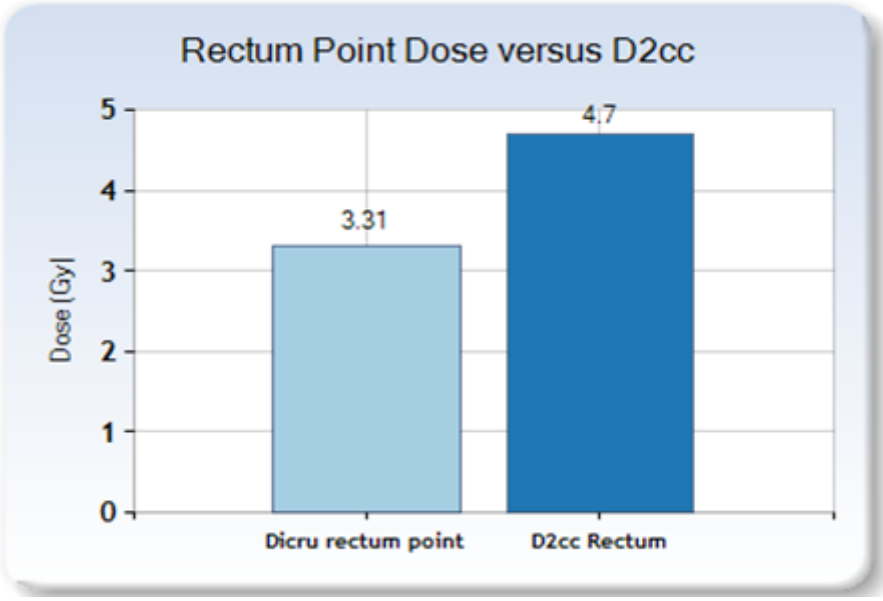
Statistical Analysis

Statistical analysis was done using online website socscistatistics.com Descriptive analysis including the mean and standard deviation of D2cc and point doses were calculated. And Ratio between D2cc and point doses of bladder and rectum calculated. Then correlation between D2cc doses and point-based doses were done using the Pearson correlation coefficient method.

Results

The mean dose to the rectum point dose and D2cc is 3.31Gy±1.24 and 4.70Gy±1.23 respectively. The mean dose to the Bladder point dose and D2cc Bladder is 4.40Gy±1.29 and 6.63Gy±1.36. The D2cc/ICRU ratio for the bladder was 1.50. The D2cc/ICRU ratio for the rectum was 1.41.





The correlation between the DICRU and D2cc for the Bladder is Moderately Positive correlation R= 0.5329 P=0.000981 (Figure1). The correlation between the DICRU and D2cc for the rectum is weak positive correlation R=0.1791 P= 0.303272 (Figure 2).

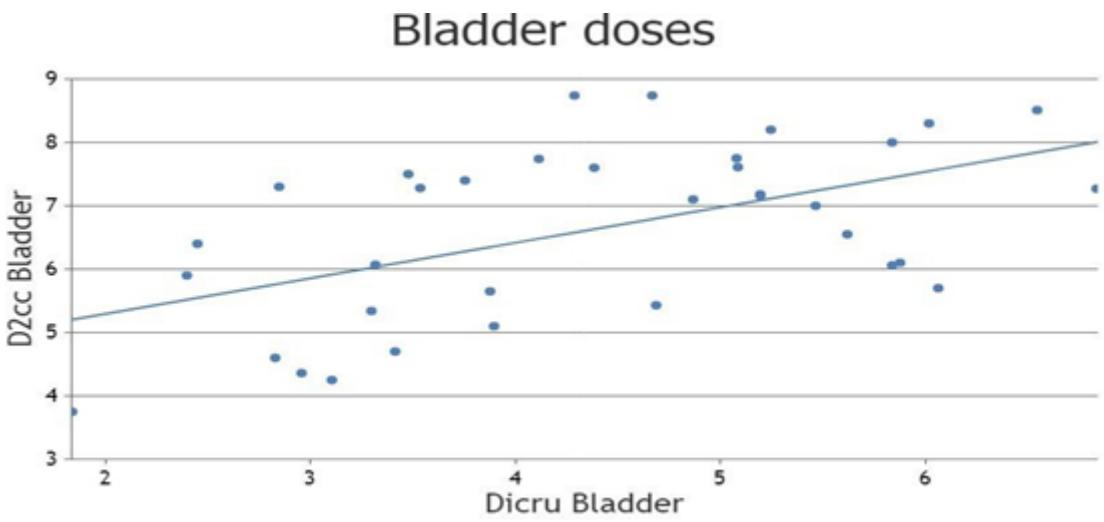


Fig1. Correlation between Bladder ICRU point doses and D2cc Bladder.(R= 0.5329 P=0.000981)

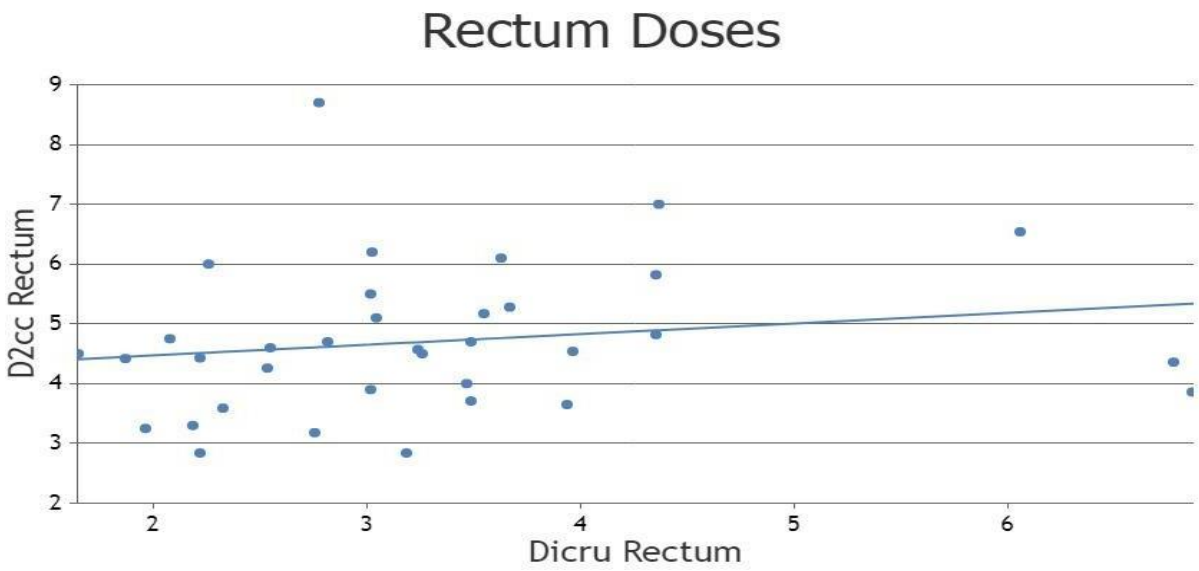


Fig2. Correlation between Rectum ICRU point Doses with D2cc Rectum (R=0.1791 P= 0.303272.)

Discussion

Bladder and rectal toxicity is a major concern of intracavitary brachytherapy for cervical carcinoma. With three-dimensional image-guided brachytherapy, it is possible to limit dose to the OAR without compromising tumor dose. Traditionally, ICRU point-based bladder and rectal dose reporting has been used as a surrogate for bladder and rectal toxicity assessment. Recently, many centers have begun to report bladder and rectal volume-based doses as recommended by the GEC ESTRO.

ICRU Point doses may not be accurate to determine the actual dose to the organ. Also, determination of these points is difficult and will have subjective variation. However, in volume-based planning, accurate delineation of organs at risk is sometimes difficult because of inadequate bladder filling, contrast, applicators artifacts. By maintaining bladder volume with negative contrast, atleast 50cc is required for accurate delineation of the bladder wall. Adequate Rectal emptying should be maintained. Adequate vaginal packing should be done to decrease the dose to the bladder and Rectum.

In this study we compared the D2cc of the bladder and the rectum with the corresponding ICRU reference points. There is a good correlation between Bladder point and D2cc doses, which is also statistically significant. However, Rectum

point doses and D2cc doses correlation is not statistically significant. It found that the mean D2cc of bladder and rectum is 1.50 and 1.41 times the bladder and rectum point doses respectively. This study suggests that ICRU bladder and Rectum point doses underestimated the particular dose received to bladder and Rectum. However, a good prospective analysis is required to conclude this.

The major limitation of the study is that it is a retrospective analysis on patient data who were already treated using ICRU point doses. However, this study proves that there is a definitive difference between doses, which may underestimate late toxicities that can occur. So, using volumetric-based planning and calculating D2cc doses for organs at risk and plan optimization based on these doses will help decrease toxicity. Other organs at risk, apart from the bladder and rectum, are the sigmoid colon and the bowel. These doses also should be taken into consideration while planning using 3-dimensional volumetric planning in Intracavitary brachytherapy in the carcinoma cervix.

Conclusion

This study suggests ICRU bladder and rectum points definitely underestimates the actual dosage received by bladder and rectum. However there is a good correlation between both point doses and rectum doses. But bladder doses correlation is clinically significant while rectum doses are not clinically significant. A good prospective study will be required to confirm this findings.

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References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021:71:209–49. doi:10.3322/caac.21660.
2. International Commission on Radiation Units and Measurements (ICRU). Dose and volume specifications for reporting intracavitary therapy in gynecology. *ICRU Report 38*. Bethesda, 1985.
3. Potter, R.; Haie-Meder, C.; Limbergen, E.V.; *et al.* Recommendations from gynaecological (GYN) GEC ESTRO working group (II): concepts and terms in 3D image-based treatment planning in cervix cancer brachytherapy— 3D dose volume parameters and aspects of 3D image-based anatomy, radiation physics, radiobiology. *Radiother.Oncol.* 78:67–77; 2006
4. Haie-Meder, C.; Potter, R.; Van Limbergen, E.; *et al.* Recommendations from Gynaecological (GYN) GEC-ESTROWorking Group (I): concepts and terms in 3D image-based 3D treatment planning in cervix cancerbrachytherapy with emphasis on MRI assessment of GTV and CTV. *Radiother. Oncol.* 74:235–45; 2005.
5. Wachter-Gerstner N, Wachter S, Reinstadler E et al. Bladder and rectum dose defined from MRI based treatment planning for cervix cancer brachytherapy: comparison of dose-volume histograms for organ contours and organ wall, comparison with ICRU rectum and bladder reference point. Radiother Oncol 2003; 68: 269–76.
6. Cheng, J.C.; Peng, L.; Chen, Y.; *et al.* Unique role of proximal rectal dose in late rectal complications for patients with cervical cancer undergoing high dose-rate intracavitary brachytherapy. *Int J.*

Radiat.Oncol. Biol. Phys. 57:1010–8; 2003.

7. Ferrigno, R.; dos Santos Novaes, P.E.; Pellizzon, A.C.; *et al.* High-doserate brachytherapy in the treatment of uterine cervix cancer. Analysis of dose effectiveness and late complications. *Int. J. Radiat. Oncol. Biol. Phys.* 50:1123–35; 2001.
8. Yaparpalvi, R.; Mutyala, S.; Gorla, G.R.; *et al*. Point vs. volumetric bladder and rectal doses in combined intracavitary-interstitial high-dose-rate brachytherapy: Correlation and comparison with published Vienna applicator data. *Brachytherapy* 7:336–42; 2008.
9. Van den Bergh, F.; Meertens, H.; Moonen, L.; *et al.* The use of a transverse CT image for the estimation of the dose given to the rectum in intracavitary brachytherapy for carcinoma of the cervix. *Radiother. Oncol.* 47:85–90; 1998.
10. Pelloski, C.E.; Palmer, M.; Chronowski, G.M.; *et al.* Comparison between CT-based volumetric calculations and ICRU reference-point estimates of radiation doses delivered to bladder and rectum during intracavitary radiotherapy for cervical cancer. *Int. J. Radiat. Oncol. Biol.Phys.* 62:131–7; 2005.
11. Addeo, D.; Duckworth, T.; Blank, S.; *et al.* Correlation between (ICRU)point doses and CT based 3D image planning of Intracavitary brachytherapy for cervical cancer. *Int. J. Radiat. Oncol. Biol. Phys.* 72:S374; 2008.
12. Kim, R.Y.; Shen, S.; Duan, J. Image-based three-dimensional treatment planning of intracavitary brachytherapy for cancer of the cervix: Dose- volume histograms of the bladder, rectum, sigmoid colon, and small bowel.*Brachytherapy* 6:187–94; 2007.
13. Steggerda MJ, Moonen LM, Damen EM, Lebesque JV. An analysis of the effect of ovoid shields in a selectron-LDR cervical applicator on dose distributions in rectum and bladder. Int J Radiat Oncol Biol Phys. 1997 Aug 1;39(1):237-45. doi: 10.1016/s0360-3016(97)00298-8. PMID: 9300759.
14. Romano KD, Hill C, Trifiletti DM, Peach MS, Horton BJ, Shah N, Campbell D, Libby B, Showalter TN. High dose-rate tandem and ovoid brachytherapy in cervical cancer: dosimetric predictors of adverse events. Radiat Oncol. 2018 Jul 16;13(1):129. doi: 10.1186/s13014-018-1074-2. PMID: 30012164; PMCID: PMC6048838.