Technical Note

A Dosimetric Analysis of the Rectal Doses in Intracavitary Brachytherapy of Carcinoma Cervix: A Prospective Study from a Single Institute

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Abstract

Introduction: Carcinoma cervix is a common gynecologic malignancy in India and is treated with radical chemoradiation where intracavitary brachytherapy (ICR) is an integral part. In ICR of cervix, the two-dimensional (2D) point-based dosimetry cervix is the most common method used in high-volume centers with rectal dose calculation at modified ICRU rectal point with rectal wire placement. The rectal dose measurement using this method underestimates the dose to the rectum, and rectal dose also varies with the type of applicator used. The aim of our study is to compare the rectal dose calculated by ICRU 38 method versus rectal dose calculated by the rectal wire method using Henschke applicator. **Materials and Methods:** This is a single-institute, dosimetric comparison study done prospectively. Fifty patients were planned for ICR after 2D orthogonal radiograph-based, computer planning by iridium 192 high-dose rate remote afterloading technique after placing the appropriate Henschke applicator. The vaginal packing was done using sterile gauze with contrast material for defining the ICRU 38 rectal point, and a rectal wire was placed for the modified ICRU rectal point. Rectal doses were calculated by both the methods and compared. **Results:** The modified ICRU rectal point recorded a lower rectal dose (mean of 25%) compared to ICRU 38 rectal point in the study patients. There were ten patients (20%) with either too much or too little contrast material which made the visualization of the rectal point and radiation planning difficult. *P* value by paired *t*-test method was 0.0001, which was statistically significant. **Conclusion:** The modified ICRU rectal point is easier to visualize than ICRU 38 method (100% vs. 80%) for dosimetry, but it underestimates the rectal doses when compared to ICRU 38 rectal point. There needs to be a correction factor applied (25% in our study for Henschke applicator) when evaluating the rectal doses calculated by rectal wire method, to reduce the rectal toxicity.

Keywords: Henschke applicator, ICRU 38 rectal point, modified ICRU rectal point, rectal dose, rectal wire

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Introduction

Carcinoma cervix is the most common gynecologic malignancy and the leading cause of cancer death among females in India.[1,2] Carcinoma cervix patients are treated with radical chemoradiation from Stage I B2 to IV A where intracavitary brachytherapy (ICR) is an integral part to achieve tumoricidal dose with minimal doses to organs at risk, such as bladder and rectum.[3,4] The two-dimensional (2D) point-based dosimetry in ICR of the cervix is the most common method used in high-volume centers. In this point-based dosimetry, the rectal doses are calculated with reference to International Commision on Radiation Units and Measurements (ICRU) rectal point with contrast vaginal packing or modified rectal point with rectal wire placement. The rectal dose measurement using the latter method underestimates the dose to the rectum.[3] But still, it is a common method used in high-volume centers. Moreover, the rectal dose also varies with the type of applicator used.[5]

The aim of our study is to compare between these two different rectal points in ICR of carcinoma cervix for patients undergoing brachytherapy at our institute using Henschke brachytherapy applicator.

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Materials and Methods

This is a single-institute, dosimetric comparison study done prospectively. The ethics committee's approval at our institute was taken for the study. At our institute, we perform about 50 brachytherapy sessions/week. We do perform 2D and three-dimensional (3D) image-guided brachytherapy at our institute. However, given the large volume of patients to be treated, the most common method used still is 2D orthogonal radiograph-based, computer planning by Iridium (Ir)-192 high-dose rate (HDR) remote afterloading technique.

Fifty patients from our institute who were diagnosed and treated with definitive chemoradiation therapy for carcinoma cervix from December 2016 to August 2017 were included in the study. Patients with biopsy proven carcinoma cervix with the International Federation of Gynecology and Obstetrics (FIGO) Stage IB2, IIA, IIB, IIIB, and IIIC disease at presentation with Eastern Cooperative Oncology Group (ECOG) performance status 1 to 2 and age ranging from 20 to 80 years with feasibility of insertion of Henschke applicator (tandem with ovoid pair) were included in the study. Staging was done by the 2018 FIGO staging system.[6] Patients with ECOG performance status more than 2 or treated with palliative intent were excluded from the study. Patients with Stage IIIA were also excluded as the applicator used in these patients was tandem and cylinder type.

We included a total of fifty patients in the study: six in the age ranging from 30 to 40 years, 24 between ages 41 and 50 years, ten between 51 and 60 years, six between 61 and 70 years, and four between 71 and 80 years.

All patients were planned to receive external radiation (external beam radiation therapy [EBRT]) of 50 Gy at 2 Gy per fraction and three fractions of ICR brachytherapy starting at 30 Gy of EBRT by Ir-192 HDR remote afterloading technique using Henschke applicator. Patients were assessed for ICR brachytherapy placement after 30 Gy of EBRT, and all patients who were fit for Henschke applicator placement were included in the study. All patients were planned after simulation and computer-based 2D planning performed by Brachyvision treatment planning system using TG-43 dose calculation formalism, using ICRU 38 point-based dosimetry. All the study patients were treated with three fractions of HDR brachytherapy to a total dose of 21 Gy in three fractions, 7 Gy per fraction to point A, with 1-week gap between the fractions. All the patients had a midline block after 40 Gy of EBRT, as an institute protocol for shielding the bladder and rectum.

The vaginal packing was done using sterile gauze with a contrast (liquid barium) material for defining the ICRU 38 rectal point, which is located 0.5 cm posterior to the posterior vaginal wall. A rectal wire was placed for all patients for calculating the rectal dose as an institute protocol. When using the rectal wire, we calculated the rectal dose using the modified ICRU rectal point, which is along the same line as the ICRU 38 rectal point but extended posteriorly onto the rectal wire, as shown in Figure 1. The orthogonal images used for planning are shown in Figures 1 and 2.

Results

A total of fifty patients were included in the study. Out of these, there were 60% of patients with FIGO Stage IIB, 38% with FIGO Stage IIIB, and 2% in FIGO Stage IIIC1 at the time of diagnoses. The clinical stage results for the study patients are shown in Figure 3. There were a total of fifty patients in the study, but we had to exclude ten patients from our analyses. These ten patients (20%) had either too much (n = 8) or too little (n = 2) contrast material which made the visualization of the rectal point and radiation

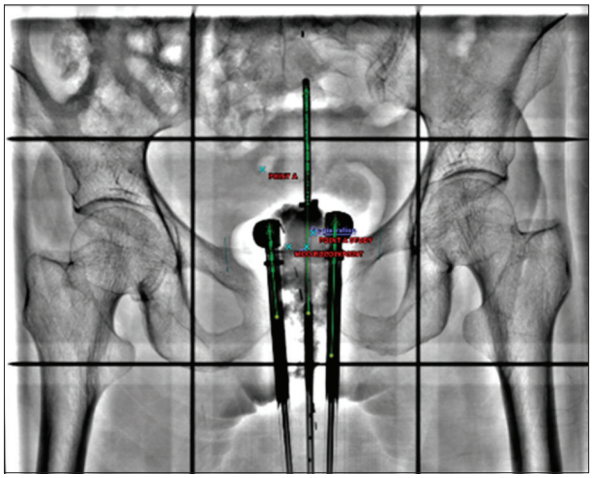

Figure 1: A planning anteroposterior radiograph with Henschke applicator in place. Rectal wire inserted and contrast vaginal packing done are visible, for calculating rectal dose at the ICRU 38 rectal point and modified ICRU rectal point

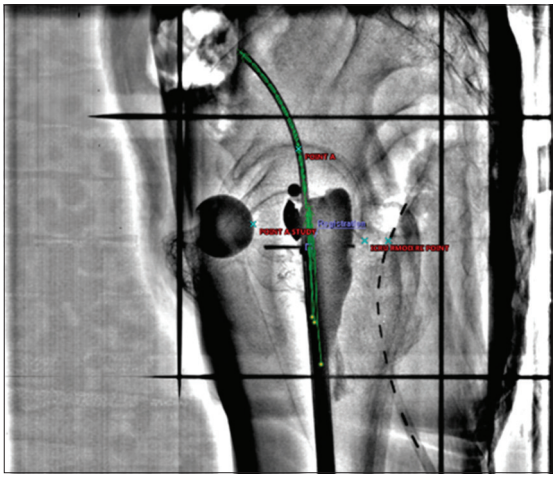

Figure 2: A lateral planning radiograph showing contrast vaginal packing and rectal wire for planning. The modified ICRU rectal point is labeled in the planning image. The ICRU 38 rectal point is anterior to it, showing the reason for lower dose recording on the rectal wire

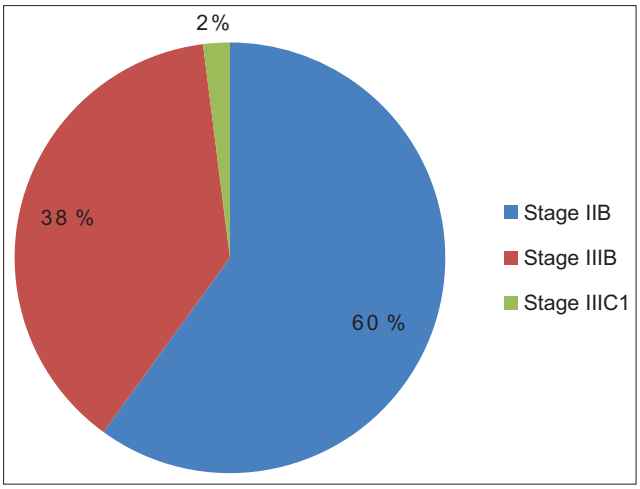

Figure 3: Pie diagram showing percentage of the study patients with stage of disease at presentation

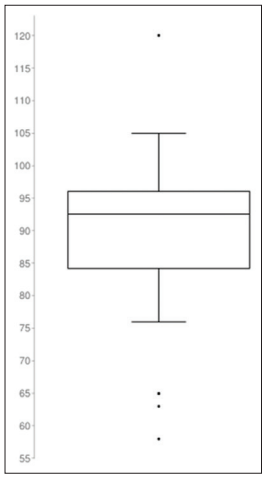

Figure 4: A box plot showing the results of the study patients with rectal doses calculated at the ICRU 38 rectal point by using vaginal contrast packing. The minimum dose was 58%, whereas the maximum dose was 120%, and the median dose was 92% of point A dose, which was 7 Gy/fraction

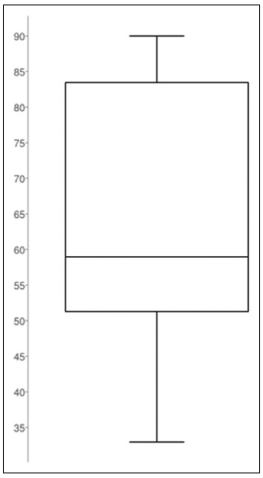

Figure 5: A box plot showing results for rectal doses calculated at the modified ICRU 38 rectal point by rectal wire method, with a median dose of 59% and the minimum and maximum doses of 33% and 90%, respectively. Doses were calculated as percentage of point A dose, which was 7 Gy/fraction

planning difficult. The rectal doses in the study patients were calculated at the ICRU 38 rectal point and the corresponding rectal point on the rectal wire (modified ICRU rectal point). The brachytherapy doses were calculated as percentage of the prescribed dose to point A, which was 7 Gy/fraction. The modified ICRU rectal point recorded a lower rectal dose (mean of 25%) compared to ICRU 38 rectal point in the study patients. The mean point A dose for the study patients was 6.95 Gy (± 0.23 Gy) on the right side and 7.02 Gy (± 0.05 Gy) on the left side.

Statistical analysis was done using paired *t*-test method after testing the data for normality with Kolmogorov–Smirnov normality test. The mean of rectal dose expressed as percentage of point A dose was 89% (± 12%) at ICRU 38 rectal point and 64% (± 17%) by modified ICRU rectal point method in the study patients.

The *P* value for the study was calculated by using the paired *t*-test method and came out to be 0.0001, which was statistically significant. The rectal doses for the study patients, calculated by the ICRU 38 rectal point by using vaginal contrast packing, showed a minimum dose of 58% and maximum dose of 120% of point A dose, with a mean dose of 89%. Similarly, the rectal doses calculated by the rectal wire method at the modified ICRU rectal point were a minimum of 33% and a maximum of 90%, with a mean value of 64%. The dosimetric results are shown in Figures 4 and 5 and Table 1.

Discussion

In brachytherapy planning for carcinoma cervix, image-guided (computed tomography [CT]-based) 3D planning is more accurate in calculating the rectal doses than 2D planning.[3,7] However, in centers with high volume of cervical cancer patients, 2D planning is still commonly practiced. The rectal dose calculation based on ICRU 38 points is still appropriate in estimating the rectal toxicity in 2D planning, in spite of its limitations.[8-12]

The rectal doses recorded according to the ICRU 38 points by using a contrast rectal packing is the standard recommendation for 2D point-based dosimetric calculations for carcinoma cervix ICR. Rectal dose calculation by using a rectal wire as a guide to calculate the rectal dose is less accurate and underestimates the rectal dose when compared to ICRU 38.[3,13] In spite of the recommendations, many high-volume centers use the rectal wire method.[7] At our institute, we perform both 3D (CT scan)-based brachytherapy planning and 2D point-based brachytherapy planning based on radiographs. We treat about 700–800 carcinoma cervix patients with brachytherapy treatments annually, and given the high volume of patients, we use the rectal wire method as it is easy to visualize on imaging and planning.

In our study, the rectal doses were 25% lower when calculated at the modified ICRU rectal point compared to the ICRU 38 rectal point. There was one similar study in which the values

Table 1: The brachytherapy doses are expressed as percentage of the point A dose, which is 7 Gy per fraction

Dosimetric parameter	Mean±SD (%)
Mean dose at the ICRU 38 rectal point	89±12
Mean dose at the modified ICRU 38 rectal point	64±17
Percentage difference in the doses calculated at two rectal points	25±15

SD: Standard deviation, ICRU: International Commision on Radiation Units and Measurements

were 15% lower by using the rectal wire method.[7] In this study, the applicator used was Fletchers applicator, and they calculated rectal dose 0.5 cm anterior to the rectal wire, while we used a Henschke applicator and calculated the rectal dose on the rectal wire, which could explain the higher difference observed in our study. Furthermore, in the study done by Shrivastava *et al*., they have calculated doses at four different corresponding points, whereas we calculated dose at a single point on the rectal wire which would correspond to the ICRU 38 point.[13]

In some studies done in literature, alternative methods to calculate rectal dose, such as rectal tube or thermoluminescence dosimetry, were evaluated with good results.

In our study, we included fifty patients, but ten patients (20% of the study patients) could not be planned based on contrast vaginal packing method due to problems in visualizing the pack and applicator. In eight patients, the contrast was too much, and we had to repack and plan as the applicator ovoids were not seen clearly. In two patients, contrast was too little, and we could not localize the posterior vaginal wall. However, in all the study patients (100%), we could clearly locate the rectal wire for planning.

The merits of our study are as follows: it is a prospective study with good sample size, all applicator insertions were done by a single radiation oncologist, and the entire planning was done and verified by a single medical physicist, to decrease the variations. Furthermore, a single type of applicator is used in the study, to avoid variations due to applicator geometry. The demerits of the study are that it is a 2D planning study, and there were significant variations in the radiation doses studied in the study patients. In some studies done in literature, alternative novel methods to calculate rectal dose, such as rectal tube or thermoluminescence dosimetry, were evaluated with promising results.[14,15] Although our study is not novel in evaluating a new technique, we evaluated two standard old techniques which are more practical for high-volume centers.

Conclusion

The modified ICRU rectal point is easier to visualize (80% vs. 100%) for dosimetry, but it underestimates the rectal doses when compared to the ICRU 38 rectal point. There needs to be a correction factor for each applicator in each institute, as we cannot generalize the results and every institute has its own protocol for planning. The correction factor for our institute using Henschke applicator was about 25%.

Hence, when using the modified ICRU rectal point by rectal wire method, it would be better to use correction factor to get the corrected rectal doses, to avoid excess rectal doses and hence decrease the rectal toxicity in the patients.

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Conflicts of interest

There are no conflicts of interest.

References

1. Bray F, Ren JS, Masuyer E, Ferlay J. Global estimates of cancer prevalence for 27 sites in the adult population in 2008. Int J Cancer 2013;132:1133-45.
2. Ferlay J, Soerjomataram I, Ervik M, Dikshit R, Eser S, Mathers C, *et al.* GLOBOCAN 2012 v1.0, Cancer Incidence and Mortality Worldwide: IARC Cancer Base No. 11. Lyon, France: International Agency for Research on Cancer; 2013. Available from: http://globocan.iarc.fr. [Last accessed on 2018 Apr 02].
3. Viswanathan AN, Thomadsen B; American Brachytherapy Society Cervical Cancer Recommendations Committee, American Brachytherapy Society. American brachytherapy society consensus guidelines for locally advanced carcinoma of the cervix. Part I: General principles. Brachytherapy 2012;11:33-46.
4. Halperin EC, Wazer DE, Perez CA, Brady LW. Perez and Brady's Principles and Practice of Radiation Oncology. 6th ed., Ch. 69. USA: Lippincott Williams & Wilkins, Wolters Kluwer; 2013.
5. Suryadevara A, Kumar MV, Vasundhara E, Alluri KR, Ahamed S, Guduru S. A dosimetric comparison between applicators used for brachytherapy in carcinoma cervix – A single-institute prospective study. Indian J Cancer 2018;55:230-2.
6. Amin MB, Edge S, Greene F, Byrd DR, Brookland RK, Washington MK, *et al*., editors. AJCC Cancer Staging Manual. 8th ed. New York: Springer International Publishing, American Joint Commission on Cancer; 2017.
7. Banerjee R, Kamrava M. Brachytherapy in the treatment of cervical cancer: A review. Int J Womens Health 2014;6:555-64.
8. Perez CA, Breaux S, Bedwinek JM, Madoc-Jones H, Camel HM, Purdy JA, *et al.* Radiation therapy alone in the treatment of carcinoma of the uterine cervix. II. Analysis of complications. Cancer 1984;54:235-46.
9. Perez CA, Grigsby PW, Lockett MA, Chao KS, Williamson J. Radiation therapy morbidity in carcinoma of the uterine cervix: Dosimetric and clinical correlation. Int J Radiat Oncol Biol Phys 1999;44:855-66.
10. Barillot I, Horiot JC, Maingon P, Truc G, Chaplain G, Comte J, *et al.* Impact on treatment outcome and late effects of customized treatment planning in cervix carcinomas: Baseline results to compare new strategies. Int J Radiat Oncol Biol Phys 2000;48:189-200.
11. Clark BG, Souhami L, Roman TN, Chappell R, Evans MD, Fowler JF. The prediction of late rectal complications in patients treated with high dose-rate brachytherapy for carcinoma of the cervix. Int J Radiat Oncol Biol Phys 1997;38:989-93.
12. Chen SW, Liang JA, Yang SN, Liu RT, Lin FJ. The prediction of late rectal complications following the treatment of uterine cervical

cancer by high-dose-rate brachytherapy. Int J Radiat Oncol Biol Phys 2000;47:955-61.
13. Shrivastava R, Umbarkar RB, Sarje MB, Singh KK. Rectal dosimetry in intracavitary brachytherapy by HDR at rural center of Maharashtra: Comparison of two methods. J Med Phys 2009;34:93-6.
14. Padoongcharoen P, Krusun S, Palusuk V, Pesee M, Supaadirek C, Thamronganantasakul K. Comparisons between the KKU-model and conventional rectal tubes as markers for checking rectal doses during intracavitary brachytherapy of cervical cancer. Asian Pac J Cancer Prev 2014;15:6115-20.
15. Huh SJ, Lim DH, Ahn YC, Lee JE, Kang MK, Shin SS, *et al.* Comparison between *in vivo* dosimetry and barium contrast technique for prediction of rectal complications in high-dose-rate intracavitary radiotherapy in cervix cancer patients. Strahlenther Onkol 2003;179:191-6.