ORIGINAL RESEARCH PAPER
Volume - 13 | Issue - 01 | January - 2024 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

DOSIMETRIC EVALUATION OF POINT A VS VOLUMETRIC BRACHYTHERAPY IN THE TREATMENT OF CARCINOMA CERVIX PATIENTS – OUR EXPERIENCE

Oncology/Radiotherapy

Manikumar S — Assistant Professor, Department of radiation oncology, NRI medical college, chinakakani, Mangalagiri, India

Tabitha Ch — Junior resident, Department of radiation oncology, NRI medical college, chinakakani, Mangalagiri, India

Jagannatha raonaidu K V — Professor, Department of radiation oncology, NRI medical college, chinakakani, Mangalagiri, India

Asha Rani V — Junior resident, Department of radiation oncology, NRI medical college, chinakakani, Mangalagiri, India

KEYWORDS

INTRODUCTION

In India, carcinoma cervix uteri is the 3rd most common cancer with an Incidence rate of 18.3% (123,907 cases) and the second leading cause of death with a mortality rate of 9.1% as per GLOBOCAN 2020(1). External beam radiotherapy (EBRT) and brachytherapy plays a vital role in curative treatment of carcinoma cervix from stage IB2 to IVA. Traditionally, according to the International Commission on Radiation Units and Measurement (ICRU) 38 report , the ICBT dose is applied to point A by using 2D planning based on radiographs (2). Numerous studies have shown that these points are far from reliable and do not reflect the three-dimensional (3D) anatomy of the patient(3). Hence, planning based on imaging (CT/MRI) has been increasingly adopted. Image guided brachytherapy planning (CT or MRI based) provide better volumetric information for superior target coverage and spatial relationship between applicator and OAR which leads to improved local control and reduced late toxicity.

MATERIALS AND METHODS

This is a single institution based study to evaluate point A vs Volume based HDR brachytherapy. Twenty biopsy proven carcinoma cervix patients who underwent brachytherapy post EBRT, treated in NRI Medical college and general hospital , from June 2022 to June 2023 were included. All the patients received EBRT dose 45Gy are proceeded to brachytherapy treatment. All the patients received a brachytherapy dose of 28 Gy in 4 fractions, 7 Gy per fraction, twice weekly. Treatment of all the patients was performed using Iridium-192 brachytherapy source using a remote afterloading machine by Gammamedplus. All the patients should undergo a MRI scan and clinical examination before brachytherapy. HRCTV contouring was done based on the guidelines given by Mahantshetty et al. (4)Treatment plans normalized to HR-CTV and point A were applied separately i.e., high-risk clinical target volume (HR-CTV) plans were renormalized with respect to point A plan. The doses to organs at risk (OAR)rectum(D 2cc), sigmoid(D 2cc), bladder(D 2cc),small bowel(D2cc) and HR-CTV(D90) in both the plans were compared. Comparative evaluation of point A vs volumetric plans was done in terms of target coverage and doses to bladder and rectum.

RESULTS

Mean dose prescribed at point A was 7Gy for every patient.

Dosimetric evaluation:

The mean doses when planned with point A plan were as follows:HR-CTV (D90)-**8.2Gy**, Rectum (D 2CC)-**4.70Gy**, Bladder (D 2CC)-**6.00Gy**, Sigmoid (D 2CC)-**5.02Gy** and Small bowel (D 2cc)-**5.01Gy.**

The mean doses when planned with volumetric plan were as follows: HR-CTV (D90)-**7.06Gy**, Rectum (D 2CC)-**3.28Gy**, Bladder (D 2CC)-**5.04Gy**, Sigmoid (D 2CC)-**4.46Gy** and Small bowel (D 2cc)-**4.32Gy.**

There is statistically significant difference in the P-value when compared between both the groups except for doses to colon (D 2cc) and small bowel (D 2cc).

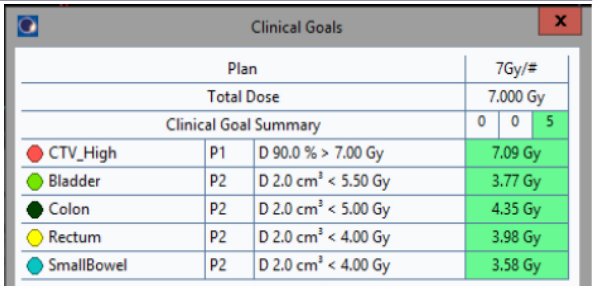

Fig no 1: clinical goals achieved in a pt by volume based plan.

Table no 1: The target volume doses and OAR(D2cc) dose when optimized to Point A (Gy) and HR-CTV comparison.

DOSE	POINT A	HR-CTV	P-VALUE
HR-CTV D90	8.2Gy	7.06Gy	0.002
Rectum (D 2CC)	4.70Gy	3.28Gy	0.002
Bladder(D 2CC)	6.00Gy	5.04Gy	0.05
Sigmoid(D 2CC)	5.02Gy	4.46Gy	0.15
Small bowel	5.01Gy	4.32Gy	0.10

The study on dosimetric evaluation of Point A versus volumetric brachytherapy in the treatment of carcinoma cervix patients showed notable differences in radiation doses delivered to various critical areas. Point A brachytherapy administered a mean dose of 7 Gy to each patient. Comparatively, volumetric planning resulted in lower mean doses for the High-Risk Clinical Target Volume (HR-CTV), rectum, bladder, sigmoid, and small bowel. Statistically significant differences were observed in the doses delivered to HR-CTV, rectum, and bladder (p-values 0.002, 0.002, and 0.05, respectively), indicating a clear dosimetric advantage of volumetric planning over Point A brachytherapy in sparing organs at risk (OAR) while effectively targeting HR-CTV.

DISCUSSION

The primary goal of High-Dose-Rate Brachytherapy (HDR-BT) in cervical cancer is to deliver a biologically significant dose to the HR-CTV while minimizing exposure to OARs. This study's findings align with broader research indicating that 3D-based volumetric brachytherapy (3D-BT) is superior to traditional 2D-based Point A brachytherapy in this regard. Studies by Kim et al.(5) and Suzumura et al.,(6) as referenced in this research, support the conclusion that 3D-BT is associated with lower toxicity, better loco-regional recurrence-free survival, and progression-free survival, although improvements in overall survival are not as evident. Furthermore, the 3D-BT technique demonstrates superior overall survival, local control, pelvic disease-free survival, and lower grade 3-4 overall and gastrointestinal toxicities, with no significant difference in metastasis-free survival and genitourinary toxicity. The study underscores the advantages of volumetric brachytherapy in reducing toxicities and enhancing the coverage of the target dose, which is crucial for improving treatment outcomes in cervical cancer patients.

The 2018 study by Paul et al.(7) compared Point A-based and volume-based high-dose-rate (HDR) brachytherapy for cervical cancer. The volume-based HDR plans showed a 6-12% reduction in the total dose to Organs at Risk (OAR) for various OAR volumes (0.1 cc, 1.0 cc, and 2.0 cc) compared to Point A-based plans. Additionally, these plans achieved an 8-37% reduction in dose per fraction to 2 cc of OAR and a 18-31% relative increase in conformal indexes per fraction, indicating improved dose conformity. However, there was an 11% reduction in the D90 (dose covering 90% of the High-Risk Clinical Target Volume) with HDRVOL planning. This study underscores the dosimetric advantages of volume-based HDR brachytherapy in cervical cancer, highlighting its potential in minimizing treatment-related toxicity and enhancing treatment precision without compromising the effective dose to the tumor volume, supporting the shift towards more personalized and precise radiation therapy approaches in oncology (Paul et al. 2018).

The study by Chigurupalli et al. (2019)(8) compared the dosimetric parameters in bone marrow sparing (BMS) and non-bone marrow sparing (non-BMS) Image Guided Volumetric Modulated Arc Therapy (IG/VMAT) for cervical carcinoma patients. It found no significant difference in homogeneity index (HI) and conformity index (CI) of Planning Target Volume (PTV) coverage between the two methods. However, BMS-IG/VMAT significantly reduced irradiated bone marrow volume in the pelvic region, particularly at lower dose areas (V5, V10, V20, V30), indicating its effectiveness in minimizing bone marrow exposure while maintaining treatment efficacy(Chigurupalli et al. 2019).

The 2019 study by Kumar et al.(9) investigated the effect of anesthesia type on dosimetric outcomes in carcinoma cervix patients undergoing intracavitary brachytherapy. Comparing General Anesthesia (GA) with Procedural Sedation (PS) in patients primarily with stage IIB cases, who received standard external beam radiation and high-dose-rate intracavitary brachytherapy, the study found no significant dosimetric differences in the sigmoid colon and bladder between the two groups. However, the rectum received higher doses under PS. This suggests that anesthesia type can affect dosimetric parameters, particularly in the rectum, potentially due to improved muscle relaxation and vaginal packing under GA. The study highlights the need to balance patient comfort, safety, and dosimetric outcomes when choosing anesthesia methods in brachytherapy for cervical cancer(Kumar et al. 2019).

The 2021 study by Mahantshetty et al.(4) examines CT-based contouring in image-guided adaptive brachytherapy for cervical cancer, noting the relative uncertainties of CT, ultrasound, and MRI in tumor volume definition. It introduces the Near Maximum Distance (NMD) parameter to refine brachytherapy planning and emphasizes the integration of clinical examination with imaging, especially in extensive disease cases. The study is particularly pertinent for low and middle-income countries with limited MRI resources, advocating for a systematic CT-based contouring method supplemented with MRI and ultrasound to enhance treatment planning accuracy and reproducibility. This approach aims to standardize volumetric imaging-based protocols and improve cervical cancer treatment outcomes globally(Mahantshetty et al. 2021).

The 2021 study by Pasha et al.(10) compared dosimetric outcomes of Intracavitary Brachytherapy (ICBT) and Interstitial Brachytherapy (ISBT) in carcinoma cervix patients, particularly those with challenging anatomies. While the D90 (dose covering 90% of the target volume) and V90 (volume receiving 90% of the prescribed dose) were similar in both techniques, ISBT demonstrated a more favorable impact on critical organs (bladder, rectum, sigmoid colon) by delivering lower mean doses. This advantage of ISBT in minimizing organ exposure is crucial for reducing potential side effects and enhancing treatment safety and effectiveness. The findings support the preference for ISBT in specific patient scenarios, emphasizing the need for personalized brachytherapy planning in cervical cancer treatment(Pasha et al. 2021).

The 2022 study by Gokulanathan et al.(11) compared the dosimetric effects of the Ring and Tandem applicator with the Fletcher Suit Delclos applicator in treating carcinoma cervix. Involving 67 patients with the Ring and Tandem and 42 with the Fletcher Suit Delclos, the study found no significant difference in bladder D2cc (highest irradiated 2cc area) between the applicators. However, the Ring and Tandem showed lower rectum D2cc and a significantly reduced incidence of Grade 2 dysuria at 3 months follow-up. The study also established a correlation between anteroposterior pelvic diameter and average D2cc in organs at risk, and between rectum volume and rectum D2cc. These results suggest that the Ring and Tandem applicator could offer better dosimetric outcomes and reduce toxicities, highlighting the critical role of applicator selection in personalized brachytherapy treatment planning and patient quality of life(Gokulanathan et al. 2022).

The 2022 meta-analysis by Hande et al.(12) compared Point-A and volumetric brachytherapy in cervical cancer treatment across 24 studies involving 5488 patients. It found that volumetric brachytherapy yielded better outcomes, with higher three-year Disease-Free Survival (79%) and Local Control (92%) compared to 67% and 86%, respectively, in the Point-A group. Although the overall survival difference wasn't statistically significant, the trend favored volumetric brachytherapy, underscoring its benefits in accuracy and reduced toxicity.It marks a shift towards volumetric BT, reflecting its growing preference and effectiveness due to precise radiation delivery, despite the absence of randomized trials. This indicates a transition in clinical practice, favoring volumetric BT for its better treatment outcomes(Hande et al. 2022).

The study by Balan and Ramasubramanian(13) used unpaired t-tests and chi-square tests for comparing numerical and categorical variables between two patient groups undergoing HDR ISBT for cervical cancer. Progression-free survival (PFS) and overall survival (OS) were assessed using Kaplan–Meier analysis, with significance set at a p-value ≤ 0.05, using IBM SPSS software version 23. The results showed no significant differences in the median age and baseline parameters between the groups. Dosimetric indices (CI, DHI, OI, DNR) were also similar across both groups. Despite slight differences in treatment regimens (concomitant chemoradiation and number of needles used), the three-year local control rates, PFS, and OS were comparable in both groups. No significant correlation was found between dosimetric data and either toxicity profile or local control.(Balan and Ramasubramanian 2023)This study compared two dose fractionation schedules in HDR ISBT for treating locally advanced, residual, or recurrent cervical cancer. Prior studies have indicated effective local control, toxicity, and survival rates with HDR brachytherapy. In this study, a 10% benefit in local control was observed with a 9Gy per fraction schedule, though it didn't significantly impact PFS or OS. The study highlighted the importance of treatment duration and found that longer treatment gaps might contribute to poorer local control. The subgroup analysis suggested a higher recurrence rate in patients with an intact cervix, indicating that a combined intracavitary and interstitial approach might be more beneficial in these cases. The findings also reflect the ongoing debate on the optimal schedule of dose fractionation in brachytherapy. This study contributes to the limited data on interstitial brachytherapy, offering insights into the efficacy of different fractionation schedules in cervical cancer treatment. However, limitations such as the retrospective design, possible biases (including interobserver bias in contouring and inherent needle displacement during ISBT), and a relatively short follow-up period must be considered when interpreting the results(Balan and Ramasubramanian 2023).

The study by Singh et al. (2023)(14) compared sequential and interdigitated brachytherapy combined with chemoradiation in treating patients with locally advanced carcinoma cervix. The research involved 63 patients and revealed that interdigitated brachytherapy resulted in significantly better overall treatment time (OTT) and mean biologically equivalent dose (BED10Gy), considering accelerated repopulation. Although the two-year follow-up showed no significant difference in overall survival (OS) and disease-free survival (DFS) between the two arms, there was a trend towards improved DFS in the interdigitated BT arm. Additionally, the incidence of local or distant failure was slightly lower in the interdigitated arm. Despite a higher incidence of late lower gastrointestinal toxicities in the interdigitated arm, the difference was not statistically significant. The study suggests that interdigitated brachytherapy with chemoradiation could be a more efficient alternative to sequential brachytherapy in the treatment of carcinoma cervix, particularly in high-patient-volume centers, due to its potential in reducing treatment time and improving resource utilization, while maintaining similar survival outcomes(Singh et al. 2023).

CONCLUSION

HRCTV-Volume based planning results in more conformal

brachytherpy plans compared with Point A plans with minimal doses to OAR's thus reducing the toxicities.

In this study, we conclude the dosimetric benefit of volume based planning in lowering OAR doses and without compromising the target coverage.

REFERENCES:

1. 356-india-fact-sheets.
2. TOD M, MEREDITH WJ. Treatment of cancer of the cervix uteri, a revised Manchester method. Br J Radiol [Internet]. 1953 May 1 [cited 2023 Dec 4];26(305):252–7. Available from: https://pubmed.ncbi.nlm.nih.gov/13042092/
3. Datta NR, Kumar S, Das KJM, Pandey CM, Halder S, Ayyagari S. Variations of intracavitary applicator geometry during multiple HDR brachytherapy insertions in carcinoma cervix and its influence on reporting as per ICRU report 38. Radiotherapy and Oncology [Internet]. 2001 Jul 1 [cited 2023 Dec 4];60(1):15–24. Available from: http://www.thegreenjournal.com/article/S0167814001003528/fulltext
4. Mahantshetty U, Poetter R, Beriwal S, Grover S, Lavanya G, Rai B, et al. IBS-GEC ESTRO-ABS recommendations for CT based contouring in image guided adaptive brachytherapy for cervical cancer. Radiotherapy and Oncology. 2021 Jul 1;160:273–84.
5. Kim YJ, Kang HC, Kim YS. Impact of intracavitary brachytherapy technique (2D versus 3D) on outcomes of cervical cancer: a systematic review and meta-analysis. Strahlenther Onkol [Internet]. 2020 Nov 1 [cited 2023 Dec 12];196(11):973–82. Available from: https://pubmed.ncbi.nlm.nih.gov/32632466/
6. Suzumura EA, Gama LM, Jahn B, Campolina AG, Carvalho H de A, de Soárez PC. Effects of 3D image-guided brachytherapy compared to 2D conventional brachytherapy on clinical outcomes in patients with cervical cancer: A systematic review and meta-analyses. Brachytherapy. 2021 Jul 1;20(4):710–37.
7. Paul AG, Nalichowski A, Abrams J, Paximadis P, Zhuang L, Miller S. Dosimetric evaluation of point A and volume-based high-dose-rate plans: a single institution study on adaptive brachytherapy planning for cervical cancer. J Contemp Brachytherapy. 2018;10(3):202–10.
8. chigurupalli kiran, Vashistha A, Patel .Deepanjali, Purohit R, Peter S, Bhandari M. Retrospective Dosimetric analysis of Bone marrow sparing vs non bone marrow sparing Image Guided Volumetric Modulated Arc Therapy in intact Carcinoma Cervix patients. Journal of Current Medical Research and Opinion [Internet]. 2019 Oct 11 [cited 2023 Dec 12];2(10):288-292–288–292. Available from: https://cmro.in/index.php/ jcmro/article/view/214
9. Kumar D, Srinivasa GY, Gupta A, Rai B, Oinam AS, Bansal P, et al. Comparative study to evaluate dosimetric differences in patients of locally advanced carcinoma cervix undergoing intracavitary brachytherapy under two different anaesthesia techniques: an audit from a tertiary cancer centre in India. J Egypt Natl Canc Inst [Internet]. 2019 Dec 1 [cited 2023 Dec 12];31(1):1–6. Available from: https://jenci.springeropen.com/articles/10.1186/s43046-019-0003-2
10. Pasha T, Channabasavaraju M, Venugopal B, Chandraraj V, Bondel S, Boraiah G, et al. A Dosimetric Comparison of Two Techniques of Brachytherapy in Carcinoma Cervix in Patients with a Difficult Application. Indian J Gynecol Oncol [Internet]. 2021 Mar 1 [cited 2023 Dec 12];19(1):1–7. Available from: https://link.springer.com/article/10.1007/s40944-020-00483-8
11. Gokulanathan N, Pandjatcharam J, Patil N, Udayakumar P, Pothuboina LK. 13P Dosimetric comparisons of brachytherapy applicators used in carcinoma cervix and their utility in toxicity prediction. Annals of Oncology [Internet]. 2022 Jun 1 [cited 2023 Dec 12];33:S387–8. Available from: http://www.annalsofoncology.org/ article/S0923753422007165/fulltext
12. Hande V, Chopra S, Kalra B, Abdel-Wahab M, Kannan S, Tanderup K, et al. Point-A vs. volume-based brachytherapy for the treatment of cervix cancer: A meta-analysis. Radiotherapy and Oncology. 2022 May 1;170:70–8.
13. Balan G, Ramasubramanian V. IMRT as an Alternative Technique for Intracavitary Brachytherapy in Patients with Carcinoma of the Cervix: A Feasibility Study Using Unified Dosimetric Index. Asian Pac J Cancer Prev. 2023 Oct 1;24(10):3563–8.
14. Singh S, Mishra H, Mishra R, Jaiswal I, Shah M, Pandey A, et al. 766P A comparative study of sequential and interdigitated brachytherapy with chemoradiation in patients of locally advanced carcinoma cervix. Annals of Oncology [Internet]. 2023 Oct 1 [cited 2023 Dec 12];34:S521. Available from: http://www.annalsofoncology. org/article/S0923753423027825/fulltext