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Original Research Article

Interfraction Variation in Point A, Point B and Organ at Risk Doses in Intracavitary Treatment of Carcinoma Cervix: A Hospital Based Analysis

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Abstract

Background: High-dose-rate (HDR) intracavitary brachytherapy (ICBT) is an integral component of the curative treatment for carcinoma cervix. However, interfraction variations in applicator placement and organ geometry can influence dose distributions, especially to organs at risk (OARs). This study aims to evaluate the interfraction dose variation in 40 patients undergoing HDR ICBT for carcinoma cervix.

Materials and Methods: A retrospective analysis was conducted on 40 histopathologically confirmed cases of carcinoma cervix (FIGO Stage IIB–IVA). All patients received EBRT of 50 Gy in 25 fractions, followed by 3 fractions of HDR ICBT (7 Gy per fraction). For each fraction, CT-based planning was performed. OAR doses (D2cc to bladder, rectum, sigmoid), Point A and B doses, V100, bladder/sigmoid/rectal volumes, and TRAK values were assessed across fractions. Comparative analysis was done using paired t-test with a statistical significance threshold of $p < 0.05$.

Results: A total of 120 ICBT applications were evaluated. While minor interfraction variations in D2cc values for bladder (mean 5.6 ± 1.3 Gy), rectum (4.5 ± 1.6 Gy), and sigmoid (4.3 ± 1.4 Gy) were observed, they were not statistically significant ($p > 0.05$). Point A and B doses remained consistent across fractions with mean values of 6.85 Gy (Right A), 6.79 Gy (Left A), and ~1.68 Gy at both B points. Organ volumes exhibited mild fluctuations but without significant dose impact. The variation in V100 and TRAK values was also statistically insignificant.

Conclusion: Although interfraction variations exist during HDR ICBT in carcinoma cervix, careful individualized planning for each fraction effectively maintains OAR doses within tolerance. A larger sample size reinforced earlier observations and supports the implementation of image-guided adaptive brachytherapy planning for optimal outcomes.

Keywords: Cervical Cancer Brachytherapy, Organ at Risk doses, Point doses.

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Introduction

Cervical cancer remains a significant public health burden worldwide, particularly in low- and middle-income countries like India, where it ranks as the second most common cancer among women and a leading cause of cancer-related mortality [1]. The standard treatment for locally advanced cervical cancer involves a combination of external beam radiotherapy (EBRT) with concurrent chemotherapy followed by intracavitary brachytherapy, as recommended by international guidelines. [2,3]

High-dose-rate (HDR) intracavitary brachytherapy (ICBT) plays a pivotal role in this multimodality treatment approach, enabling highly conformal dose escalation to the tumour while achieving rapid dose fall-off to spare surrounding organs at risk (OARs), such as the bladder, rectum, and sigmoid colon. [4,5] However, inter-fractional changes in applicator geometry and organ positioning introduce variability in dose delivery. Patient movement, tumour regression, and organ deformation can affect D2cc values, necessitating fraction-wise dosimetric evaluation. [6] This study, analyses 40 patients to assess the significance of interfraction dose variations in a real-world hospital-based setting.

Materials and Methods

This is a hospital based prospective study conducted at State Cancer Institute, Gauhati Medical College after obtaining clearance from the Institutional Ethical Committee vide No. SCI/GMC/ECR/2020/72.

Biopsy-proven carcinoma cervix patients with FIGO stage IIB to IVA were included in the study. External Beam Radiotherapy was delivered to a dose of 50Gy in 25 fractions using Three Dimensional conformal Radiation Technique (3DCRT). Following EBRT, High Dose Rate (HDR) Brachytherapy was given at a dose of 7Gy per week for a total of 3 fractions.

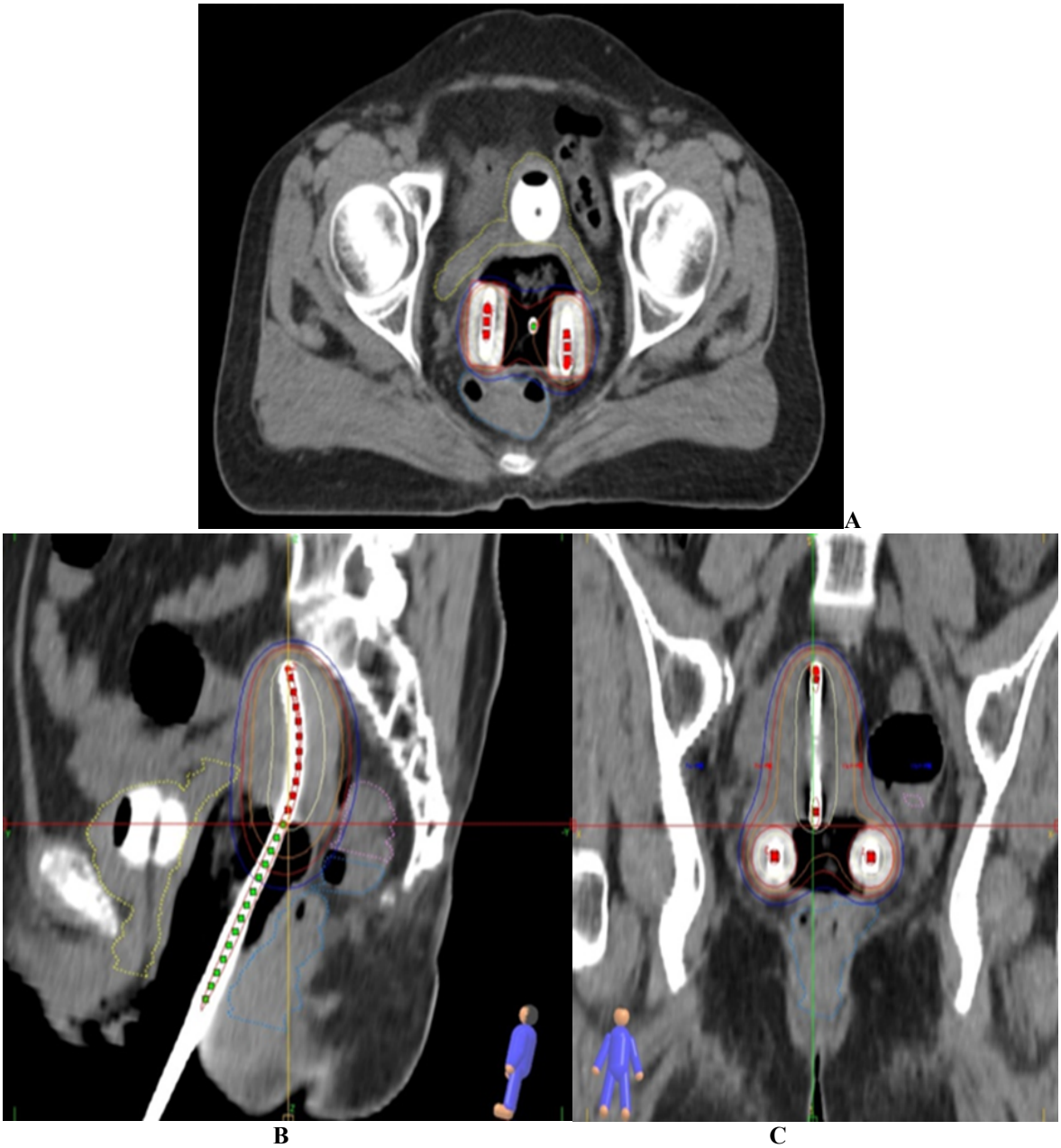
Applicator insertion was performed under sedation or anesthesia with strict aseptic precautions followed by CT-based planning for each fraction. The bladder, rectum and sigmoid were contoured on the CT images. Dose was prescribed to Point A and the following parameters were recorded for each application:

- D2cc doses to bladder, rectum, and sigmoid
- Right and Left Point A and B doses
- Total Reference Air Kerma (TRAK)
- V100 (%)
- Organ volumes

The contours and the planning isodose curves are depicted in figure 1.

Treatment was then delivered in the HDR Multisource model of Eckert and Ziegler BEBIG GmbH.

Statistical Analysis: Mean, SD, and paired t-test was applied to compare values across fractions I, II, and III, using SPSS version 25. P value < 0.05 was considered statistically significant.



A **B** **C**

Fig 1(A, B, C): Axial, Sagittal and Coronal CT images showing QAR contours and Isodose curves

Results

A total of 40 patients were included in the study. Each patient received 3 fractions of ICBT following EBRT, accounting to a total of 120 applications. The demographics of the patients are represented in table 1. The D2cc of the OAR'S and dose to point A&B, Organ volumes, TRAK and V100 are also presented in tables 2 to 5.

Table 1: Demographics and Treatment

No. of patients	**40**
No. of Applications	120
Median Age (years)	53 (38-65)
FIGO Stage IIB	20
IIIA/B	15
IVA	5

Table 2: D2cc OAR Doses

Organ	**Mean**	**D2cc (Gy) SD**	**Min–Max**	**P-value**
Bladder	5.6	1.3	2.5–8.9	0.31
Rectum	4.5	1.6	2.0–11.2	0.29
Sigmoid	4.3	1.4	1.2–9.0	0.34

Table 3: Point A and B Doses

Dose Point	**Mean (Gy)**	**SD**	**P-value**
Right A	6.85	0.48	0.26
Left A	6.79	0.45	0.28
Right B	1.67	0.09	0.36
Left B	1.68	0.10	0.32

Table 4: Organ Volumes (cc)

Organ	**Mean Volume**	**SD**	**P-value**
Bladder	72.4	30.2	0.24
Rectum	41.5	15.3	0.27
Sigmoid	29.7	17.2	0.25

Table 5: TRAK & V100

Parameter	**Mean**	**SD**	**P-value**
TRAK	0.481	0.036	0.33
V100 (%)	91.9	10.6	0.24

Our results showed that inter-fractional variation in doses to the bladder, rectum, and sigmoid colon were statistically insignificant ($p > 0.05$). The minimal and maximal D2cc values observed ranged between 2.5–8.9 Gy for bladder, 2–11.2 Gy for rectum, and 1.2–9 Gy for sigmoid across all fractions. Additionally, Point A and Point B doses were consistent across all fractions. Organ volumes demonstrated mild fluctuations without significant dosimetric impact.

Discussion

Brachytherapy is indispensable in the management of locally advanced cervical cancer. However, geometric uncertainties such as tandem angulation changes, tumor regression, bladder filling, and rectal distension may influence dose distribution between fractions.

In the present study, mean D2cc doses to bladder, rectum, and sigmoid remained within acceptable tolerance limits and did not demonstrate statistically significant interfraction variation. These findings suggest stable applicator positioning and effective standardization of the brachytherapy procedure.

Applicator-related geometrical variation and organ motion were cited as sources of potential dose fluctuation, but were successfully mitigated by individualized planning. The study demonstrated the benefit of image-guided, fraction-specific planning to reduce interfraction variability, aligning directly with findings in this expanded analysis of 40 patients. Morris et al. trial helped establish concurrent chemoradiation followed by a brachytherapy boost as the standard of care for high-risk cervical cancer. Given this intensive treatment, minimizing toxicity from the brachytherapy portion is paramount. In this study, by demonstrating a reliable method to keep OAR doses low and consistent, contributes directly to improving the safety and therapeutic ratio of this established standard of care. [7]

On comparison with similar published studies like Mukundan et al. (2020) also reported negligible interfraction variations in D2cc when CT-based individualized planning was performed for each ICRT application. [8]

Sharma et al. (2018) observed that non-individualized planning often led to increased radiation dose to OARs, especially the rectum and bladder, underlining the importance of re-planning for each fraction. [9]

Patil et al. (2022) demonstrated that adaptive planning significantly reduced D2cc dose variations in HDR brachytherapy for carcinoma cervix. They reported up to 20–30% higher doses to OARs when anatomical variations weren't accounted for. [10]

Mejia et al. (2017) highlighted that variability in uterine axis, tandem angulation, and organ deformation (due to bladder/rectum filling or tumour regression) can lead to clinically significant dosimetric differences when fixed planning strategies are followed. [11]

Kagei et al. (2003) established the foundational problem by documenting significant interfractional variation in organ position for cervical cancer patients. In this study methodology of re-planning each fraction directly confronts this challenge. The fact that no statistically significant dose variation to the bladder, rectum, and sigmoid demonstrates that individualized approach effectively mitigates the dosimetric impact of the organ motion described by Kagei et al. [12]

Despite the inherent geometric and anatomical challenges of multi-fractionated brachytherapy, such as tumor regression, uterine perforation risk, or organ deformation, careful treatment planning and image guidance can reliably maintain target and OAR dosimetry within acceptable thresholds.

Key Factors Influencing Dose Variation:

- Across studies including ours, the following factors consistently emerge as influencers of D2cc and Point A/B variability:
- Variations in applicator geometry or position (e.g., tandem or ovoid displacement).
- Organ deformation or volume changes (e.g., bladder filling or rectal distension).
- Tumor response between fractions resulting in anatomical shifts.
- Differences in clinician technique during applicator insertion.

Clinical Implications and Recommendations: Our results reaffirm the necessity of fraction-specific image-guided adaptive planning, in line with findings from these and other multicenter studies.

Image-guided adaptive brachytherapy (IGABT) using CT or MRI ensures that OAR doses remain within tolerance while maximizing tumor control.

This further supports the GEC-ESTRO recommendations, which advocate for volume-based planning and adaptive optimization methods during brachytherapy planning.

Conclusion

Interfraction variation in D2cc doses and at Points A and B in HDR intracavitary brachytherapy for carcinoma of the cervix was found to be statistically insignificant. These findings, when interpreted with existing literature signifies the importance of individualized, image-guided, fraction-specific planning to account for anatomical and applicator-related changes across successive fractions. Larger prospective studies incorporating MRI-based planning and AI-assisted dose delivery may further refine interfraction management strategies.

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