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Original research article

A STUDY ON DOSIMETRIC COMPARISON BETWEEN POINT A BRACHYTHERAPY AND VOLUMETRIC BRACHYTHERAPY IN PATIENTS WITH LOCALLY ADVANCED CERVICAL CANCER

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Abstract

Background: Locally invasive cervical cancer is managed using EBRT with chemotherapy and brachytherapy. Point A brachytherapy which integrates 2D images of the HR-CTV delivers not only deliver significant radiation dose, but also is associated with damage to the surrounding organs (organs at risk - OAR). However, volumetric brachytherapy which forms 3D images of HR-CTV using CT or MRI has lower radiation exposure to OAR's.

Materials and Methods: A total of 30 patients with biopsy proven locally advanced cervical cancer who presented to the Department of radiation oncology, NRI medical college, Mangalagiri, Guntur were included in the study. All patients underwent EBRT with chemotherapy.

Results: The mean dose of radiation to OAR's was significantly lower with volumetric brachytherapy than with point A brachytherapy.

Conclusion: present study concludes that radiation exposure to OAR is relatively lower with HDR- volumetry brachytherapy than with HDR- point A brachytherapy.

Keywords: cervical cancer, brachytherapy, point A, dosimetry

Introduction

Cervical cancer is the fourth most common type of cancer and fourth most common cause of death due to cancer in women globally [1]. In developing nations, it is one of the most common causes of cancer death with incidence rate of 47.3 per 100,000 women. However, in developed nations, with widespread use of cancer screening

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methods, the incidence rates have reduced drastically. Further reduction in incidence of cervical cancer is expected with implementation of vaccination programs against Human Papilloma virus [2, 3].

Previously, for patients with locally advanced cervical cancer, External Beam radiation therapy was the standard modality of choice. This involves external beam radiation exposure to pelvic lymph nodes, parametria and primary tumor with a dose to control microscopic disease progression. However, the treatment has evolved to addition of chemotherapy (which acts as a radio sensitizer) and brachytherapy to EBRT for overall improvement in local control (LC) and disease-free survival (DFS) [4, 5].

Brachytherapy involves the application of a radioactive source in close proximity to the tumor. This allows for a very high dose to the tumor with relative sparing of the surrounding normal structures [6]. Earlier, the prescribed dose to point A was based on two orthogonal X-ray films. As a result, one was not able to visualize the cervical tumor, and there had been uncertainty about whether the whole cervical tumor is covered with the prescribed dose or not. However, with advancement in medical technology, 3D images of the cervical tumor were created using CT or MRI.

The image guided brachytherapy (IGBT) is based on using Magnetic Resonance Imaging (MRI) for accurate target identification and dose delivery to high-risk clinical target volume (HR-CTV); and advanced intra-cavitary (IC) and interstitial (IS) techniques to facilitate higher dose deliveries for bulky tumors or for poor response to chemo-radiation [7, 8]. It provides better volumetric information for superior target coverage which leads to improved LC and reduced radiation related toxicities [9].

Materials and Methodology

This prospective study was conducted in the Department of radiation oncology, NRI Medical college and general hospital, Mangalagiri, over 1 year period, i.e. from August 2022 to August 2023. 30 patients with biopsy proven cervical cancer who underwent brachytherapy post external beam radiotherapy (EBRT) during the study period were included. These patients had received EBRT dose of 45 Gy, following which they received Brachytherapy of 28 Gy in 4 fractions and one fraction of 7 Gy twice weekly.

Brachytherapy was performed using iridium -192 source. A thorough clinical examination was done. All patients were subjected to MRI scanning before brachytherapy. Based upon the guidelines by Mahantshetty *et al.* [10], HRCTV contouring was done. Point A brachytherapy was compared with volumetric brachytherapy in terms of target coverage and doses to bladder and rectum.

High-risk clinical target volume (HR-CTV) is used as one of the indices to measure the dose given to the cervical tumor. The HR-CTV encompasses the whole cervix and the presumed extra-cervical tumor extension at the time of brachytherapy which is a major risk for local recurrence because of residual macroscopic disease. HR-CTV D90 is the minimum dose delivered to 90% of the HR-CTV, and is considered a good parameter with indications of strong correlation with the regional tumor control rate [10, 11].

Results

A total of 30 patients with biopsy proven cervical cancer were involved in this study. The mean age of diagnosis of cervical cancer in study group is 48.2 years.

The mean dose prescribed at point A was 8.1Gy.

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Table 1: Dosimetric evaluation

	Mean doses with point A plan	Mean doses with volumetric plan	P-Value
HR-CTV (D90)	8.7 Gy	7.03 Gy	0.004
Rectum (D 2CC)	5.1 Gy	4.04 Gy	0.004
Bladder (D 2CC)	6.03 Gy	5.1 Gy	0.012
Sigmoid (D 2CC)	5.12 Gy	4.98 Gy	0.24
Small bowel (D 2cc)	5.24 Gy	4.7 Gy	0.23

There is statistically significant difference in the P-value when compared between both the groups except for doses to colon (D 2 cc) and small bowel (D 2 cc), suggestive of advantage of volumetric planning over point A brachytherapy in sparing organs at risk while targeting HR-CTV.

Discussion

The observations made in present study suggest that 3D based volumetric brachytherapy delivers a significant dose to HR- CTV with minimal exposure to surrounding organs.

Studies by Kim *et al*. [12] and Suzumura *et al*. [13] also made similar observations and conclude that 3D-BT is associated with lower toxicity, better loco-regional recurrence-free survival, and progression-free survival. However, there was no significant difference in metastasis-free survival and genitourinary toxicity.

Paul *et al*. [14] in their study observed that 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. Furthermore, these plans achieved an additional 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.

Chigurupalli *et al*. [15]. 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.

Kumar *et al*. [16] investigated the effect of anesthesia type by comparing General Anesthesia (GA) with Procedural Sedation (PS) in patients primarily with stage IIB

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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, 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 emphasizes the importance of patient's comfort and safety during the procedure which can be done by adequately sedating them.

Mahantshetty *et al*. [17] examined CT-based contouring in image-guided adaptive brachytherapy for cervical cancer, noting the relative uncertainties of CT, ultrasound, and MRI in tumor volume definition. The concept of Near Maximum Distance (NMD) parameter was emphasized to refine brachytherapy planning. The study underscores 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.

Pasha *et al*. [18] 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 study concludes that fractionated HDR brachytherapy can amount to significant variation in OAR doses if re-simulation and re-plan is not performed for every fraction and ICBT application.

Gokulanathan *et al*. [19] compared the dosimetric effects of the Ring and Tandem applicator with the Fletcher Suit Delclos applicator in treating carcinoma cervix and found no significant difference in bladder D2cc 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. These results suggest that the Ring and Tandem applicator could offer better dosimetric outcomes and reduce toxicities.

Hande *et al*. [20] did a meta-analysis comparing Point-A and volumetric brachytherapy in cervical cancer treatment across 24 studies involving 5488 patients and 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.

Singh *et al*. [21] compared sequential and interdigitated brachytherapy combined with chemoradiation in 63 patients with locally advanced carcinoma cervix. The research concluded that inter-digitated brachytherapy resulted in significantly better overall treatment time (OTT) and mean biologically equivalent dose (BED10 Gy), 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.

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Conclusion

HRCTV-Volume based planning results in more focussed brachytherpy plans compared with Point A plans with minimal doses to OAR's thus reducing the toxicities which is observed in this study.

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Conflicts of Interest: NIL.

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