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COMPARISON OF EBRT TARGET VOLUME DELINEATION BETWEEN PLANNING CT IMAGES AND MRI PELVIS (T2W & DWI) IN CARCINOMA CERVIX

Radiotherapy

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ABSTRACT

Cervical cancer is among the most common gynaecological malignancies, and approximately 70% of patients present with locally advanced cervical cancer (LACC) at diagnosis, for which external-beam radiotherapy (EBRT) with concurrent chemotherapy followed by brachytherapy is the standard of care. Accurate delineation of the gross tumour volume (GTV) is a prerequisite for conformal radiotherapy. Although computed tomography (CT) based planning is the current standard, the soft-tissue planes between tumour and organs at risk are often poorly defined on CT. This institutional cross-sectional observational study compared GTV delineation in 31 patients with LACC (FIGO IB3–IVA) using planning CT and two magnetic resonance imaging (MRI) sequences—T2-weighted (T2W) and diffusion-weighted imaging (DWI). The mean GTV-primary was 79.6 cc on CT, 52.2 cc on T2W MRI and 52.7 cc on DWI MRI. A statistically significant difference was found between the three modalities (Friedman test, $p < 0.001$); however, T2W and DWI did not differ significantly from each other ($p = 1.000$). GTV-MRI was on average about 27% smaller than GTV-CT. Strong positive correlations were observed between CT and T2W (rho = 0.856), CT and DWI (rho = 0.785) and T2W and DWI (rho = 0.905). Nodal volumes did not differ significantly across modalities ($p = 0.093$). Owing to superior soft-tissue contrast, MRI yields smaller and potentially more precise tumour volumes than CT, which may reduce treatment volumes and spare normal tissue. MRI is therefore a valuable imaging modality for target delineation in carcinoma cervix.

KEYWORDS

Carcinoma Cervix, Gross Tumour Volume, EBRT, MRI, T2-weighted, Diffusion-weighted Imaging

INTRODUCTION

Cervical cancer is one of the most prevalent malignant tumours among women. According to GLOBOCAN 2022, an estimated 6,62,301 new cases and 3,48,874 deaths were attributed to this malignancy worldwide[1]. In India, carcinoma of the cervix accounts for a substantial proportion of all female cancers. Approximately 70% of patients present with locally advanced disease at initial diagnosis, and concurrent chemoradiotherapy remains the standard of care[2].

External-beam radiotherapy (EBRT) with concurrent chemotherapy followed by brachytherapy is the recommended strategy for FIGO stage IB3 to IVA disease. The EBRT target volume should encompass the gross tumour volume (GTV) together with the entire uterus, parametrium and at-risk nodal volumes. While conformal radiotherapy controls disease effectively, large treatment volumes can cause serious late toxicity in the bowel, vagina and bladder[3]. Accurate delineation of the GTV, clinical target volume and organs at risk is therefore a prerequisite for planning and delivering EBRT[6].

CT-based planning is currently the standard for EBRT in locally advanced cervical cancer (LACC); however, the planes between tumour and adjacent organs at risk are often poorly delineated on CT. Magnetic resonance imaging (MRI) offers superior soft-tissue resolution and a pivotal role in defining the GTV, particularly for parametrial and vaginal involvement[7,8]. Functional sequences such as diffusion-weighted imaging (DWI) provide additional information on tumour cellularity and aggressiveness[9,10]. The aim of this study was to compare GTV delineation in LACC using planning CT versus MRI T2-weighted (T2W) and DWI sequences.

AIM AND OBJECTIVES

To determine the GTV of carcinoma cervix using MRI (T2W and DWI) and planning CT, and to correlate GTV delineation between the MRI sequences and planning CT.

MATERIALS AND METHODS

This was an institution-based cross-sectional observational study conducted in the Department of Radiotherapy, GSL Medical College, Rajahmundry, over 18 months (May 2022 to 2024). A total of **31 patients** with histopathologically confirmed carcinoma cervix were enrolled.

Inclusion criteria

were histopathologically confirmed carcinoma cervix, ECOG performance status < 2, LACC stage IB3–IVA, and age up to 70 years.

Exclusion criteria

were previous pelvic irradiation, other malignant disease, and post-operative cervical cancer cases. Staging followed the FIGO 2018 system, and written informed consent and institutional ethics clearance were obtained.

All patients received EBRT (50 Gy/25 fractions or 56 Gy/28 fractions) on an Elekta Versa HD linear accelerator with concurrent weekly cisplatin 40 mg/m², followed by three fractions of 7 Gy HDR brachytherapy. Patients were simulated supine with a knee rest, and contrast-enhanced CT of the pelvis was acquired at 3 mm slices from the L2–L3 junction to mid-thigh. Images were transferred to the Monaco 5.11.03 treatment planning system. Planning CT was fused with T2W and DWI images by automatic DICOM-based registration, and the GTV, CTV, PTV and organs at risk were delineated.

Statistical analysis

was performed using SPSS v20. The Shapiro–Wilk test assessed normality; non-normal quantitative data were summarised as median and inter-quartile range (IQR). The Friedman test compared three related variables, and Spearman's rank-order correlation measured association. Bland–Altman plots assessed agreement. A p value < 0.05 was considered significant.

RESULTS

Thirty-one patients with LACC were analysed. The mean age was 51.97 ± 11.62 years (median 51; IQR 45–59), and squamous cell carcinoma was the only histology (100%), most commonly moderately differentiated grade 2 (68%). Stage IIB was the most frequent presentation (41%).

The mean GTV-primary was **79.6 cc on planning CT** (median 65.0; IQR 38.4–100.7), **52.2 cc on T2W MRI** (median 47.5; IQR 18.1–70.0) and **52.7 cc on DWI MRI** (median 52.1; IQR 24.1–72.2) (Table 1, Figure 1). The Friedman test showed a statistically significant difference among the three modalities ($p < 0.001$).

Post-hoc pairwise comparison revealed no significant difference between T2W and DWI GTV (p = 1.000), whereas both differed significantly from planning CT (p < 0.001). On average, GTV-MRI was approximately 27% smaller than GTV-CT.

Table 1: Distribution of GTV-Primary (cc) by imaging modality (n = 31)

Modality	Mean	Median	IQR
Planning CT	79.6	65.0	38.4–100.7
MRI T2W	52.2	47.5	18.1–70.0
MRI DWI	52.7	52.1	24.1–72.2

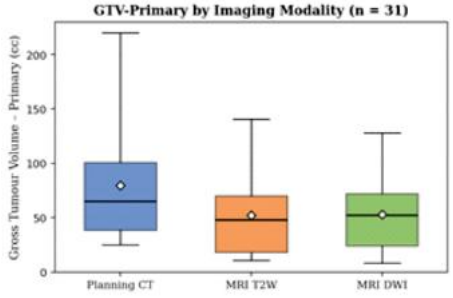

Figure 1: GTV-primary by imaging modality (box = IQR, line = median, ◇ = mean).

Spearman correlation showed a very strong positive correlation between CT and T2W GTV (rho = 0.856, p < 0.001), a strong correlation between CT and DWI GTV (rho = 0.785, p < 0.001), and a very strong correlation between T2W and DWI GTV (rho = 0.905, p < 0.001) (Table 2).

Table 2: Correlation of GTV between modalities (Spearman's rho)

Comparison	rho	p value
CT vs T2W	0.856	< 0.001
CT vs DWI	0.785	< 0.001
T2W vs DWI	0.905	< 0.001

Nodal volumes were measurable in 8 patients; the mean nodal volume was 11.46 cc on CT, 8.44 cc on T2W and 8.55 cc on DWI, with no significant difference across modalities (p = 0.093). Bland–Altman analysis showed close agreement between T2W and DWI (mean bias −0.5 cc), whereas both MRI sequences gave systematically smaller volumes than CT (mean bias ≈27 cc).

DISCUSSION

At our centre, cervical cancer constitutes 30–40% of all malignancies annually, and most cases present in a locally advanced stage. Owing to its superior soft-tissue contrast and ability to differentiate tumour from bladder and rectum, MRI has been recommended for diagnosis, staging and treatment planning by the GYN GEC-ESTRO working group[42,49]. The mean patient age in our study (51.97 years) is consistent with the literature, which reports cervical cancer most commonly affecting women in the fifth and sixth decades[50,51].

In the present study, GTV delineated on MRI was significantly smaller than on CT, with MRI volumes about 27% lower. This agrees with reports that indistinct tumour–OAR planes on CT lead to overestimation of tumour volume, whereas MRI provides sharper boundaries[8,52]. The very strong correlation between T2W and DWI (rho = 0.905) and the lack of a significant difference between them suggest that both sequences provide comparable volumetric information, consistent with prior observer-agreement studies[53,60].

The lack of a significant difference in nodal volumes reflects the comparable detectability of enlarged nodes on both CT and MRI[62,64]. Collectively, these findings reinforce the value of MRI-guided delineation for sparing normal tissue[65].

Limitations

include the small sample size, which precludes definitive statistical conclusions, difficulties in direct superimposition of CT and MRI images, and possible inter-observer variability dependent on expertise.

CONCLUSION

Significant differences were observed between GTV-T2W, GTV-DWI and GTV-CT, with MRI volumes being on average about 27% smaller than CT volumes. The high soft-tissue contrast of MRI reduces uncertainty in GTV delineation, which can translate into smaller EBRT fields, improved target coverage and better sparing of adjacent normal tissue, and may permit safe dose escalation. Despite the small sample size, MRI—both T2W and DWI—proved beneficial and well correlated with CT. MRI is therefore one of the best imaging modalities for target delineation in carcinoma cervix, and larger studies are warranted to validate these findings.

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