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AN AUDIT OF AORTIC BIFURCATION LEVEL IN PATIENTS WITH CERVIX CANCER – IMPLICATIONS FOR RADIATION THERAPY PLANNING

Oncology/Radiotherapy

Surekha Goyal Assistant Professor, Department of Radiation Oncology, Vydehi Institute of Medical Sciences & Research Centre, Bengaluru.

Surya Prakash Vankina Assistant Professor, Department of Radiation Oncology, Vydehi Institute of Medical Sciences & Research Centre, Bengaluru.

Geeta S Narayanan Professor & Head, Department of Radiation Oncology, Vydehi Institute of Medical Sciences & Research Centre, Bengaluru.

ABSTRACT

OBJECTIVES: To assess the level of aortic bifurcation concerning lumbar vertebra in patients with carcinoma cervix and to discuss the implications for radiation therapy planning for target coverage, toxicity, and treatment techniques. **METHODS:** In this retrospective observational study (n=1004), vertebral level of aortic bifurcation in patients diagnosed (histological) to have carcinoma cervix as been measured on radiation planning CT scan and categorised into those occurring at interspace and at the level of the vertebral body. **RESULTS:** Aortic bifurcation occurred above L4-5 interspace in 83% of patients. The commonest site of bifurcation was observed opposite the body of the L4 vertebra (68 %) followed by L4-L5 interspace (12%) and L3-L4 interspace (9.4%). Of note, one (0.1%) patient had a very high level of bifurcation at the level of L2-L3 interspace. **CONCLUSION:** In conclusion, L4-L5 as the superior border of the radiation field increases the risk of nodal failure in the common iliac region. The radiation field should encompass the aortic bifurcation with a sufficient margin for setup error and beam penumbra. An increase in GI toxicity as a result of a higher bifurcation level should be mitigated by the use of conformal techniques.

KEYWORDS

Aortic bifurcation, Cervical Cancer, Radiotherapy, 2D Planning,3DCRT, Recurrence

INTRODUCTION:

Carcinoma cervix is the 2^{nd} most common (16.5%) cancer in Indian women with an annual incidence of 96922 and accounts for 60,078 cases of cancer-related deaths annually[1]. External beam radiotherapy (+/- concurrent chemotherapy) followed by brachytherapy is the standard of care in the management of cervical cancer. EBRT can be delivered using four field box (2D) techniques, 3D conformal radiotherapy (3DCRT) or intensity-modulated radiotherapy (IMRT).

The target volume for radiotherapy planning includes the primary tumour and draining lymph nodes (common iliac, internal/external iliac, obturator and presacral). Historically, treatment planning for cervical cancer is based on bony landmarks (Image.1) with the upper border of the radiotherapy field at L4-L5 interspace to include common iliac lymph nodes in the treatment fields.

Due to the paucity of modern infrastructure, 2D planning(skin marking/ x-ray based planning) based on bony landmarks is still widely practised in low and middle-income countries. Superimposition (Image.2) of the conventional 2D radiotherapy field with the superior border at the level of L4-L5, onto a CT, delineated target volume (from the level of aortic bifurcation) shows that the common iliac lymph nodes are missed by the treatment field.

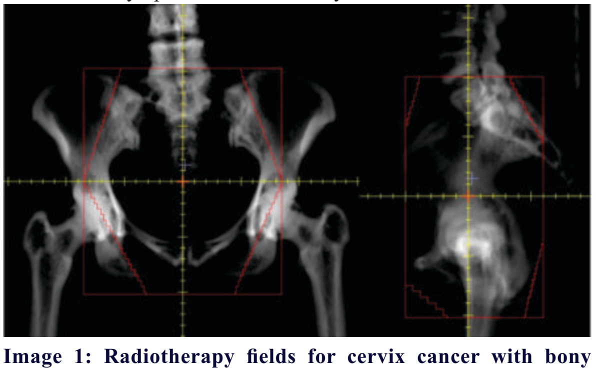

Image 1: Radiotherapy fields for cervix cancer with bony landmarks as reference

External beam radiotherapy by 3DCRT or IMRT mandates delineation of target volumes on CT (computed tomography) data sets. Contouring guidelines by Bansal et al[2], recommend delineating the gross tumour, uterine cervix, uterine corpus, parametria, the upper third of the vagina, uterosacral ligaments as part of the primary CTV. The nodal CTV includes the common iliac (from aortic bifurcation), internal and external iliac, obturator, and presacral lymph nodes.

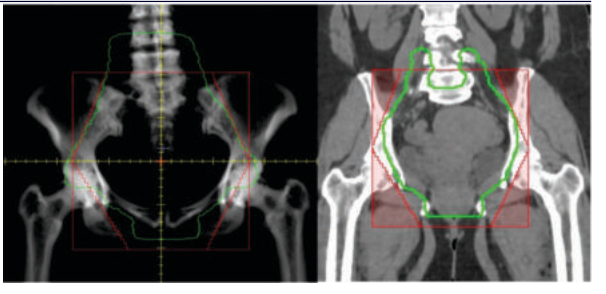

Image 2: Superimposition of 2D radiotherapy field on CT target volume (Green)

Review of literature[3, 4,5,6,7] has shown that aortic bifurcation occurs above L4-L5 interspace in the majority of cervix cancer patients and 2D planning based on bony landmarks will miss the common iliac lymph nodes resulting in an increased risk of recurrence.

The level of bifurcation above L4-L5 ranged from **70.7% to 84.6%** among these studies. This anatomic variation might have resulted from the small number (n≤116) of patients enrolled in these studies. We intend to assess the level of aortic bifurcation in a larger study population.

AIM OF STUDY:

To assess the level of aortic bifurcation concerning lumbar vertebra in patients with carcinoma cervix and to discuss the implications for radiation therapy planning for target coverage, toxicity, and treatment techniques.

MATERIALS AND METHODS:

This retrospective observational study (n=1004) was undertaken after obtaining approval from the institutional scientific advisory/ethics committee. Patients diagnosed (histological) to have carcinoma cervix and who received radiation therapy with curative intent from the years 2007 to 2020 were included in this study. Vertebral level of aortic bifurcation has been measured from the radiation planning CT scan in the Eclipse (Varian™) or Monaco (Elekta™) treatment planning systems.

The level of bifurcation has been categorised into those occurring at interspace and opposite the body of the vertebra. Bifurcation at the level of the vertebral body has been further categorised into upper/lower (within 1 cm from interspace) and mid (> 1 cm from interspace).

RESULTS:

Radiation planning CT scans of 1,004 patients have been analysed as part of this study.

Aortic bifurcation occurred above L4-5 interspace in 83% of patients. The commonest site of bifurcation was observed opposite the body of the L4 vertebra (68 %) followed by L4-L5 interspace (12%) and L3-L4 interspace (9.4%). Of note, one (0.1%) patient had a very high level of bifurcation at the level of L2-L3 interspace. Aortic bifurcation against the vertebral levels has been tabulated [Table 1] and graphically represented [Fig.1]

Table 1: Level Of Aortic Bifurcation

VERTEBRAL LEVEL	N (%)
BODY OF L3(LOWER)	50(5%)
BODY OF L3(MID)	5(0.5%)
BODY OF L4(LOWER)	256(25.4%)
BODY OF L4(MID)	218(21.7%)
BODY OF L4(UPPER)	210(21%)
BODY OF L5(LOWER)	5(0.5%)
BODY OF L5(MID)	4(0.4%)
BODY OF L5(UPPER)	39(3.8%)
L2-L3 INTERSPACE	1(0.1%)
L3-L4 INTERSPACE	95(9.4%)
L4-L5 INTERSPACE	121(12%)

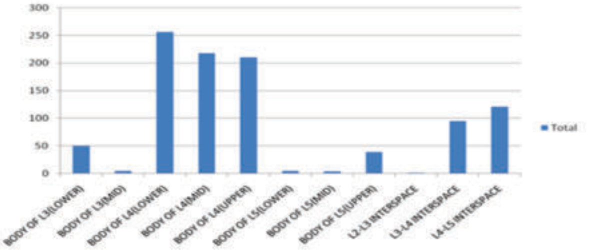

Figure 1: Graphical representation - Level of aortic bifurcation

DISCUSSION:

To our knowledge, this is the largest study (n=1004) ever done to assess the level of aortic bifurcation. The aortic bifurcation level being above L4-L5 interspace (83%) is in close agreement with the findings of Kaushal S et al[6] (81.3%) and Ponni et al[7] (84.6%). L4 vertebral body is the most common site (68%) of bifurcation is similar to the findings of Bhavana Rai et al[4] (64%), Mishra H et al[5] (57.8%), and Kaushal S et al[6] (64.3%). Cadaveric studies by Appaji et al[8], Deswal et al[9] and Prakash[10] et al showed similar results. L3-4 interspace being the commonest (53.84%) site of bifurcation in the study by Ponni et al[7] could be due to the small numbers (n=26) included.

The findings from our study reiterate the observation[3, 4,5,6,7] that the upper border of the radiation field at L4-L5 interspace will miss the common iliac nodal station in the majority of patients (~83%) with cervix cancer, resulting in a marginal risk of failure. Considering additional margin for setup error and beam penumbra, 2d field borders are inadequate even for those patients with a bifurcation at L4-L5 interspace/upper border of L5. Gulia A et al11 demonstrated that a superior field border at L4-L5 will fail to encompass the planning target volume in 96% of patients (n=50). Bhavana Rai et al[4] studied (n = 116) the patterns of recurrence in cervical cancer patients who received radiotherapy with the cranial border of CTV at the L4-L5 junction. Aortic bifurcation was above the L4-L5 junction in 82/116(70.7%) patients. Of the 9 recurrences above the field, 5 were between L4-L5 interspace and aortic bifurcation. The other 4 recurrences were above aortic bifurcation in the para-aortic region.

In the EMBRACE study (n=1338)[12], common iliac nodes at diagnosis constituted about 30% (n=697). 27% of the nodal failures (n=152) following treatment were in the common iliac region. Inferring from the above studies, it is evident that the upper border of the radiation field at the L4-L5 interspace will underdose the common iliac region resulting in an increased risk of nodal failure. However, a superior field border corresponding to the level of bifurcation will result in increased dose[13] to the small bowel. As the level of aortic bifurcation goes higher, it is pertinent to use conformal radiation techniques (3DCRT/IMRT) to reduce small bowel toxicity. Chopra S et al[14] demonstrated that image-guided intensity-modulated radiotherapy (IG-IMRT) reduces $\geq$ grade 2 late gastrointestinal toxicity by 50% when compared to 3D conformal radiotherapy (3DCRT) in cervix cancer patients receiving post-op radiotherapy.

In conclusion, L4-L5 as the superior border of the radiation field increases the risk of nodal failure in the common iliac region. The radiation field should encompass the aortic bifurcation with a sufficient margin for setup error and beam penumbra. An increase in GI toxicity as a result of a higher bifurcation level should be mitigated by the use of conformal techniques. In low-resource settings, where only telecobalt machines are available, treating the patients in the full bladder and using corner shielding of radiation portals can reduce bowel toxicity. While treating on a linear accelerator, the level of aortic bifurcation can be used as a criterion to select patients for IMRT, given the time and resource intensiveness of this technique.

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