The bifurcation level and geometric anatomy of abdominal aorta – Does it matter in cervical malignancy? Experience from tertiary cancer center

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ABSTRACT

Background: The course, the origin of the branch, and the division of the aorta may vary and the aortic bifurcation level and branching can be determined by arteriogram, magnetic resonance imaging, computed tomography (CT) scan, and cadaveric dissection. **Aims and Objectives:** This study aimed to find the variation in aortic bifurcation levels in cervical malignancy patients who underwent radiotherapy. **Materials and Methods:** Between January 2018 and December 2022 previously untreated, histologically proven squamous cell carcinoma of the cervix patients who received radiotherapy in our department were selected for this retrospective analysis. A planning contrast-enhanced CT scan with a 3 mm slice thickness was done in a CT simulator to delineate the target volume and aorta, common iliac vessels in all patients. **Results:** 407 cervical carcinoma patients who received radiotherapy in Linear Accelerator (LINAC) were included in this analysis. The aortic bifurcation is most commonly situated at the level of the L3–L4 intervertebral disc in 290 (71.25%) cases with a range between the upper L3 body and the lower L5 body. The common iliac bifurcation was situated at the level of L5–S1 in 338 cases (83.04%) and S1 vertebral body in 63 cases (15.47%). The average length of the left common iliac artery was 4.58 cm and the right common iliac artery was 4.44 cm. The diameter of the aorta at the level of just before the bifurcation is 1.39 cm. The average diameter of the left common iliac artery and right common iliac artery were 1.21 cm and 1.13 cm, respectively. The right and left take-off angles (αR, αL) are 25.58° and 23.78°, respectively. **Conclusion:** The knowledge regarding the anatomic variation of branching and bifurcation of the aorta of utmost importance for surgical procedures, interventional radiology procedures, and proper radiotherapy treatment planning. Acknowledging these anatomic variations may also reduce complications.

Key words: Radiotherapy; Aortic bifurcation; Vertebral level

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INTRODUCTION

The anatomical description of abdominopelvic great vessels is well known to medical practitioners and easily available in any anatomy textbook.[1] The abdominal aorta descends in front of the lumber vertebra and divides into two common iliac arteries in front of the 4th lumber vertebra or front of the L4–L5 intervertebral disc.[1] The course, the branch's origin, and the aorta's division may vary. The aortic bifurcation level and branching can be determined by arteriogram, magnetic resonance imaging, computed tomography (CT) scan, and cadaveric dissection.[2] Different degrees of pathological involvement between right and left iliac arteries in symptomatic arterio-occlusive disease were reported in the literature way back in 1976.[3] In one study by Kaushal et al., from north India, the bifurcation

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of abdominal aorta was situated at the L3–L4 level in the majority of patients.[4] In another study, bifurcation was found at the L3/L4 vertebral bodies in 13% of patients and at the level of the L4 vertebral body in 67% of patients.[5] Data regarding geometric dimensions are sparse in the literature. The knowledge regarding the anatomic variation of branching and bifurcation of the aorta of utmost importance for surgical procedures, interventional radiology procedures, and proper radiotherapy treatment planning.

Aims and objectives

This study was intended to explore the variation in aortic and common iliac arterial bifurcation levels and geometry in cervical malignancy patients who received pelvic external beam radiotherapy (EBRT) as standard treatment.

MATERIALS AND METHODS

Between January 2018 and December 2022 previously untreated, histologically proven carcinoma of the cervix who received radiotherapy in our department were selected for this retrospective analysis. Inclusion criteria were (1) age > 20 years and not more than 70 years, (2) histological proof of malignancy, and (3) Stage I-IVA. The exclusion criteria were (1) age >70 years and < 20 years and (2) previously treated with any radiation or chemotherapy. All patients were immobilized in the supine position, hands placed over the chest; a contrast-enhanced CT scan with a 3 mm slice thickness was done in a CT simulator to delineate the target volume and aorta, common iliac artery. We have used the Treatment Planning System inbuilt caliper and scale in centimeter. The parameters studied were as follows: (a) the level of bifurcation of the aorta and common iliac artery, (b) the length of both common iliac arteries, (c) the take-off angle of right and left common iliac arteries at the level of bifurcation, (d) diameter of the aorta just proximal to the bifurcation, (e) diameter of common iliac artery just distal to the bifurcation, and (f) the angle between aortic longitudinal central line axis and the plane formed by both common iliac arteries. The technique to ascertain the geometric parameter is illustrated in Figures 1-5.

Data collection and analysis

From January 2018 to December 2022, according to inclusion and exclusions criteria, as mentioned earlier, 407 histologically proven cervical cancer patients were included in this retrospective analysis. The level of aortic bifurcation, common iliac bifurcation, and vascular anomalies were studied. All the collected data were recorded on an Excel sheet and analyzed on the Statistical Package for the Social Sciences version 20.

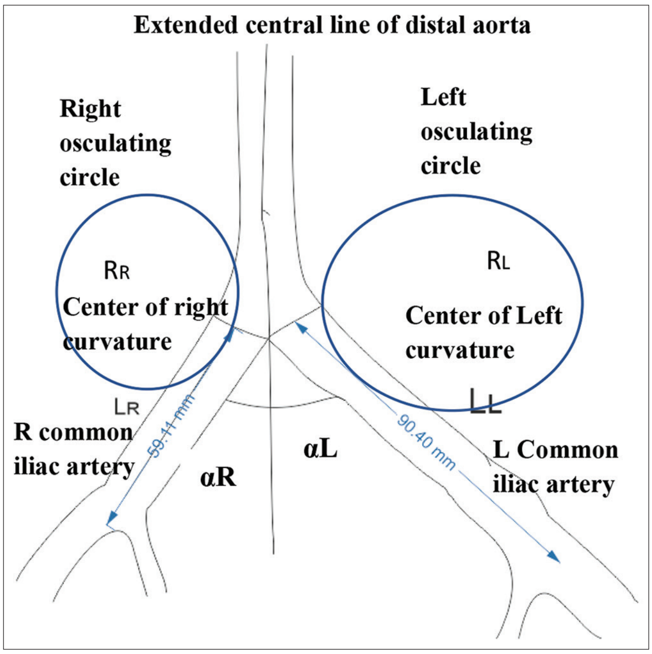

Figure 1: Anatomical geometry of aortic-common bifurcation; αR-take-off angle of the right common iliac artery at the bifurcation, the αL-take-off angle of the left common iliac artery at the bifurcation. LL: Length of left CI, RL: Length of right CI artery

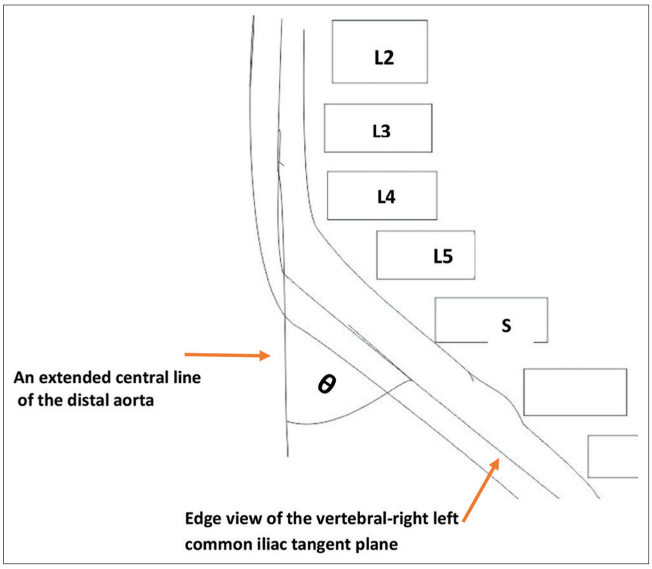

Figure 2: Section of aortic-common iliac bifurcation through the mid-sagittal plane. θ = The angle between the aortic longitudinal central line axis and the plane formed by both iliac arteries

RESULTS

A total of 407 cervical carcinoma patients who received radiotherapy in LINAC were included in this retrospective analysis. The aortic bifurcation is most commonly situated at the level of the L3–L4 intervertebral disc in 290 (71.25%) patients with a range between the upper L3 body and the lower L5 body. In 71 (17.44 %) cases, bifurcation was seen in L4–L5 intervertebral disc and in 38 cases (9.33%)

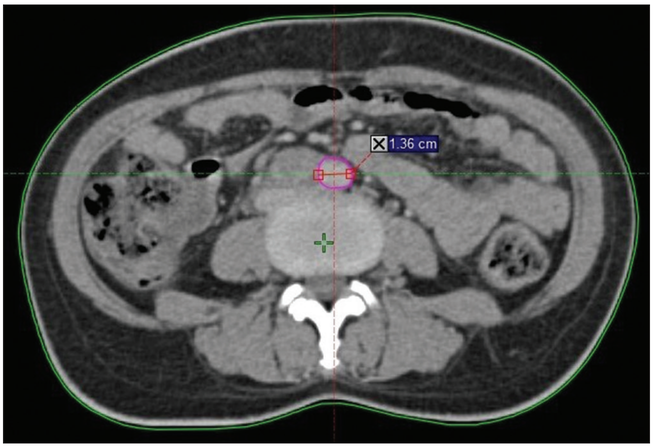

Figure 3: The diameter aorta just proximal to the bifurcation

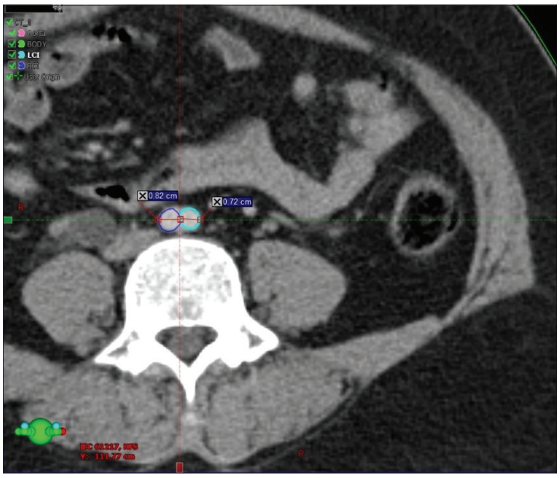

Figure 4: The diameter of right and left common iliac artery

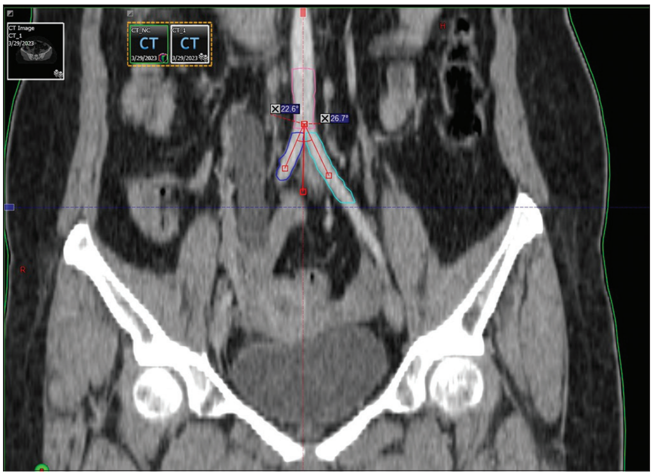

Figure 5: The take-off angle of the right common iliac artery at the bifurcation (αR) and the take-off angle of the left common iliac artery at the bifurcation (αL)

L4 vertebral body. The least common site of bifurcation was the upper L5 vertebral body in 8 cases (1.96%). The common iliac bifurcation was seen at the level of L5–S1 in 338 cases (83.04%) and S1 vertebral body in 63 cases (15.47%). The least common level was L5 vertebral body 6 (1.47%). The bifurcation level of the abdominal aorta and the common iliac artery are summarized in Tables 1 and 2, respectively.

The average length of the left common iliac artery was 4.58 cm and the right common iliac artery was 4.44 cm. The diameter of the aorta at the level just before the bifurcation is 1.39 cm. The average diameter of the left common iliac artery and right common iliac artery was 1.21cm and 1.13 cm, respectively. The right and left take-off angles (αR, αL) are 25.58° and 23.78°, respectively. The Bulkier disease (≥4 cm), gross external iliac, and internal iliac nodes were present in 219 (53%), 36 (8.84%), and 9 (2.21%) cases, respectively.

DISCUSSION

Squamous cell carcinoma cervix is one of the leading causes of death among women, worldwide, especially in developing countries. According to the GLOBOCAN 2020, the total number of cases of cervical cancer worldwide was 6,04,127, among which India contributed 1,23,907 cases.[6,7] The treatment of carcinoma cervix mainly depends upon its stage. Treatment of carcinoma cervix is mainly dependent on radiation therapy, in the form of the external beam radiotherapy (EBRT), and brachytherapy.[8] The pelvic nodes are distributed surrounding the common iliac, external iliac, internal iliac, arteries, and veins and divided into common iliac, external iliac, internal iliac, circumflex iliac, obturator nodal, and presacral nodal group.[1,9] Two-D planning using an X-ray simulator based on a bony landmark and L4–L5 intervertebral space is the superior border of the radiotherapy portal in case of carcinoma cervix to cover common iliac nodes. In comparison to 3-D conformal radiotherapy, 2-D radiotherapy planning is a simpler and non-inferior treatment of the carcinoma cervix. However, the inappropriate portal size and design may lead to subtherapeutic dose to target volume which ultimately increases the chances of failure.[10] Forget about the 4-D CT simulator, even today many oncology centers in developing countries do not have an X-ray simulator, and radiotherapy 2-D (dimensional) planning is solely based on bony landmarks.

There are two types of variation: first is structural and second is locational.[2,11] Aortoiliac anomalies are rarely reported in the literature and are usually detected during investigation for other medical conditions. Aortic bifurcation was as low as the level S2 vertebrae level has been reported in the literature and associated with other anomalies like an ectopic kidney.[12] In one study by Pirró et al., the bifurcation of the aorta was

Table 1: The aortic bifurcation level (n-407)

Level	n (%)
L3–L4 intervertebral disc	290 (71.25)
L4–L5 intervertebral disc	71 (17.44)
L4 vertebral body	38 (9.33)
Upper L5 vertebral body	8 (1.96)

Table 2: The common iliac of bifurcation level (n-407)

Level	n (%)
L5–S1 intervertebral disc	338 cases (83.04)
S1 vertebral body	63 cases (15.47)
L5 vertebral body	6 (1.47)

situated between the L3 and S1 vertebral level, and in 50% of patients, the bifurcation was at the level of the L5 vertebra.[13] Another study by Lee et al., found that only 4% of patients' bifurcation occurs at the L4–L5 intervertebral disc space level and 10% of patients at the L3–L4 intervertebral disc level. In 45% and 38% of patients, bifurcation occurs upper and lower half of the L4 vertebral body, respectively.[14] One study of aortic common iliac bifurcation on cadaveric specimens from India by Deswal et al., reported that aortic bifurcation was seen in between the L3 and L5 vertebral body. In 64% of cadaveric specimens, bifurcation occurs at the level L4 vertebrae.[15] In our study, the aortic bifurcation was most commonly situated at the level of the L3–L4 intervertebral disc 290 (71.25%) with a range between the upper L3 body and the lower L5 body. In 64% of cadaveric specimens, bifurcation occurs at the level L4 vertebrae.[15] In our study, the aortic bifurcation is most commonly situated at the level of the L3–L4 intervertebral disc 290 (71.25%) with a range between the upper L3 body and the lower L5 body.

One retrospective analysis on 3-D CT angiographic anatomy of great vessels by Inamasu et al., reported that around 55% of patients had artic bifurcation at the L4 vertebra and in 23% of patients at the level L4–L5 disc. The author concluded that data obtained from 2-D, and 3-D studies can serve as a versatile evaluation of aortoiliac anatomy and can facilitate surgical, interventional radiological procedures, and perioperative vascular complications.[16]

One retrospective analysis from Chandigarh, north India by Rai et al., reported that almost 71% of patients' aortic bifurcation was above L4–L5 intervertebral disc level. The author also reported that nodal failure occurs between Aortic bifurcation and L4–L5 level (i.e., above the upper border radiation portal.[17] Beadle et al., also concluded that in the case of cervical carcinoma after radiotherapy, the majority of recurrence occurs above the upper border of the radiation portal.[18] As previously stated, X-ray and CT simulators may not be available in the resource-constrained center, and conventional two-dimensional radiotherapy planning is solely based on bone landmarks and surface anatomy.[19]

Depending on the stage of the disease, EBRT is used to treat gross primary and nodal diseases including the cervix, uterus, vagina, parametria, uterosacral ligaments pelvic nodes, common iliac, and para-aortic lymph nodes. If there are nodes in surgical staging, or radiological imaging (node negative), the radiation volume should include, external iliac, internal Iliac, obturator nodal, and presacral nodal groups. For the patients with a higher risk of lymph node involvement, i.e., bulkier disease, suspected or confirmed node confined to the low true pelvis, the radiation treatment volume should be extended to cover the common iliac nodes, i.e., up to bifurcation of the aorta. Similarly, extended-field pelvic and para-aortic radiotherapy is recommended in patients with documented common iliac nodes and para-aortic nodal disease,[20] and if we want to cover the area of aortic bifurcation, the radiation field should extend above the L4 vertebral body. In our study, bulkier disease (≥4 cm), gross external iliac, and internal iliac nodes were present in 219 (53%), 36 (8.84%), and 9 (2.21%) cases, respectively. If we placed the upper border of the radiation portal at the L4–L5 junction, we may have missed the upper common nodal area coverage in these cases.

The major strength of our study was that we evaluated the planning CT scan of more than 400 cervical cancer patients, i.e., our study may be representative of the general population.

Limitations of the study

The limitation of Our study was single institutional, and only female patients were included.

CONCLUSION

This study was intended to explore the variation in aortic and common iliac arterial bifurcation levels in cervical malignancy patients who received an external beam as standard treatment. In our study, in the majority of patients (71%) aortic bifurcation occurs at the L3–L4 intervertebral level. The knowledge regarding the anatomic variation of branching and bifurcation of the aorta of utmost importance for surgical procedures, interventional radiology procedures, and proper radiotherapy treatment planning. Acknowledging these anatomic variations may also reduce complications.

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REFERENCES

1. Pitman GA, Moss D and Stringer DM. Posterior abdominal wall and retro-peritoneum. In: Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. Amsterdam: Elsevier Ltd.; 2016. p. 1083-97.
2. Atalar MH, Salk I, Bozbiyik N and Cetin A. Diagnosis of high bifurcation of the abdominal aorta with associated vascular variations: Case report with multidetector computed tomography. Pol J Radiol. 2015;80:523-525.
   https://doi.org/10.12659/PJR.895240
3. Shah PM, Scarton HA and Tsapogas MJ. Geometric anatomy of the aortic--common iliac bifurcation. J Anat. 1978;126(Pt 3):451-458.
4. Kaushal S, Negi M and Bhardwaj N. Evaluation of aortic bifurcation in cervical cancer patients. Int J Sci Healthc Res. 2020;5(3):278-280.
5. Chithriki M, Jaibaji M and Steele RD. The anatomical relationship of the aortic bifurcation to the lumbar vertebrae: An MRI study. Surg Radiol Anat. 2002;24(5):308-312.
   https://doi.org/10.1007/s00276-002-0036-3
6. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209-249.
   https://doi.org/10.3322/caac.21660
7. Available from: https://gco.iarc.fr/today/data/factsheets/populations/356-india-fact-sheets [Last accessed on 2022 Jun 20].
8. Perez CA and Kavanagh BD. Uterine cervix. In: Perez CA, Brady LW, Halperin EC, Schmidt-Ulrich RK, editors. Principles and Practice of Radiation Oncology. Philadelphia, PA: Lippincott Williams and Wilkins; 2004. p. 1800-1915.
9. Taylor A, Rockall AG, Powell ME. An atlas of the pelvic lymph node regions to aid radiotherapy target volume definition. Clin Oncol (R Coll Radiol). 2007;19(7):542-550.
   https://doi.org/10.1016/j.clon.2007.05.002
10. Thakur P, Revannasiddaiah S, Rastogi M, Gupta MK, Seam RK and Gupta M. Uncertainty concerning the 4-field box technique for stage-IB2 carcinoma of the uterine cervix. J Med Phys. 2013;38(1):41-43.
    https://doi.org/10.4103/0971-6203.106604
11. Raikos A, Paraskevas GK, Natsis K, Tzikas A and Njau SN. Multiple variations in the branching pattern of the abdominal aorta. Rom J Morphol Embryol. 2010;51(3):585-587.
12. Degheili JA, Malhas H, Yoo TK and Dergham MY. A very low-positioned aortic bifurcation. Vasc Specialist Int. 2020;36(2):112-115.
    https://doi.org/10.5758/vsi.200009
13. Pirró N, Ciampi D, Champsaur P and Di Marino V. The anatomical relationship of the iliocava junction to the lumbosacral spine and the aortic bifurcation. Surg Radiol Anat. 2005;27(2):137-141.
    https://doi.org/10.1007/s00276-004-0301-8
14. Lee CH, Seo BK, Choi YC, Shin HJ, Park JH, Jeon HJ, et al. Using MRI to evaluate the anatomic significance of aortic bifurcation, right renal artery, and conus medullaris when locating lumbar vertebral segments. AJR Am J Roentgenol. 2004;182(5):1295-1300.
    https://doi.org/10.2214/ajr.182.5.1821295
15. Deswal A, Tamang BK and Bala A. Study of aortic-common iliac bifurcation and its clinical significance. J Clin Diagn Res. 2014;8(7):AC06-AC08.
    https://doi.org/10.7860/JCDR/2014/8767.4559
16. Inamasu J, Kim DH and Logan L. Three-dimensional computed tomographic anatomy of the abdominal great vessels pertinent to L4-L5 anterior lumbar interbody fusion. Minim Invasive Neurosurg. 2005;48(3):127-131.
    https://doi.org/10.1055/s-2004-830262
17. Rai B, Bansal A, Patel F, Gulia A, Kapoor R and Sharma SC. Pelvic nodal CTV from L4-L5 or aortic bifurcation? An audit of the patterns of regional failures in cervical cancer patients treated with pelvic radiotherapy. Jpn J Clin Oncol. 2014;44(10):941-947.
    https://doi.org/10.1093/jjco/hyu107
18. Beadle BM, Jhingran A, Yom SS, Ramirez PT and Eifel PJ. Patterns of regional recurrence after definitive radiotherapy for cervical cancer. Int J Radiat Oncol Biol Phys. 2010;76(5):1396-1403.
    https://doi.org/10.1016/j.ijrobp.2009.04.009
19. Kumar RV. Conventional radiotherapy planning of cervical cancer in the resource-constrained set-up: Utilizing soldering lead wire to delineate radiotherapy portal. Gynecol Oncol Rep. 2020;34:100650.
    https://doi.org/10.1016/j.gore.2020.100650
20. National Comprehensive Cancer Network (NCCN). NCCN Clinical Practice Guidelines in Oncology. Cervical Cancer Version 1. Philadelphia, PA: National Comprehensive Cancer Network; 2023. Available from: https://www.nccn.org [Last accessed on 2023 May 16].

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AB- Conceptualization, methodology, data collection, data interpretation, writing of the manuscript, and reviewing of the final manuscript;
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