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SPECIAL SECTION: RECTAL CANCER

Nodal drainage pathways in primary rectal cancer: anatomy of regional and distant nodal spread

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Abstract
Nodal involvement is a significant prognostic factor in rectal cancer and difficult to assess preoperatively. An understanding of the patterns of nodal spread from different regions of the rectum can assist in this process and is essential for the purposes of surgical planning. In this article we define patterns of spread to mesenteric and pelvic sidewall nodal subgroups and discuss the importance of accurate anatomic localization of nodes for the purposes of staging and surgical planning.

Keywords Rectal cancer · Rectal adenocarcinoma · Lymph node · MRI · CT

Introduction

Lymph node spread is an important prognostic factor in rectal cancer. An understanding of lymphatic drainage pathways from different regions of the rectum, the most common nodal groups' involved and accurate localization of these nodes to mesenteric, pelvic sidewall and retroperitoneal compartments is important in the accurate staging and surgical planning of rectal cancer.

The rectum has a dual blood supply: from the mesenteric vessels i.e., the inferior mesenteric and superior rectal vessels and from pelvic sidewall vessels i.e., branches of the internal iliac artery including the middle and inferior rectal arteries. Lymphatic drainage from the rectum for the most part follows the course of these arteries.

Definitions of the rectum and pathways of lymphatic drainage

There are numerous definitions of the rectum: anatomical, surgical, and radiological.

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The anatomic definition of the rectum specifies its superior or upper extent as the point of coalescence of the taenia to form a continuous outer longitudinal muscle layer in the rectum. Inferiorly the anatomic rectum ends at the dentate line, which also is the point of transition between columnar epithelium lining the rectum and the squamous epithelium lining the anatomic anal canal, which extends down from the dentate line to the anal verge [1].

In contrast the current convention in the radiology literature places the inferior end of the rectum at the level of the anal verge, incorporating the anatomic anal canal into the lower rectum. The superior end of the rectum is placed 15 cm above the anal verge.

There are various definitions of the rectum put forward by different surgical societies; the Japanese society for cancers of the colon and rectum defines the rectum as extending from the sacral promontory to the upper edge of the puborectalis muscle, a definition that moderately aligns with the anatomic boundaries of the rectum. While, the American society of colon and rectal surgeons classifies any tumor whose distal margin is 15 cm or less from the anal verge as a rectal cancer [2, 3].

The subdivisions of the rectum also vary, but the most commonly used approach by both radiologists and surgeons in the United States is to divide the rectum into three sections from the anal verge, the lower rectum (0–5 cm), middle (5–10 cm), and upper (10–15 cm).

The limitation of this approach is that it does not reflect the pathways of lymphatic drainage of the rectum which is a key determinant of nodal involvement. From the perspective

of patterns of lymphatic drainage, the peritoneal reflection is an important landmark. The peritoneal reflection can also be localized to approximately the level of the middle rectal valve of Houston or 6-9 cm above the anal verge. In addition the peritoneal reflection itself can also be easily identified on a significant percentage of rectal MRI scans [4, 5].

Rectal tumors located above the peritoneal reflection drain almost exclusively along nodes following the mesenteric vessels, and include the pararectal/mesorectal nodes, the superior rectal and finally the inferior mesenteric nodes. A reflection of this almost exclusive upward pathway of lymphatic drainage in high rectal tumors is the low incidence of pelvic sidewall nodal involvement in tumors above the peritoneal reflection which in surgical studies was found to be 1.5–3.6%. This incidence is seen to increase to about 21% in tumors that were located at the level of the peritoneal reflection. In contrast tumors located below the peritoneal reflection also drain upwards along the mesenteric vessels, but have significant drainage laterally towards pelvic sidewall nodes. This is reflected in the 41.8% incidence of metastatic pelvic sidewall nodes seen in rectal tumors below the peritoneal reflection. It is to be noted, however, that pelvic sidewall nodes even in low rectal tumors are seen primarily in T3–T4 tumors and are rare in early stage rectal tumors [6, 7] (Fig. 1).

A third lymphatic drainage zone is located inferior to the dentate line or the anatomic anal canal. Tumors located below this point drain upward along the mesenteric lymphatics but also laterally to superficial inguinal nodes which are defined on cross sectional images as nodes caudal to the inguinal ligament.

Nodal anatomy

As previously mentioned pathways of lymphatic drainage for the rectum can be broadly compartmentalized to two separate regions, the mesenteric nodes and extra mesenteric which include pelvic sidewall and retroperitoneal nodes. Since lymphatic drainage pathways follow the rectal blood supply, most commonly the arteries, the names of the nodes reflect the adjacent vessel and the sub-classification of these nodes reflects the relationship of the node relative to the vessel.

Mesenteric nodes

This drainage pathway refers to nodes located in the mesorectum and the mesentery of the sigmoid colon; and includes pararectal nodes also called mesorectal nodes, superior

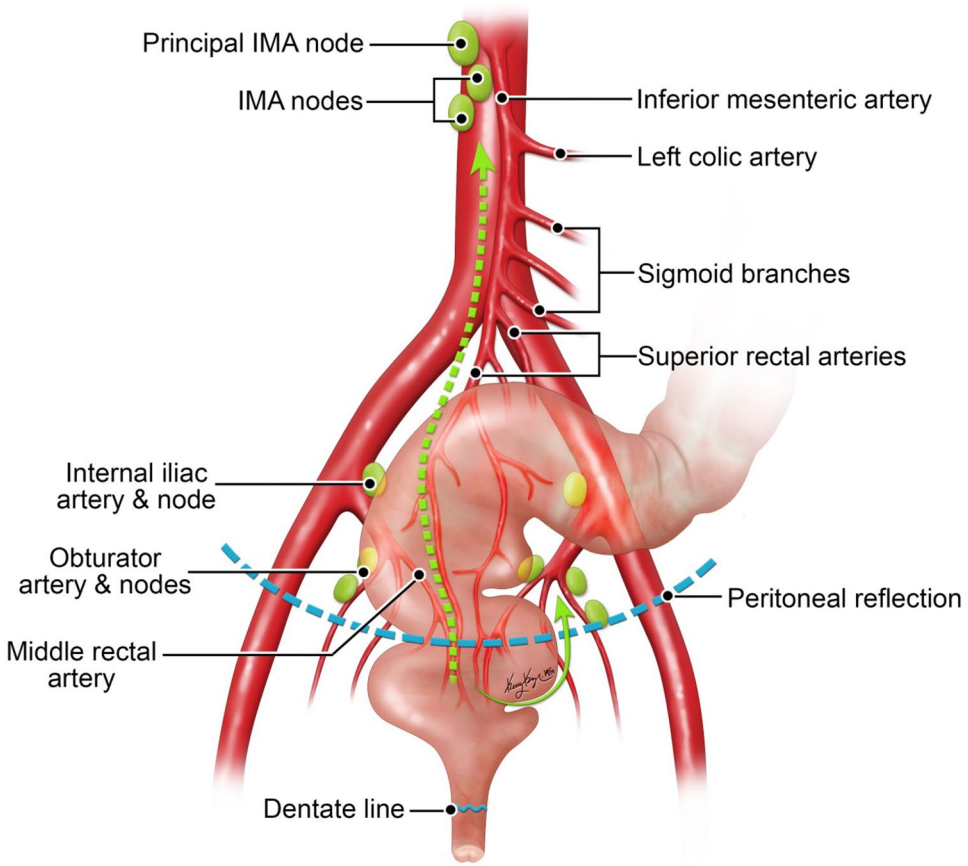

Fig. 1 Lymphatic drainage from the entire rectum and anal canal is upward (dotted light green arrow) along mesenteric vessels. Mesenteric nodes can be classified as the principal IMA node at origin of the IMA from aorta, IMA nodes seen along IMA to level of the left colic artery and superior rectal nodes. Lymphatic drainage from below the peritoneal reflection (dotted blue line) also extends laterally to pelvic sidewall nodes. These nodes are located primarily along the obturator and internal iliac vessels

rectal nodes, inferior mesenteric artery nodes, and principal inferior mesenteric artery (IMA) node [8].

The principal IMA node refers to the node at the point of origin of the inferior mesenteric artery from the aorta. While all the remaining nodes along the inferior mesenteric artery to the point of origin of the left colic artery are categorized simply as IMA nodes (Figs. 1 and 2). This represents the most common pathway of nodal spread in rectal cancer. When metastatic nodes are present in rectal cancer, the overwhelming majority involves the mesenteric compartment, and of these involved nodes most are located in the mesorectum [6, 9].

Pelvic sidewall nodes

The overall incidence of pelvic sidewall involvement in all rectal tumors is 8.8–23% [6, 7, 9]. However, as previously mentioned, pelvic sidewall nodal involvement is uncommon in rectal tumors located above the peritoneal reflection, but can be seen in tumors at and below the peritoneal reflection [6].

The pelvic sidewall nodal groups are classified and named according to the adjacent vessel as common iliac, external iliac, and internal iliac/hypogastric nodes and can be further classified into subgroups.

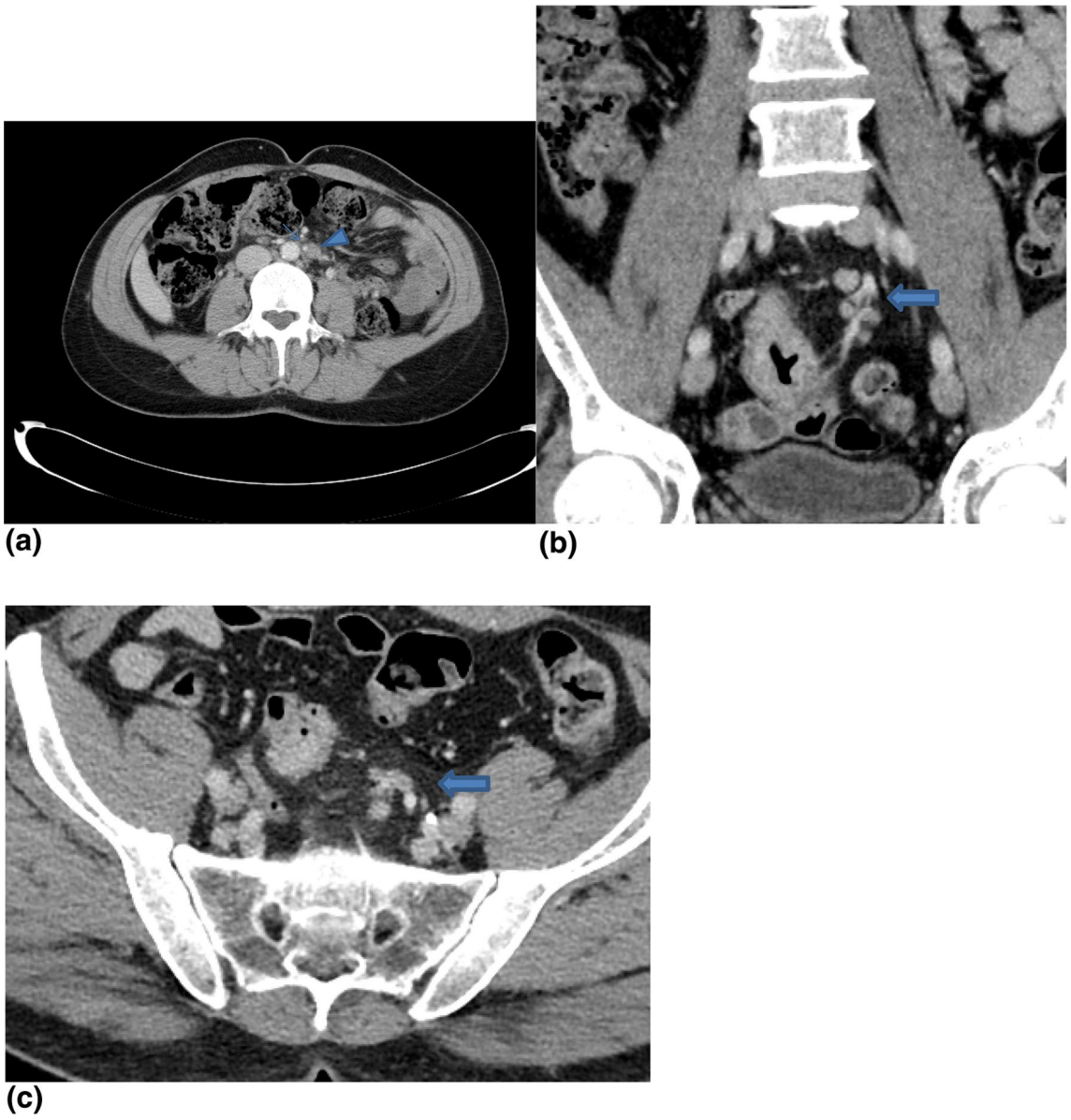

Fig. 2 **a** The principal IMA node (arrowhead) is identified adjacent to the inferior mesenteric artery (arrow) close to the origin of artery from the aorta. **b** and **c** Superior rectal nodes are seen along the course of the superior rectal vessels in the axial and coronal planes (arrows)

External iliac nodes are subdivided into lateral, middle and medial chains. The lateral subgroup as the name suggests are located lateral to the external iliac artery, the middle between the artery and vein, and medial posterior to the external iliac vein. The nodes in the medial subgroup are in close proximity to nodes along the obturator vessels and are the subject of some controversy as they are frequently indistinguishable from obturator nodes that are seen along the course of the obturator artery as it runs from its origin from the internal iliac/hypogastric artery along the obturator internus exiting the pelvis at the obturator foramen (Fig. 3a and b) [10].

The lateral and middle chain external iliac nodes are almost never involved in rectal cancer. These nodal groups have their main afferent lymphatics from the lower limb. In a study by Moriya et al. of 149 Duke C tumors arising below the peritoneal reflection, no external iliac nodal metastasis were found [11]. Consequently, although enlarged oblong nodes are frequently observed in these locations on cross sectional imaging, based on patterns of lymphatic spread in rectal cancer these nodes are unlikely to be involved even

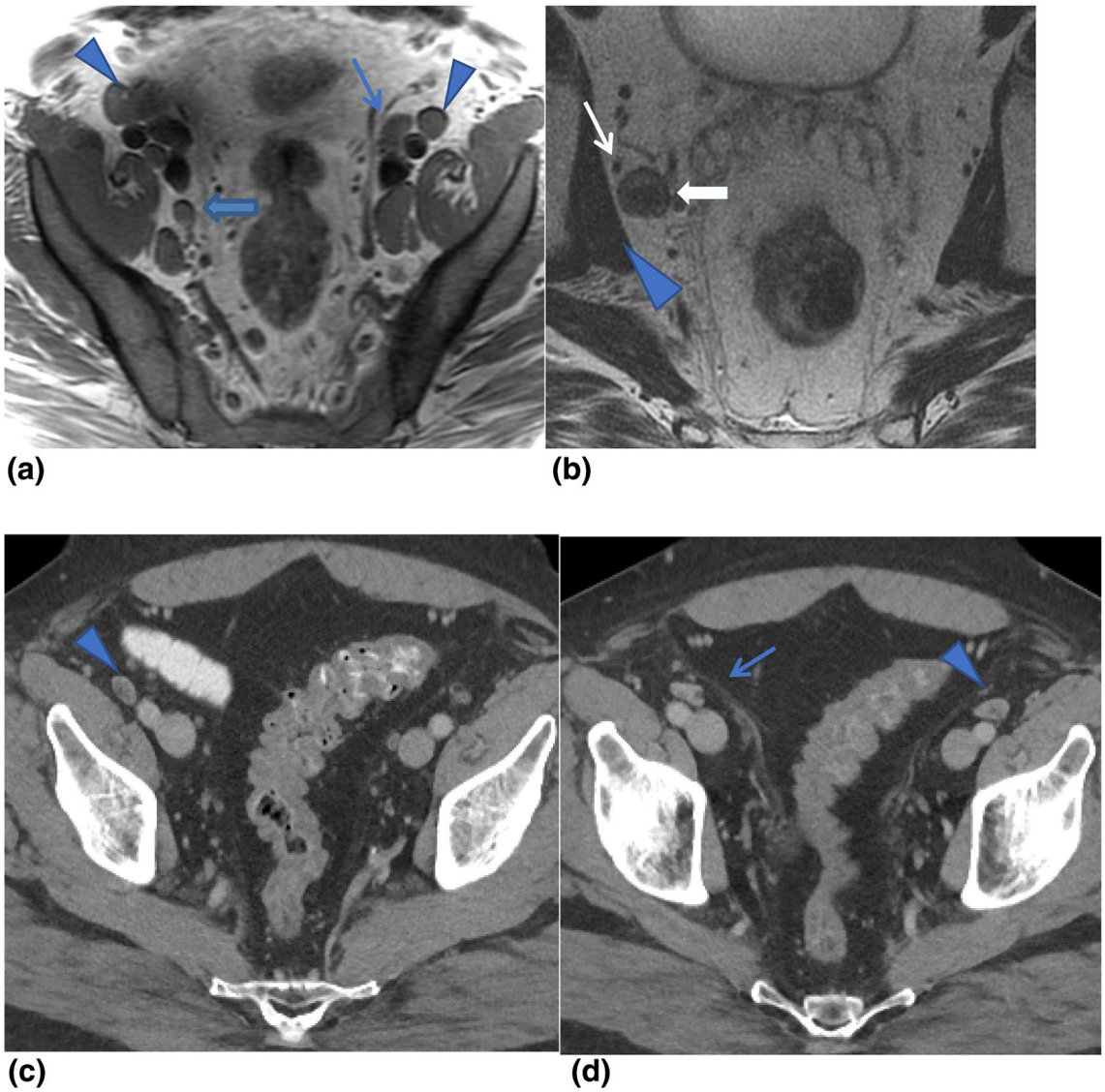

Fig. 3 External iliac nodal subgroups: **a** Lateral (arrowheads), middle (small arrow on left) external iliac nodes receive afferent lymphatic supply from the lower extremity and are rarely involved in rectal cancer. Medial external iliac nodes (large blue arrow) are in close proximity and can overlap with obturator nodes. **b** Obturator nodes (large white arrow) however are generally seen more posteriorly adjacent to the obturator artery (small white arrow) and medial to the obturator internus muscle (arrowhead). **c** and **d** Enlarged oblong nodes are commonly seen in the middle (small arrow) and lateral subgroups (arrowheads) of external iliac nodes. These are generally not involved in rectal cancer

if enlarged. The exception is rectal tumors extending below the dentate line which can metastasize to superficial inguinal nodes and subsequently to external iliac nodes (Fig. 3 c and d).

Hypogastric or internal iliac nodes drain all the visceral pelvic structures via lymphatics that follow the middle rectal, uterine, superior and inferior vesical, and inferior rectal vessels and consequently are frequently involved in pelvic malignancies.

Lymphatic spread from the lower rectum primarily spreads laterally to obturator and internal iliac nodes. This is reflected in the surgical literature, the pelvic sidewall nodes most commonly involved in rectal cancer are internal iliac nodes (11%) followed closely by nodes along the obturator artery (6%) (Figs. 1, 3b and 4) [6].

Common iliac and retroperitoneal nodes

A sub-classification of common iliac nodes similar to the subgroups of external iliac nodes has also been described.

Lateral chain common iliac nodes are a continuation of the lateral chain external iliac nodes. While the medial chain nodes occupy the space between the common iliac arteries at the sacral promontory. These nodes receive lymphatic's that ascend along the lateral sacral vessels in the presacral space [10]. This posterior pathway of lymphatic drainage to lateral sacral nodes although seen in rectal cancer is relatively uncommon.

The middle chain common iliac nodes are located posterior to the common iliac artery and vein abutting the L5 nerve root as it passes anterior to the sacral alae. These nodes receive afferents lymphatic's from the hypogastric/internal iliac region and the lateral sacral region (Fig. 5a).

The lymphatic spread then extends from the common iliac nodes to the para-aortic region which is broadly sub classified as left para-aortic and right latero-aortic. The right latero-aortic subgroup is further classified as aortocaval, precaval, laterocaval, and retrocaval nodes (Fig. 5b) [10, 12].

As previously mentioned superficial inguinal nodes are rarely involved in rectal cancer seen only in rectal tumors that have extended below the dentate line. Superficial inguinal nodes are defined as nodes caudal to the inguinal ligament located along the femoral vessel (Fig. 6) [12].

Regional and non-regional or metastatic nodes in rectal cancer

In the staging of rectal cancer nodal spread is further classified as regional or non-regional. Regional nodes are described by N stage while non-regional nodes are categorized as distant spread or M disease.

According to the recent AJCC guidelines (8th edition), regional nodes in rectal cancer have been broadly defined as mesorectal/pararectal, superior rectal, inferior mesenteric, internal iliac, and inferior rectal nodes. Although obturator nodes are not mentioned in the AJCC guidelines at MD Anderson, these are considered regional nodes.

Left para-aortic, aortic bifurcation, common iliac, external iliac, and superficial inguinal nodes qualify as non-regional or metastatic (M) disease. Although external iliac nodes are rarely involved in rectal cancer, when seen this implies M disease.

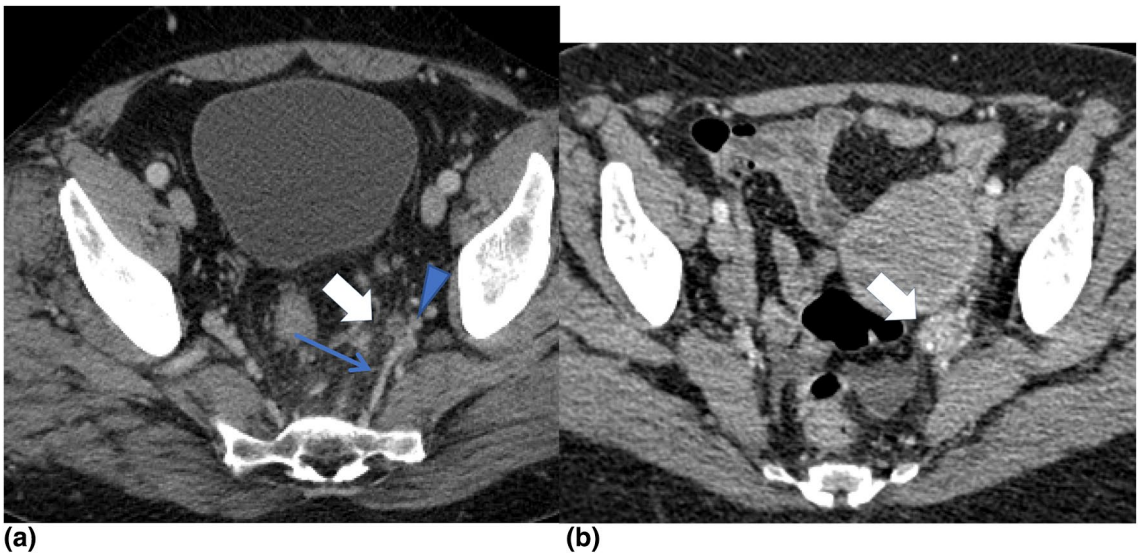

Fig. 4 **a** Internal iliac node (white arrow) seen adjacent to the internal iliac artery (arrow head). The lateral sacral vein (small arrow) is noted posteriorly arising from the internal iliac vein. **b** Large calcified internal iliac node (white arrow) is obscuring adjacent vessels

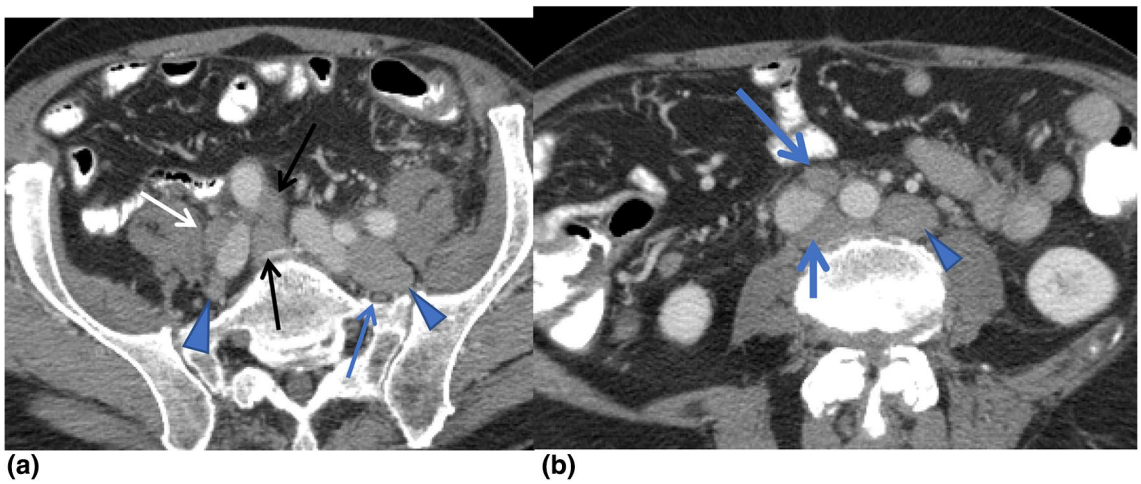

Fig. 5 **a** Common iliac subgroups are medial chain (black arrow) between the common iliac arteries, middle chain (arrow heads) anterior to sacral alae and L5 nerve root (blue arrow) and lateral chain (white arrow). **b** Left para-aortic(arrowhead), aortocaval and retrocaval nodes (blue arrows)

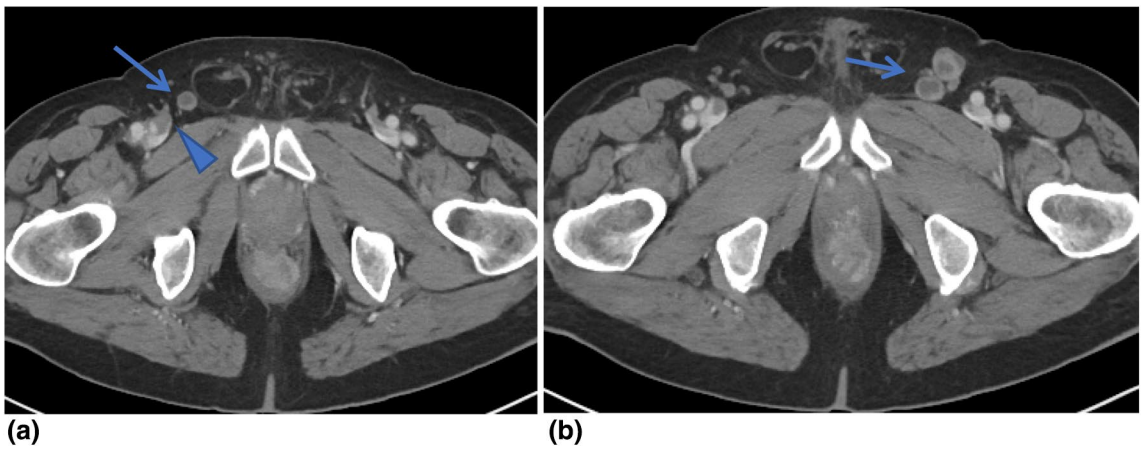

Fig. 6 Superficial inguinal nodes are located below the inguinal ligament. These are regional nodes for tumors arising below the dentate line but metastatic or non-regional node for tumors located above the dentate line. **a** Necrotic node (arrow) on the right at the saphenofemoral junction (arrowhead) is a principal node for anal carcinoma. **b** Similar necrotic superficial inguinal nodes are seen on the right (arrow)

It is important to note that anal carcinoma is staged separately under the AJCC guidelines and superficial inguinal nodes are regional nodes and are described under N stage [13].

Potential pitfalls in the localization of nodes on cross sectional imaging

Distinguishing nodes in the mesenteric compartment that are confined within the mesorectum and mesentery for the sigmoid colon from those along the pelvic sidewall and retroperitoneum is frequently a challenge on cross sectional imaging.

However this is of tremendous clinical significance from the staging and surgical perspective as mesenteric nodes are local spread and resected during a routine total mesorectal excision when there is the appropriate high ligation of the inferior mesenteric artery. Nodes in the retroperitoneum, along the common iliac, and external and internal iliac vessels on the other hand lie outside the surgical plane of a total mesorectal excision and would be left behind unless correctly localized preoperatively. In addition, common iliac and para-aortic nodes are viewed as non-regional nodes or M disease from the perspective of staging and correct localization is essential from this perspective as well.

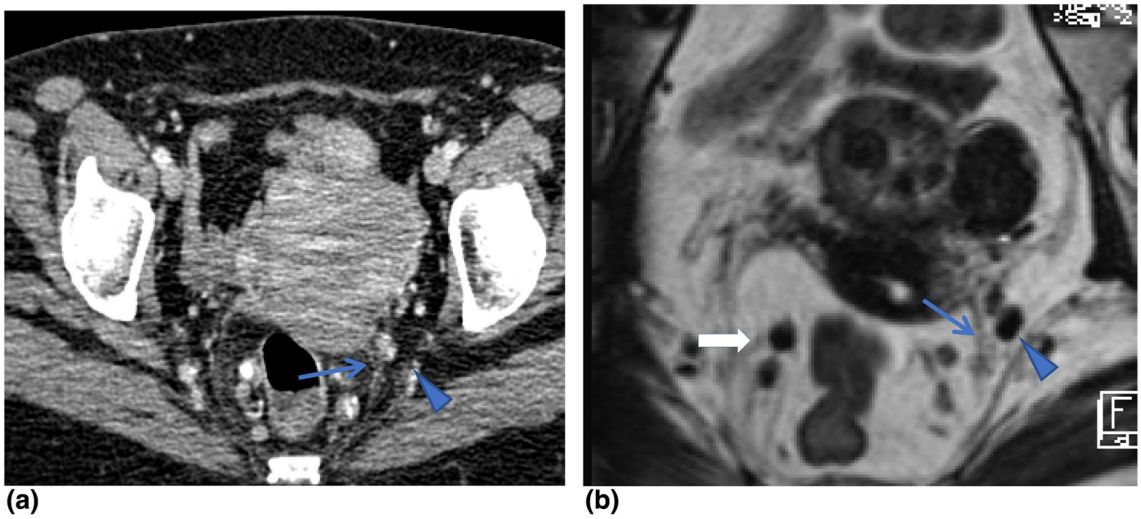

Fig. 7 **a** Calcified node (arrowhead) identified just outside the mesorectal fascia (blue arrow) on the left should not be confused with mesorectal adenopathy. **b** Oblique axial T2w mutliplanar reconstruction in the same patient better defines the mesorectal fascia (blue arrow) and sidewall node just outside the fascia (arrowhead). In addition note is made of calcified metastatic mesorectal nodes on the right (white arrow)

In our experience, the challenge of correct localization most commonly arises in separating mesorectal from lateral sacral nodes, superior rectal from common iliac, inferior mesenteric from retroperitoneal nodes, and, occasionally, mesorectal from obturator and internal iliac nodes (Fig. 7).

This challenge is most easily addressed by identifying the vessel accompanying the node. Nodes in the mesocolon and mesorectum accompany the inferior mesenteric and superior rectal vessels. Consequently, although the superior rectal nodes are close to common iliac nodes on cross sectional imaging, the superior rectal nodes are adjacent to or abut the superior rectal vein and artery reflecting their correct compartment (Fig. 8). In terms of anatomy, the inferior mesenteric vein starts as the superior rectal vein at the level of the anal canal and continues adjacent to the superior rectal artery medial to the left ureter and common iliac vessels. The superior rectal vessels become the inferior mesenteric vessels above the confluence with the left colic artery and vein. Superiorly the inferior mesenteric vein diverges from the course of the inferior mesenteric artery and ascending on the left psoas muscle in close proximity to the gonadal vessels. The termination of the inferior mesenteric vein may be into the superior mesenteric vein, the splenic vein, or the confluence of the superior mesenteric and splenic veins [14].

Factors impacting the likelihood of pelvic sidewall nodal involvement in rectal cancer

We have discussed anatomic factors such as the height of the tumor from the anal verge that impact the likelihood of pelvic sidewall nodal involvement. In addition since lateral lymphatic spread from the rectum is primarily to internal iliac and obturator nodes, these are the nodal groups most commonly involved in rectal cancer. Reflecting the importance of these anatomic features in the predicting nodal involvement, a recently published multi-institutional study attempting to establish size parameters for pelvic sidewall nodal involvement in rectal cancer was restricted to rectal tumors located below the peritoneal reflection and to assessment of only internal iliac and obturator nodes [15].

There are some additional factors that predict the likelihood of sidewall nodal involvement these include tumor size, (> 3 cm), annular tumors, tumor differentiation, i.e., poorly differentiated, and presence of metastatic mesorectal nodes [7, 16]. It is likely that the determination of nodal involvement in rectal cancer will move away from the use of nodal size alone, which has proven an inept criterion to incorporating some of these additional factors. A recent paper attempted this approach by proposing a predictive nomogram for determining nodal involvement in rectal cancer, and found that this more accurately predicted nodal metastasis and reduced inter-observer variability [17].

Summary

Nodal involvement in rectal cancer follows lymphatic drainage pathways and thus is determined by the location of the tumor within the rectum. The most common pathway of spread is along the mesenteric vessels. Lateral spread to pelvic sidewall nodes is most commonly to internal iliac and obturator nodes. It is seen in rectal tumors located below

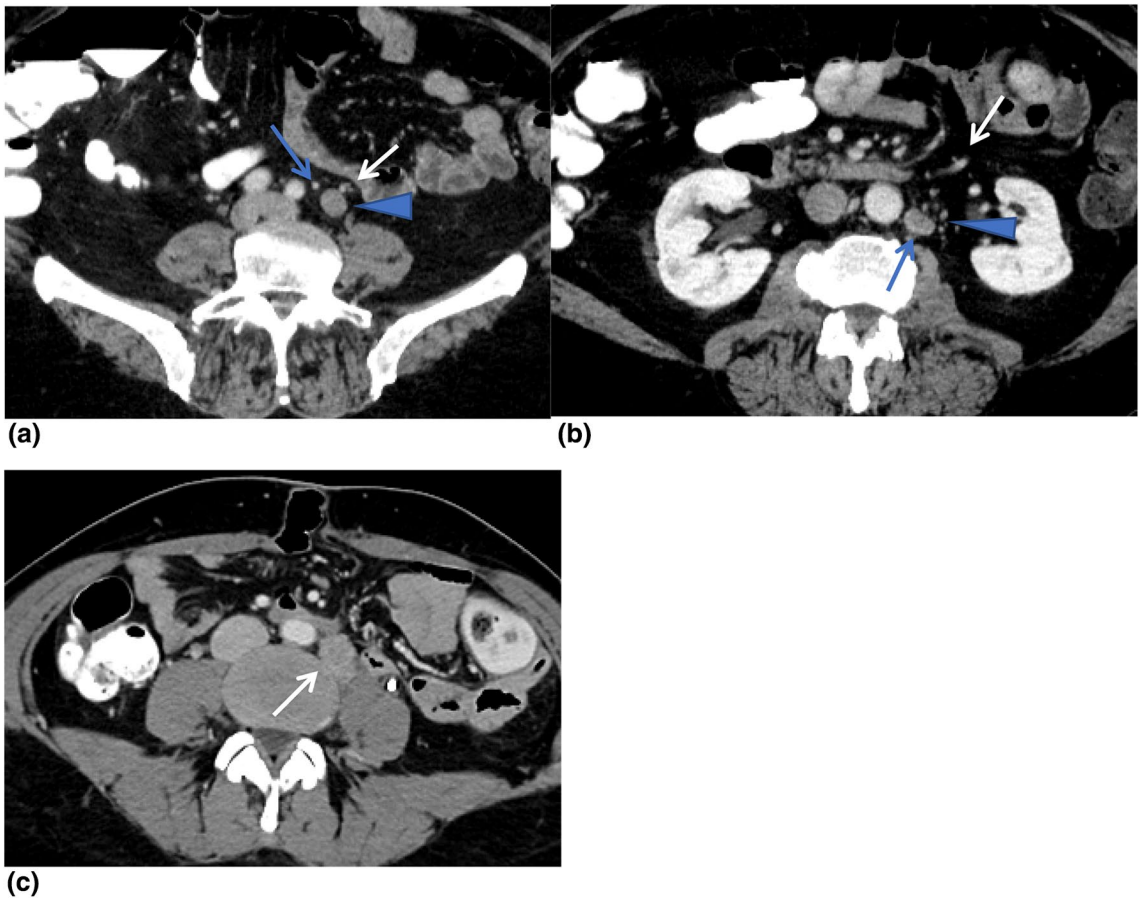

Fig. 8 **a** Inferior mesenteric node (arrowhead) located in the mesocolon along the inferior mesenteric vein (white arrow) and artery (blue arrow) can be confused for a retroperitoneal node i.e., left para-aortic node. **b** A node (blue arrow) seen posterior to the gonadal vessels (arrowheads) can be accurately localized to the retroperitoneum as the gonadal vessels are located in the retroperitoneum. These nodes although close in location on imaging are in separate anatomic compartments. Inferior mesenteric vein (white arrow) is seen in the paraduodenal fold anteriorly. **c** Nodal recurrence (white arrow) after mesenteric resection for a sigmoid carcinoma abuts the vertebral body and is in the same plane as the aorta localizing it to the retroperitoneum

the peritoneal reflection and is uncommon in tumors located above the peritoneal reflection.

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References

1. Heald RJ, Moran BJ. Embryology and anatomy of the rectum. Semin Surg Oncol. 1998 Sep;15(2):66-71. PubMed PMID: 9730411. Epub 1998/09/08.
2. General rules for clinical and pathological studies on cancer of the colon, rectum and anus. Part I. Clinical classification. Japanese Research Society for Cancer of the Colon and Rectum. Jpn J Surg. 1983 Nov;13(6):557-573. PubMed PMID: 6672390. Epub 1983/11/01.
3. Monson JR, Weiser MR, Buie WD, Chang GJ, Rafferty JF, Buie WD, et al. Practice parameters for the management of rectal cancer (revised). Dis Colon Rectum. 2013 May;56(5):535-550. PubMed PMID: 23575392. Epub 2013/04/12.
4. Sauer I, Bacon HE. Influence of lateral spread of cancer of the rectum on radicability of operation and prognosis. Am J Surg. 1951 Jan;81(1):111-120. PubMed PMID: 14799702. Epub 1951/01/01.
5. Gollub MJ, Maas M, Weiser M, Beets GL, Goodman K, Berkers L, et al. Recognition of the anterior peritoneal reflection at rectal MRI. AJR Am J Roentgenol. 2013 Jan;200(1):97-101. PubMed PMID: 23255747. Epub 2012/12/21.
6. Steup WH, Moriya Y, van de Velde CJ. Patterns of lymphatic spread in rectal cancer. A topographical analysis on lymph node metastases. Eur J Cancer. 2002 May;38(7):911-918. PubMed PMID: 11978516. Epub 2002/04/30.
7. Hojo K, Koyama Y, Moriya Y. Lymphatic spread and its prognostic value in patients with rectal cancer. Am J Surg. 1982 Sep;144(3):350-354. PubMed PMID: 7114377. Epub 1982/09/01.
8. Charnsangavej C, Dubrow RA, Varma DG, Herron DH, Robinson TJ, Whitley NO. CT of the mesocolon. Part 2. Pathologic considerations. Radiographics. 1993 Nov;13(6):1309-1322. PubMed PMID: 8290726. Epub 1993/11/01.
9. Morikawa E, Yasutomi M, Shindou K, Matsuda T, Mori N, Hida J, et al. Distribution of metastatic lymph nodes in colorectal

cancer by the modified clearing method. Dis Colon Rectum. 1994 Mar;37(3):219-223. PubMed PMID: 8137667. Epub 1994/03/01.
10. Park JM, Charnsangavej C, Yoshimitsu K, Herron DH, Robinson TJ, Wallace S. Pathways of nodal metastasis from pelvic tumors: CT demonstration. Radiographics. 1994 Nov;14(6):1309-1321. PubMed PMID: 7855343. Epub 1994/11/01.
11. Y M. Importance of Lymphatic Spread. In: Soreide O, Norstein J In: Rectal Cancer Surgery: Optimisation S, Documentation, editor. Optimisation, Standardisation, Documentation;https://doi.org/10.1007/978-3-642-60514-7. New York, NY: Springer-Verlag Berlin Heidelberg; 1997. p. 153-164.
12. McMahon CJ, Rofsky NM, Pedrosa I. Lymphatic metastases from pelvic tumors: anatomic classification, characterization, and staging. Radiology. 2010 Jan;254(1):31-46. PubMed PMID: 20032141. Epub 2009/12/25.
13. AJCC Cancer Staging Manual. 8th ed. Switzerland: Springe; 2017.
14. Akpinar E, Turkbey B, Karcaaltincaba M, Karaosmanoglu D, Akata D. MDCT of inferior mesenteric vein: normal anatomy and pathology. Clin Radiol. 2008 Jul;63(7):819-823. PubMed PMID: 18555041. Epub 2008/06/17.
15. Ogura A, Konishi T, Cunningham C, Garcia-Aguilar J, Iversen H, Toda S, et al. Neoadjuvant (Chemo)radiotherapy With Total Mesorectal Excision Only Is Not Sufficient to Prevent Lateral Local Recurrence in Enlarged Nodes: Results of the Multicenter Lateral Node Study of Patients With Low cT3/4 Rectal Cancer. J Clin Oncol. 2019 Jan 1;37(1):33-43. PubMed PMID: 30403572. Pubmed Central PMCID: PMC6366816. Epub 2018/11/08.
16. Ueno M, Oya M, Azekura K, Yamaguchi T, Muto T. Incidence and prognostic significance of lateral lymph node metastasis in patients with advanced low rectal cancer. Br J Surg. 2005 Jun;92(6):756-763. PubMed PMID: 15838895. Epub 2005/04/20.
17. Liu Y, Wang R, Ding Y, Tu S, Liu Y, Qian Y, et al. A predictive nomogram improved diagnostic accuracy and interobserver agreement of perirectal lymph nodes metastases in rectal cancer. Oncotarget. 2016 Mar 22;7(12):14755-14764. PubMed PMID: 26910373. Pubmed Central PMCID: PMC4924749. Epub 2016/02/26.