Anatomy of Lymphatics

2

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Abstract

To facilitate a clearer understanding of the topographical arrangement of lymphatics, pictorial demonstrations based on actual cadaveric dissections of four segments of the digestive tract (esophagus, stomach, colon, and rectum) are provided.

1. The lymphatics of the esophagus: Due to the pressure of the aortic arch from the left, asymmetrical development of the ascending lymphatics along the trachea and esophagus is observed. The typical right ascending lymphatic chain reaches the lower neck and follows upstream along the inferior thyroid artery to reach the right venous angle. Several branches are given off from this chain at various levels to finally reach the venous angle. As the left ascending chain is generally poorly developed, most of the lymphatics of the left tracheobronchial nodes move rightward to join the right chain. The left chain is located close to and anterior to the left recurrent laryngeal nerve. The lymphatic chain of the lower thoracic esophagus connects with the lymph vessels of the left gastric nodes via the superior diaphragmatic nodes close to the esophagus.
2. The lymphatics of the stomach: In general, lymphatics accompany the typical arteries and finally connect to the coeliac nodes at the origin of the coeliac trunk. However, in the case of the right gastroepiploic artery, lymph vessels do not accompany the artery, but rather they run along the vein and drain into the superior mesenteric nodes. Furthermore, atypical lymphatics are observed: (a) those which descend along the posterior gastric artery to join the splenic lymphatics, and (b) those which run along the cardioesophageal branch of the left inferior phrenic artery, and then descend along this artery, to finally drain into the lateral aortic nodes.

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3. The lymphatics of the colon: The lymphatics of the right hemicolon accompany the colic branches of the superior mesenteric artery and then gather around this artery. Before reaching the superior mesenteric artery, lymph vessels cross the superior mesenteric vein. The lymphatics of the left hemicolon also run along the inferior mesenteric artery and gather at the lateroaortic nodes. Some lymph vessels cross in front of the abdominal aorta and reach the interaorticocaval nodes.
4. The lymphatics of the rectum: In addition to the classically recognized superior group, the lateral (middle) group of the lymphatics are demonstrated. In order to reach the subaortic nodes, lymphatics from the rectum first reach the nodes of the interiliac area with or without accompanying the middle rectal artery. The iliac lymph vessels surround and run alongside the iliac blood vessels. Before reaching the interiliac area, the lymphatics cross over or under the cord of the umbilical artery. Some lymph vessels from the posterior wall of the rectum run backwards and pierce the fascial membrane between the right and left hypogastric nerves before reaching the subaortic nodes. The subaortic nodes are of great importance as they perform the role of a terminal station of the pelvic lymphatics as well as the starting station of the para-aortic lymphatics.
5. The para-aortic nodes (lumbar nodes): Para-aortic nodes surround not only the abdominal aorta, but also the inferior vena cava. The para-aortic lymphatics originate from the subaortic nodes and from the lateral aortic and lateral caval nodes at the level of the lower ends of the aorta and inferior vena cava. These lymphatics are also well developed behind the two great blood vessels. Up to the level of the renal blood vessels, the lymphatics surrounding the inferior vena cava gather around the interaorticocaval nodes. The lymph vessels from the uppermost interaorticocaval and lateral aortic nodes converge behind the aorta to form the thoracic duct.

Keywords
Esophageal lymphatics · Gastric lymphatics · Lymphatics of the large intestine
Para-aortic lymph nodes · Topographical anatomy

Abbreviations

aa Arch of aorta
ac Ascending colon
acc Accessory nerve
ai Angular incisure
alg Accessory left gastric artery
an Anterior group node of deep lateral cervical nodes
ap Appendix vermiformis
apa Appendicular artery
av Anterior vagus trunk
az Azygos vein

aza Arch of azygos vein
bc Brachiocephalic trunk
bca Brachiocephalic angle node
bd Common bile duct
bt Bifurcation of trachea
cae Caecum
cc Common carotid artery
cd Cardia
ceb Cardioesophageal branch
ch Common hepatic artery
ci Common iliac artery
civ Common iliac vein
co Coeliac node
cp Caudate process
ct Coeliac trunk
di Diaphragm
du Duodenum
eb Esophageal branch
ec External carotid artery
ei External iliac artery
eiv External iliac vein
epc Epicolic node
es Esophagus
gb Gallbladder
gct Gastrocolic trunk
gd Gastrodudenal artery
hb Hepatic branch (anterior vagus)
hp Hepatic artery proper
ica Ileocolic artery
iil Interiliac node
ii Internal iliac artery
ij Internal jejunal vein
ile Ileum
im Intermediate node
ima Inferior mesenteric artery
imv Inferior mesenteric vein
ipv Left inferior phrenic vein
ita Internal thoracic artery
itb Inferior tracheobronchial node
ith Inferior thyroid artery
ivc Inferior vena cava
jd Jugulodigastric node
jo Jugulo-omohyoid node
la Lateral aortic node
lb Left bronchus
lbc Left brachiocephalic vein

lc Lateral caval node
lca Left colic artery
lg Left gastric artery
lga Ligamentum arteriosum
lgo Left gastro-omental artery
lgv Left gastric vein
li Liver
lia Ligamentum arteriosum
lip Left inferior phrenic artery
lk Left kidney
ll Left lung
ln Lateral group node of deep lateral cervical nodes
lrv Left renal vein
lt Lumbar trunk
lv Left vagus nerve
lva Levator ani
mca Middle colic artery
mra Middle rectal artery
of Omental foramen node
ov Ovarian vein
pa Pre-aortic
pb Pubic bone
pc Paracolic node
pd Pancreaticoduodenal node
pe Peritoneum
pg Posterior gastric artery
ph Phrenic nerve
pl Pleura
poc Postcaval node
pr Principal node
prm Promontorium
ps Pelvic splanchnic nerve
pso Psoas major
pu Pubis
pua Pulmonary artery
pv Portal vein
py Pylorus
rb Right bronchus
rbc Right brachiocephalic vein
rc Recurrent laryngeal nerve
rca Right colic artery
rg Right gastric artery
rgo Right gastro-omental artery
rgov Right gastro-omental vein
rk Right kidney
rl Right lung

rrv Right renal vein
S1 First sacral vertebra
Sa Subaortic node
sc Subclavian artery
scv Subclavian vein
sg Short gastric artery
sh Superior hypogastric plexus
si Sigmoid colon
sia Sigmoid artery
sl Superior laryngeal nerve
sm Submandibular gland
sp Spleen
spa Splenic artery
spv Splenic vein
sr Suprarenal gland
sra Superior rectal artery
srpd Superior retropancreaticoduodenal node (Rouvière)
srv Suprarenal vein
st Stomach
sth Superior thyroid artery
sva Superior vesical artery
svc Superior vena cava
syt Sympathetic trunk
ta Testicular artery
tc Thyroid cartilage
td Thoracic duct
th Thyroid gland
tr Trachea
tv Testicular vein
ua Uterine artery
ub Urinary bladder
ur Ureter
ut Uterus
utt Uterine tube
va Venous angle
vc Vertebral column
vg Vagus nerve
vgn Vagina

2.1 Introduction

In routine dissections students have little chance to observe the lymphatics which are very complicated and difficult to dissect. Yet the lymphatics are crucial structures, not to be overlooked, because for cancer surgery, precise knowledge of the lymphatics of an affected organ is of utmost importance. The gastrointestinal tract

is long and extends over many regions. Each organ has a very specific relationship with the lymphatics. In addition to common problems, there are many specific difficulties based on topographic anatomical relationships. In cancer surgery, in particular, the precise and detailed anatomy of the lymphatics of the affected organ(s) and their topographic relationships is of utmost importance. In this chapter, the basic anatomy of the lymphatics of the esophagus, stomach, colon, and rectum is described. To facilitate understanding, a pictorial demonstration of actual dissections of the lymphatics surrounding each organ is included. For orientation, schemes based upon actual dissection findings are shown. In anatomy and particularly in lymphatics, terminology can be a hurdle; therefore, an attempt was made to provide a range of terms including basic terminology from Rouvière [1], the terminology used in cancer guidelines in Japan [2–4], and Terminologia Anatomica (1998 [5]) from the Federative Committee on Anatomical Terminology (FCAT) of the International Federation of Anatomists (IFAA).

2.1.1 Lymphatics of the Esophagus

The esophagus is situated within three regions: cervical, thoracic, and abdominal regions. Here, the cervical and thoracic lymphatics will be discussed.

2.1.1.1 Lateral Cervical Nodes (Internal Jugular Chain)

Lymphatics of the cervical part of the esophagus drain into the deep lateral cervical nodes. The prominent lateral cervical nodes are located along the internal jugular vein and have been termed the internal jugular chain (Rouvière [1], Feind in Haagensen [6]) (Fig. 2.1) [7]. According to the positional relationship to this vein, this chain is subdivided into anterior and lateral groups which are connected by numerous transverse lymph vessels; these vessels run both over and behind the jugular vein. The well-developed lateral group descends and drains into the venous angle, while the anterior group gradually becomes less developed, descends behind the omohyoid muscle, then traverses over and under the jugular vein and joins the lateral group to finally drain into the venous angle. In addition to these deep cervical lymphatics, a superficial lymph vessel runs on the thyroid gland and crosses over the lower part of the internal jugular vein to join the jugulo-omohyoid node.

The deep anterior cervical nodes are sometimes called the juxtavisceral nodes based on their location and nodal associations (Rouvière [1], Feind in Haagensen [6]). In this specimen a paratracheal node close to the lower end of the right lobe of the thyroid gland sends a vessel to the large nodes located in front of the junction of brachiocephalic veins (Fig. 2.2) [7]. From these brachiocephalic angle nodes two vessels ascend in front of the right brachiocephalic vein and drain into the right venous angle. Between the left tracheal wall and the left brachiocephalic vein well-developed lymph chains are detected. Some deep nodes of these paratracheal chains receive lymph from the esophagus.

A typical accompanying lymph vessel along the inferior thyroid artery is shown in Fig. 2.3. From a lymph node mass close to the lower end of the right thyroid lobe and near the right groove between the trachea and esophagus, a lymph vessel

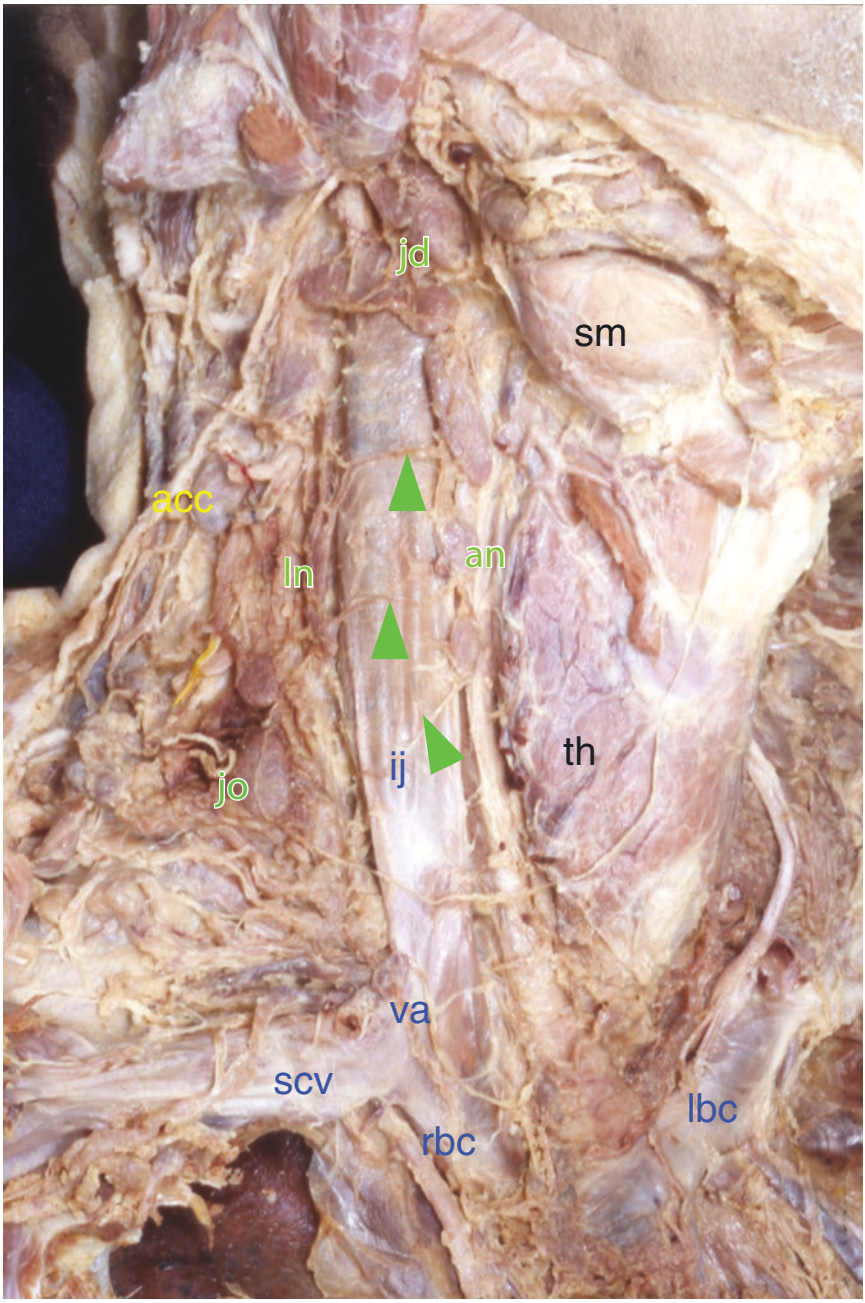

Fig. 2.1 Lateral deep cervical lymphatic chains. Anteromedial and posterolateral to the right internal jugular vein, the lymphatic chains, which are connected by numerous transverse slender lymph vessels (green arrowheads), finally drain into the venous angle (Specimen 1, male)

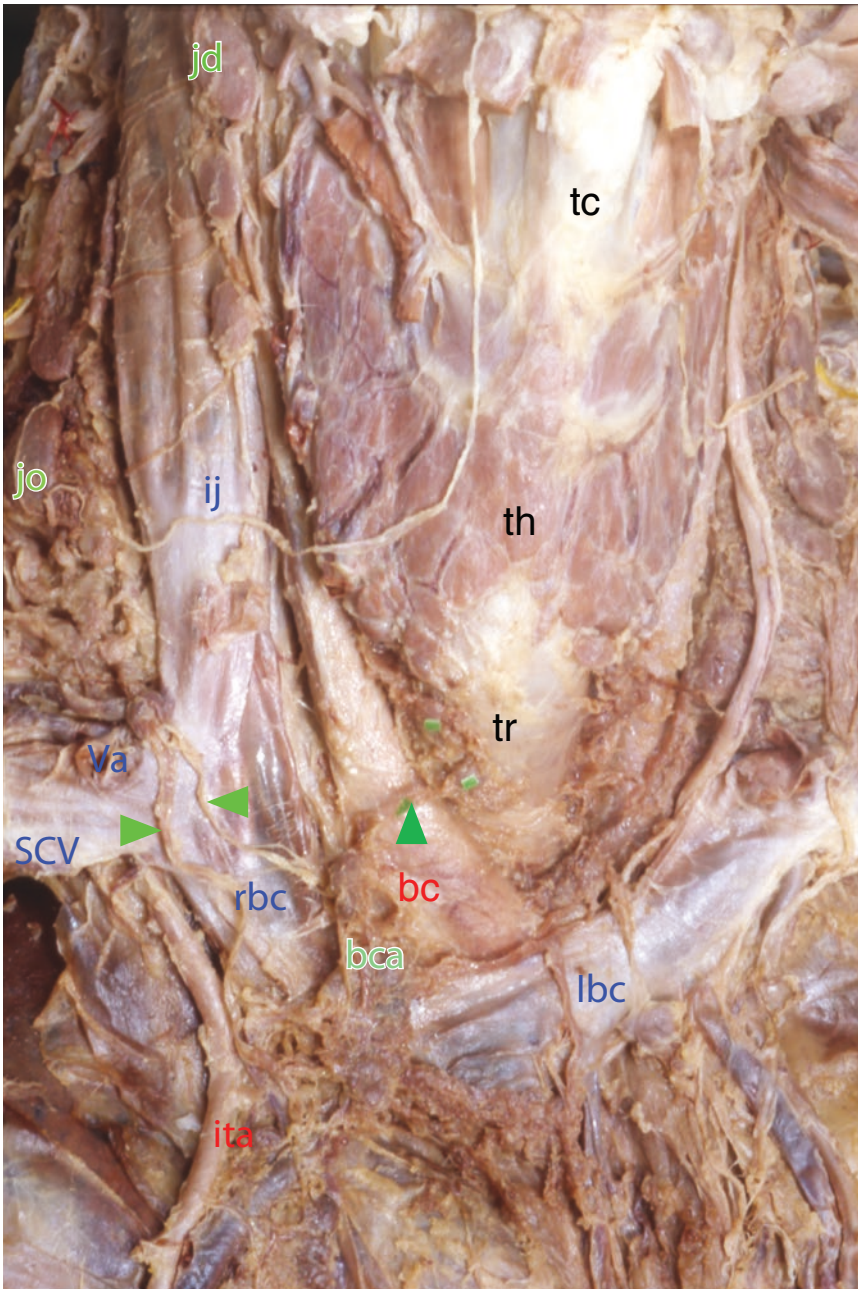

Fig. 2.2 Brachiocephalic angle nodes. From the right paratracheal nodes, close to the lower end of the right thyroid lobe, a lymph vessel (dark green arrowhead) drains into the nodes at the confluence of the brachiocephalic veins (brachiocephalic angle nodes). From these nodes, two thick lymph vessels (light green arrowheads) obliquely ascend to drain into the venous angle (Specimen 1, male)

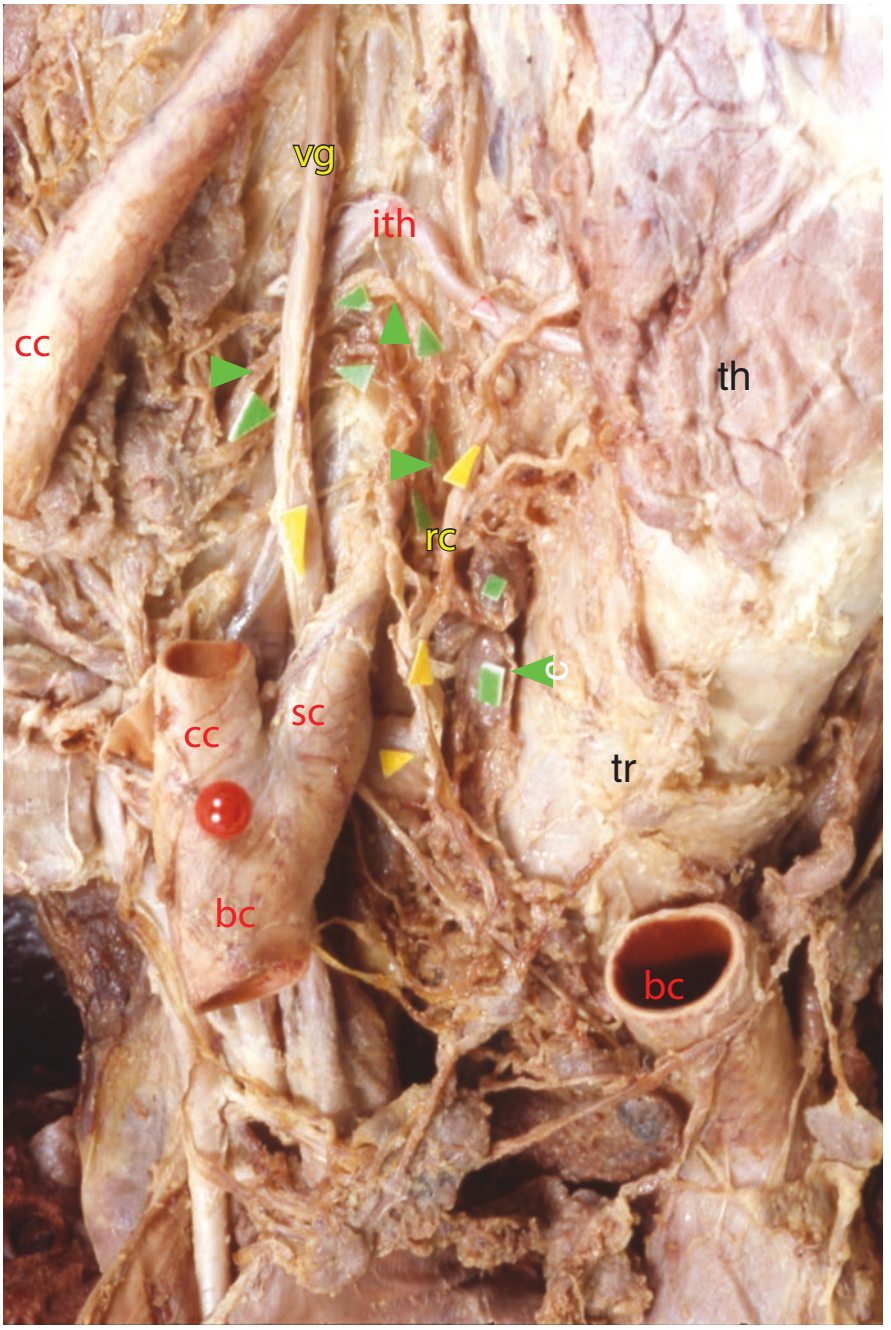

Fig. 2.3 A lymph vessel along the inferior thyroid artery. The brachiocephalic and right common carotid arteries have been cut. A lymph vessel (green arrowheads) originates from the right paratracheal chain and runs parallel to and caudal to the inferior thyroid artery to reach the venous angle area (Specimen 1, male)

originates, runs parallel and caudal to the inferior thyroid artery, and then continues to the node mass near the origin of this artery. During its course, it first crosses the recurrent laryngeal nerve and then the vagus nerve (yellow arrowheads) before reaching the venous angle area.

A lymph vessel from the left paratracheal node group, which drains into the left venous angle, is shown in Fig. 2.4. From the upper end of the left cervical paratracheal node mass, which is situated in front of the left margin of the esophagus, a lymph vessel originates; it follows an arched course in front of the recurrent laryngeal nerve to reach the venous angle.

A special dissection of the lymphatics and autonomic nerves from behind is demonstrated (Fig. 2.5, Saito et al.) [8]. After the en masse removal of the tongue, pharynx, esophagus, and sympathetic trunks, dissection was performed from behind. Note the well-developed internal jugular lymphatic chains and also the slender lymph vessels along the carotid arteries. In the upper part of the pharynx and in the transitional area of the pharynx and esophagus, also in the area of the cervical esophagus, dense networks of lymphatics can be seen. Behind the pharynx and along its lateral margin, lymphatics connect to the abovementioned networks.

The lymphatics of the thoracic esophagus are closely related to the tracheobronchial lymphatics. First, the tracheobronchial ascending lymphatics are shown (Fig. 2.6) [9]. In general there are four main ascending pathways: right and left superficial pathways, which run along the great blood vessels, and right and left deep pathways, which run along the trachea and esophagus. Here, the right and left deep pathways will be explained.

A typical right deep pathway is seen in Fig. 2.7. From the right tracheobronchial nodes, a lymphatic chain ascends along the right margin of the trachea, reaches the lower neck and then changes direction to run obliquely along the inferior thyroid artery and finally drains into the venous angle. From the vertical ascending course, shown in Fig. 2.8, several lymphatic vessels originate at various levels and then run obliquely to reach the venous angle [10].

In a rather rare example, interestingly, a lymphatic vessel from the right tracheobronchial node can be very lengthy, yet still take a direct course to the venous angle (Fig. 2.9) [11]. Although the frequency of such a lengthy and non-interrupted lymphatic vessel remains to be clarified, for esophageal and lung cancer this is a particularly critical pathway, due to its direct course.

It is also important to note here that there are lymphatic pathways which run directly from the esophagus. In an important example (Fig. 2.10) [11], after reflection of the vagus, it was noted that lymph vessels ascend to reach the venous angle, not only from the tracheobronchial nodes, but also from the esophagus and primarily from the vertebral column.

In addition to the discussion of the abovementioned lymphatic pathways, significant node groups should be carefully considered based on their critical location. In the space between the arch of the azygos and the subclavian artery (Baréty's space [12]), there are no large structures to compress the right side of the trachea and esophagus, thereby allowing the development of lymph nodes and vessels (Fig. 2.11) [13]. The nodes in front of the right vagus are more closely related to the trachea,

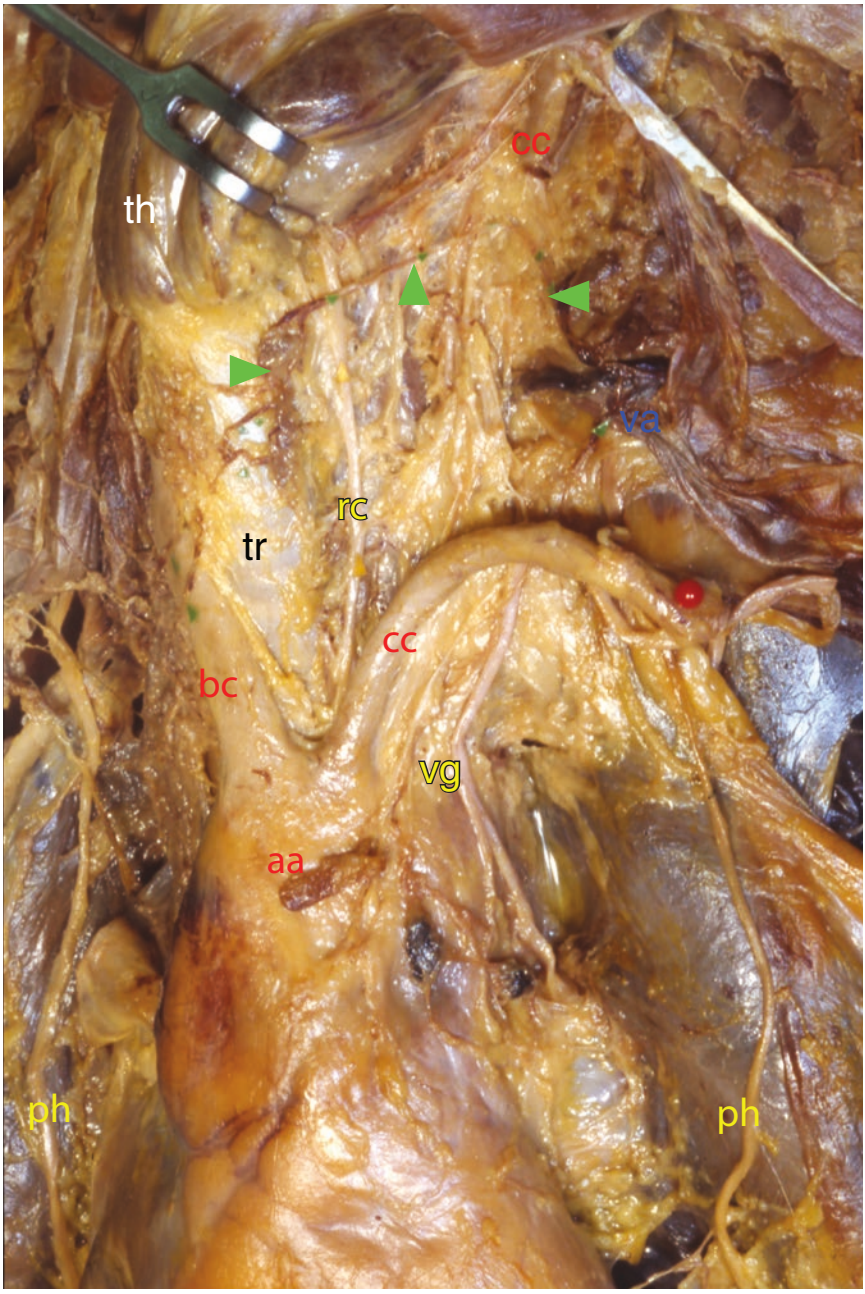

Fig. 2.4 A lymph vessel from the left paratracheal chain to the left venous angle. The left common carotid artery has been cut at the level of the thyroid gland and its proximal segment is pulled inferiorly (red pin). A lymph vessel (green arrowheads), from the nodes slightly below the thyroid, runs laterally to reach the venous angle (Specimen 2, male)

Fig. 2.5 Posterior dissection of the pharynx and upper esophagus as viewed from behind. Although the difference between the lymphatics (reddish) and nerves (whitish) is barely distinguishable in this picture, it is obvious that the lymphatics from the hypopharynx and upper esophagus run laterally to converge at the venous angle area (taken from Fig. 2.8 of Saito et al. [8])

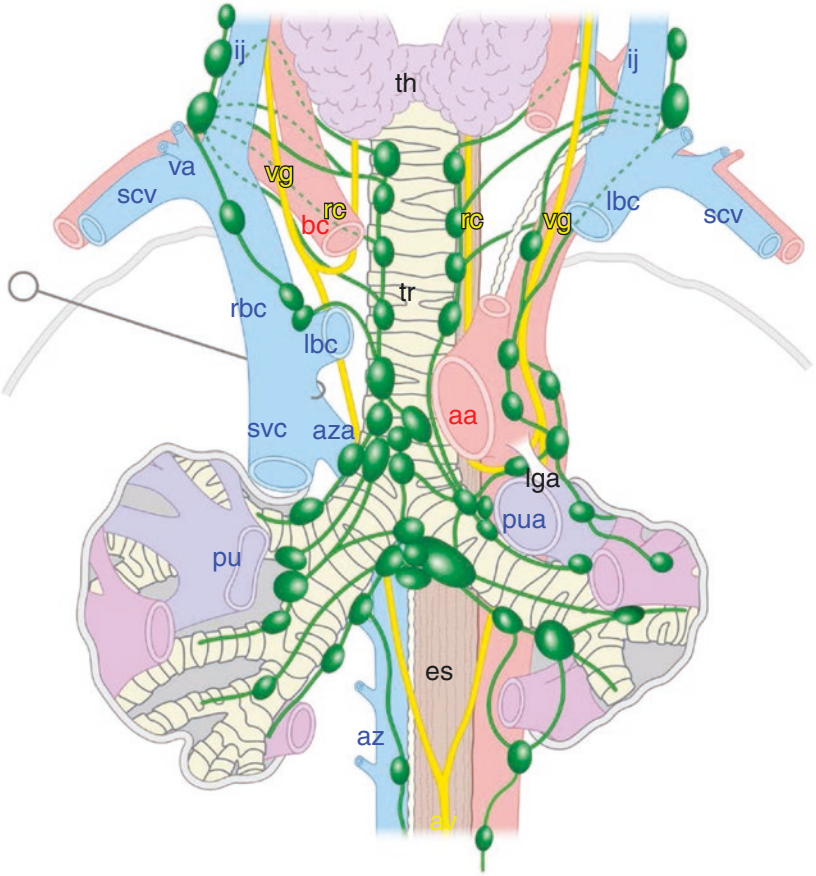

Fig. 2.6 Diagram of the ascending mediastinal lymphatics from the lungs and esophagus. After removal of the heart and pericardium, the left brachiocephalic vein was cut, and the superior vena cava was pulled to the right to reveal the lymphatic arrangement along the bronchi, trachea and esophagus

while those behind the nerve are more closely related to the esophagus. The nodes adjacent to the subclavian artery, sometimes noted as the "highest mediastinal nodes," are thought to hold a significant position.

The left deep pathways are classified into two types of pathways: (1) A well-developed lymphatic pathway which ascends in front of and adjacent to the left recurrent laryngeal nerve (Fig. 2.12a) [11]. Interestingly, behind the left recurrent laryngeal nerve, numerous segmental branches are distributed to the esophagus (Fig. 2.12b) [11]. (2) A lesser developed pathway, which follows the same route as the above pathway, is poorly developed, due to the pressure of the aortic arch against the left margin of the trachea (Fig. 2.13). Some lymph vessels from the left tracheobronchial nodes obliquely cross the trachea and ascend as a right pathway.

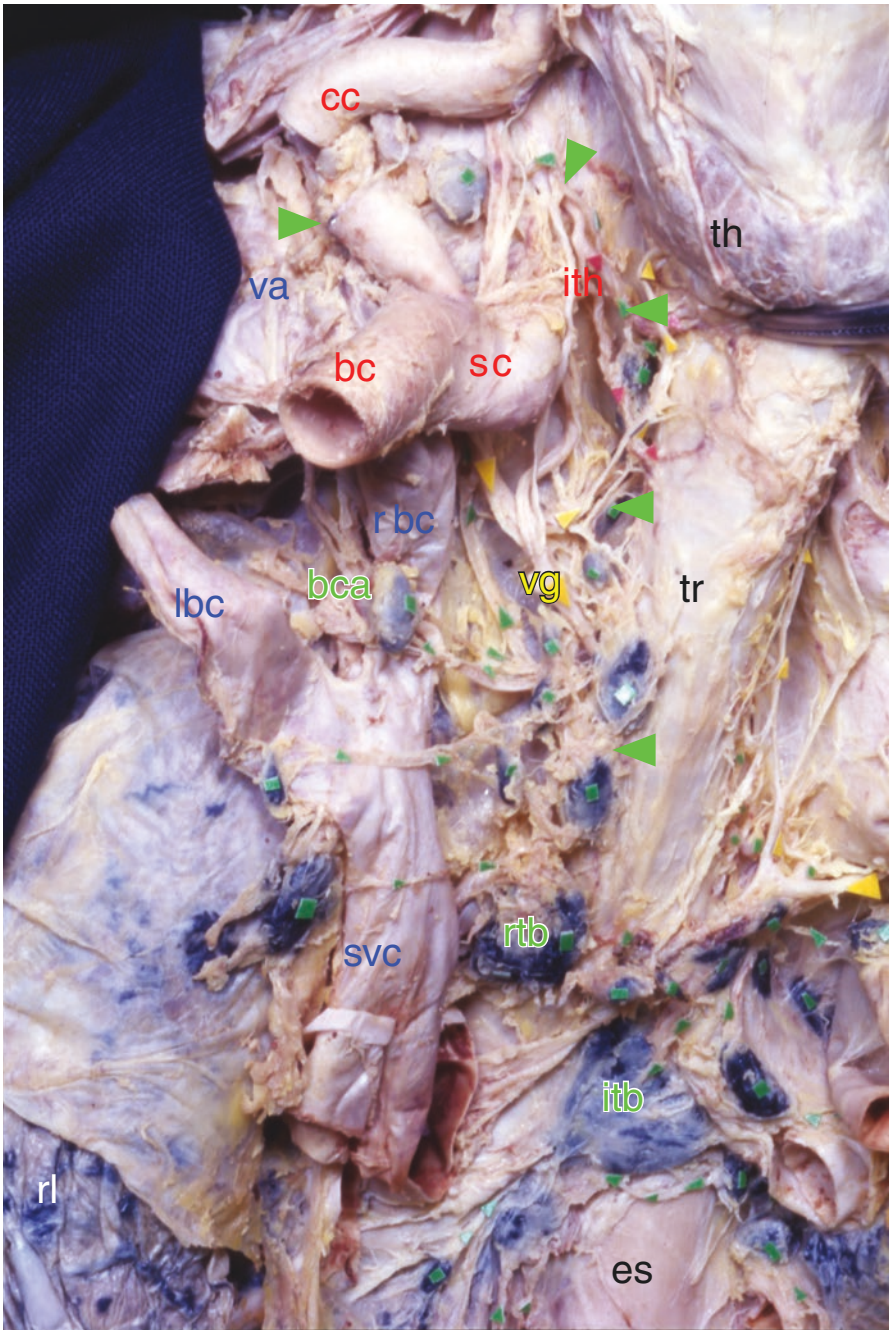

Fig. 2.7 Typical right paratracheal lymphatic chain. The brachiocephalic trunk and veins have been cut and shifted to reveal the course of the lymphatics. The right paratracheal lymphatic chain (green arrowheads), ascends to the lower neck and runs lateralward along the inferior thyroid artery to reach the right venous angle (Specimen 3, male)

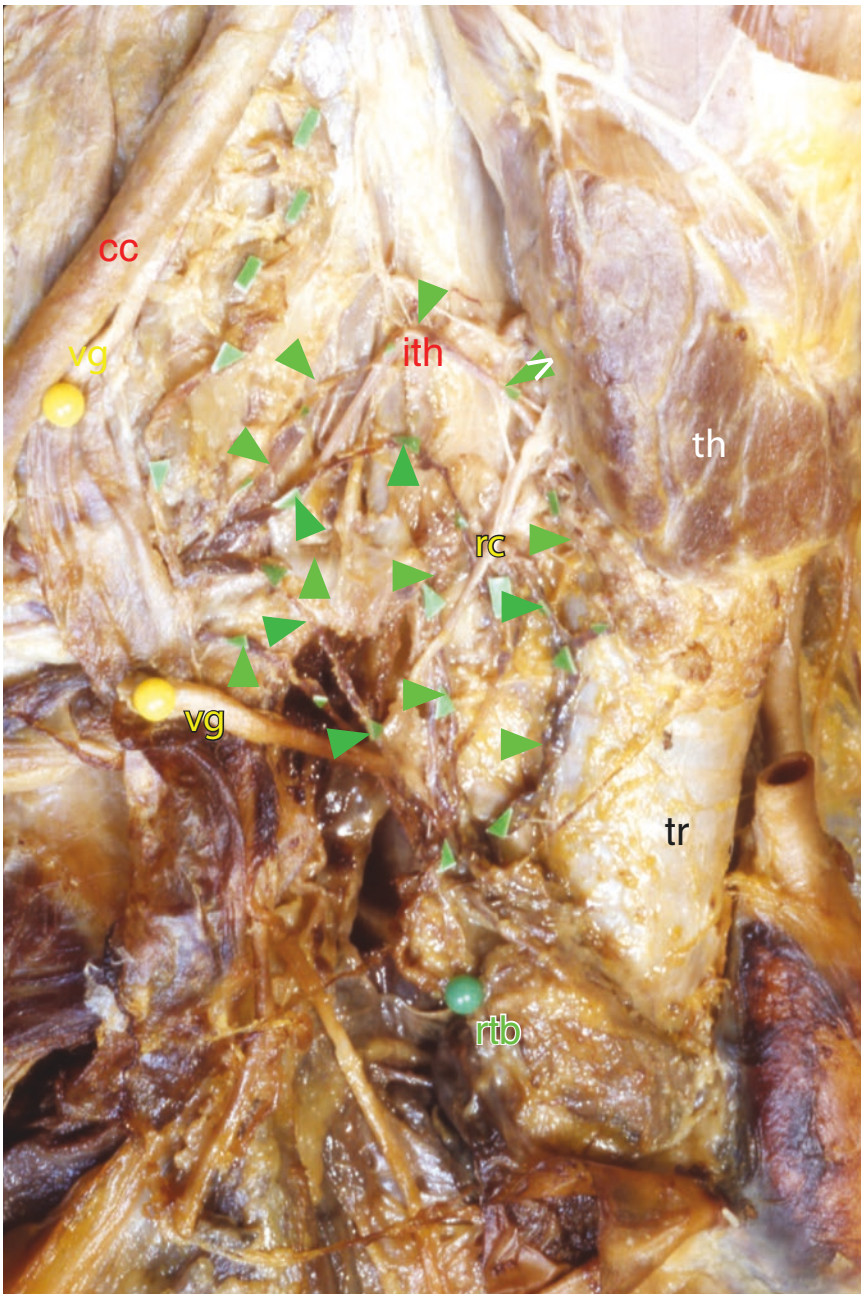

Fig. 2.8 Numerous oblique lymphatic branches to the venous angle. As indicated by the two alternating shades of green arrowheads, these five lymphatic branches originate at various levels from the ascending right paratracheal lymph chain (Specimen 4, male)

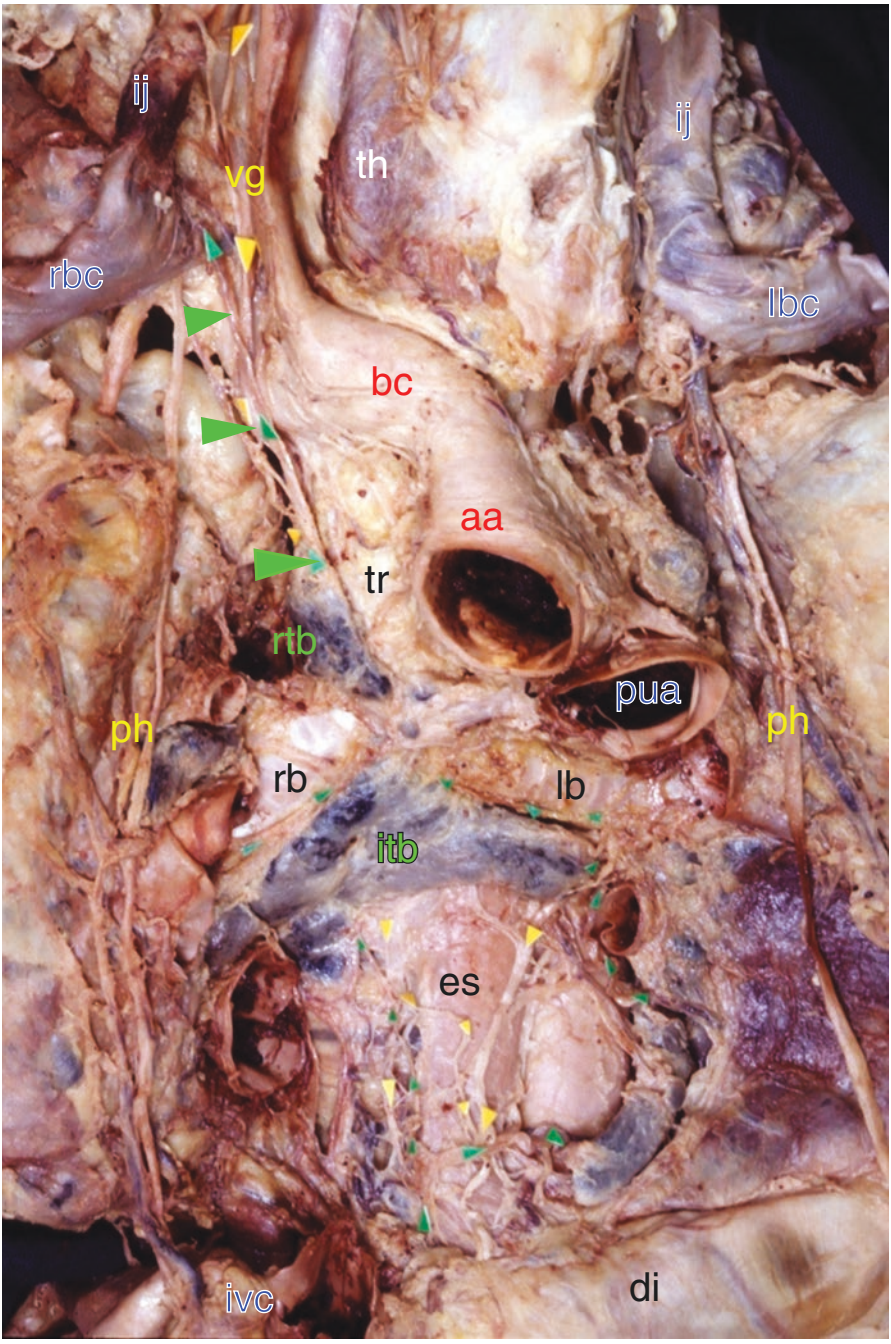

Fig. 2.9 Rare direct lymph vessel to the venous angle. A lengthy lymph vessel (green arrowheads), which originates from the right tracheobronchial node, ascends slightly rightwards to directly drain into the right venous angle (Specimen 5, male)

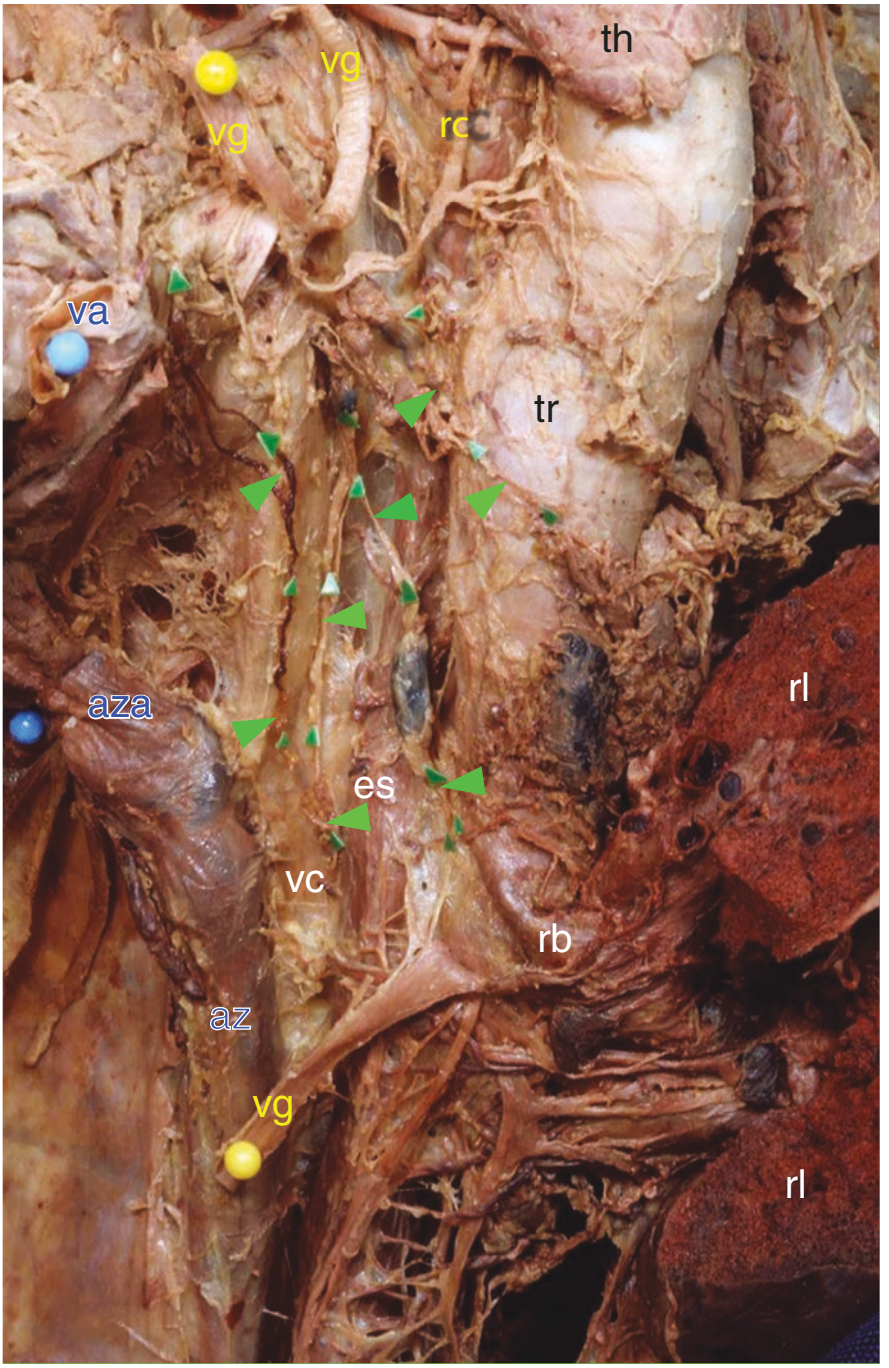

Fig. 2.10 Unique lymph vessels from three structures (trachea, esophagus and vertebral column). After cutting the vagus (yellow pin), the right side of the trachea and esophagus were dissected. As seen from a slightly oblique view, four direct vessels, which converge to the right venous angle, are shown by the green arrowheads (Specimen 1, male)

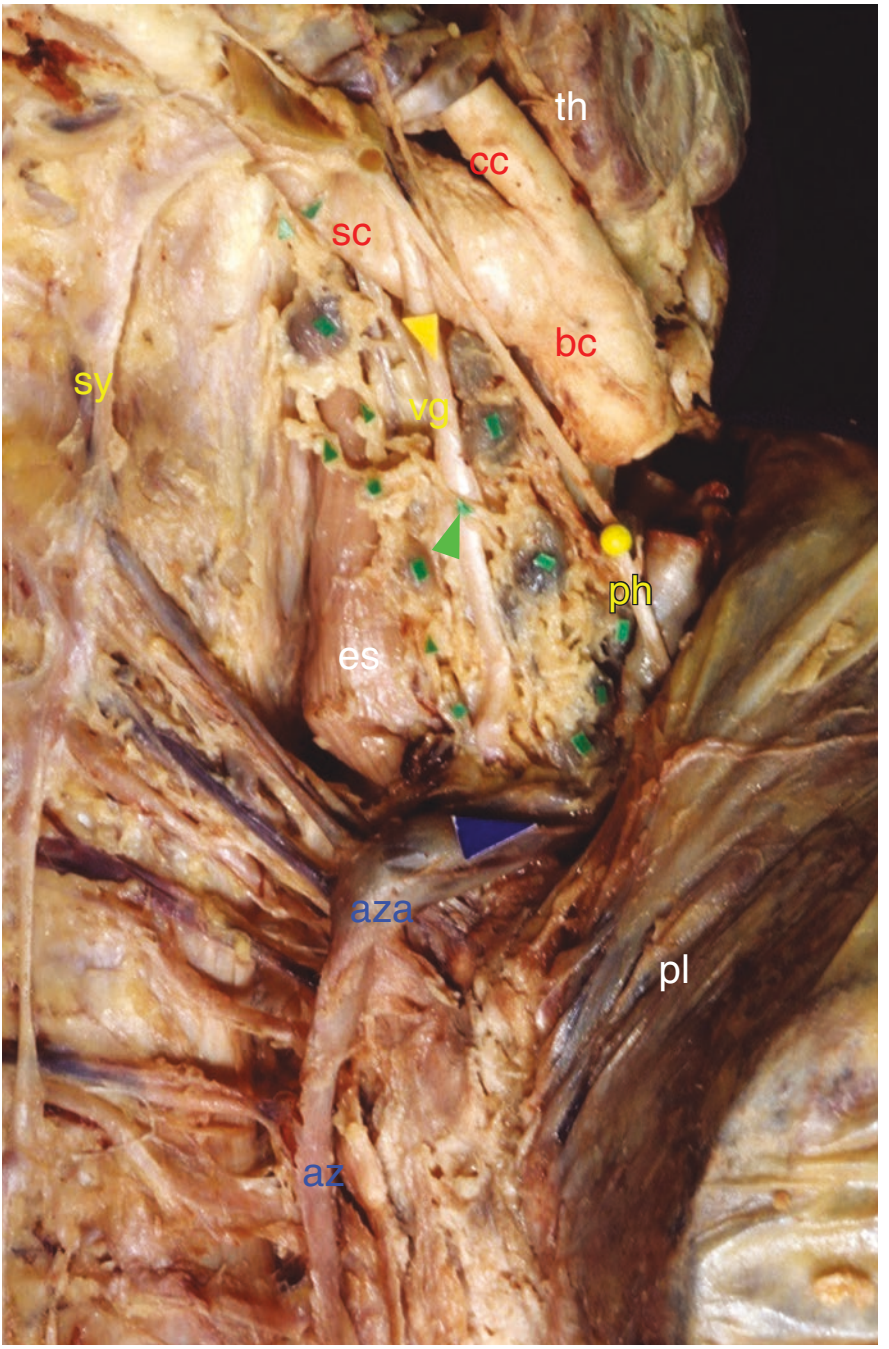

Fig. 2.11 Lymphatics within Baréty's space. The right tracheoesophageal lymphatics are well developed in the space (Baréty's space) between the subclavian artery and the arch of the azygos vein (blue arrowhead). Some communications among these nodes and their relationships to the vagus nerve are seen. Some connections are hidden behind the vagus nerve. Green arrowhead: communicating lymph vessel; yellow pin: phrenic nerve; yellow arrowhead: vagus nerve (Specimen 6, male)

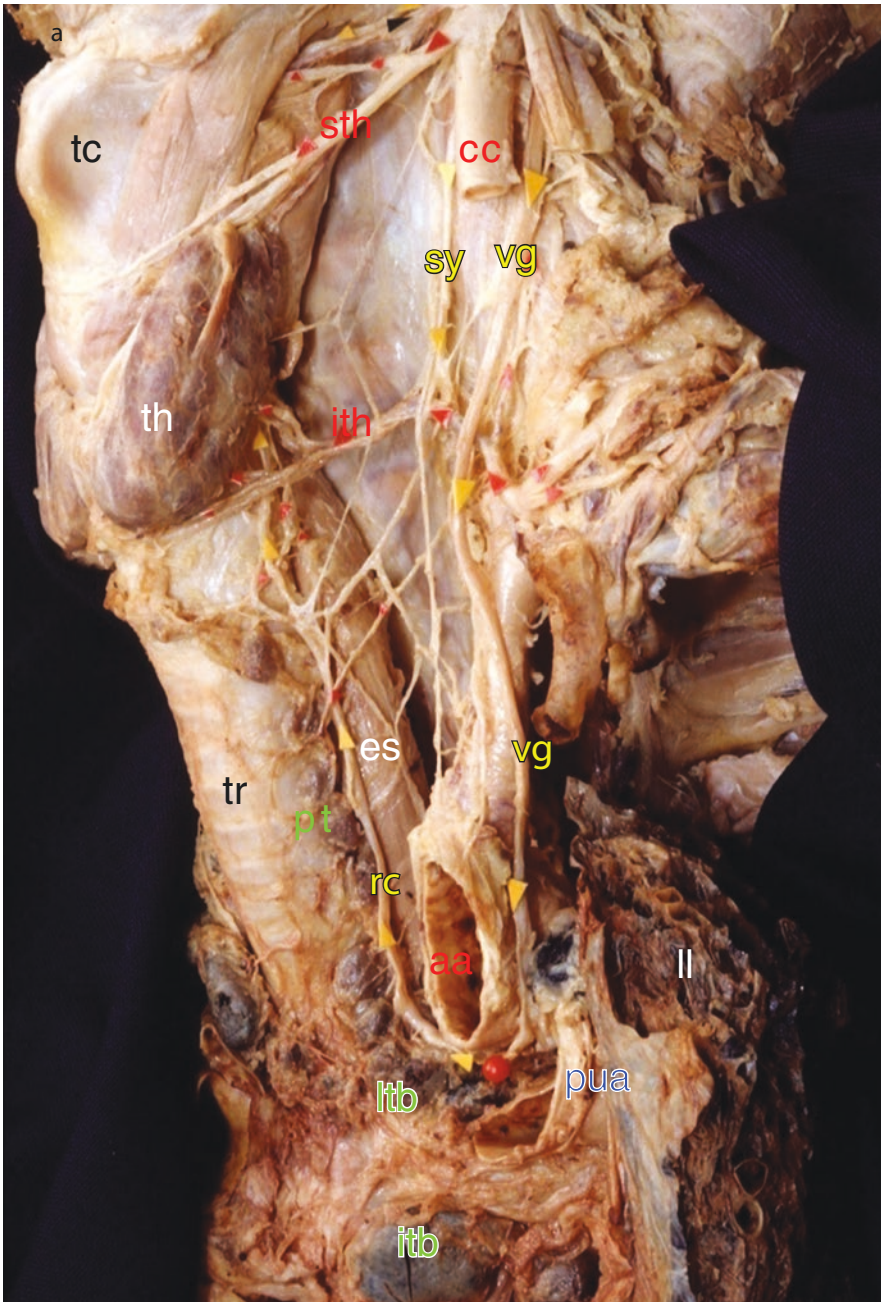

Fig. 2.12 Relationship between the left paratracheal lymph chain and the recurrent laryngeal nerve. (**a**) A well-developed left paratracheal lymph chain, as seen from the left. The lymph chain ascends immediately anterior to and medial to the left recurrent laryngeal nerve. [The original position of the ligamentum arteriosum is shown by the red pin.] (**b**) After the thyroid cartilage was median sectioned and reflected posteriorly, the left recurrent laryngeal nerve was pulled anteriorly, to reveal numerous segmental branches to the esophagus (Specimen 7, male). Yellow arrowheads: vagus and recurrent laryngeal nerves

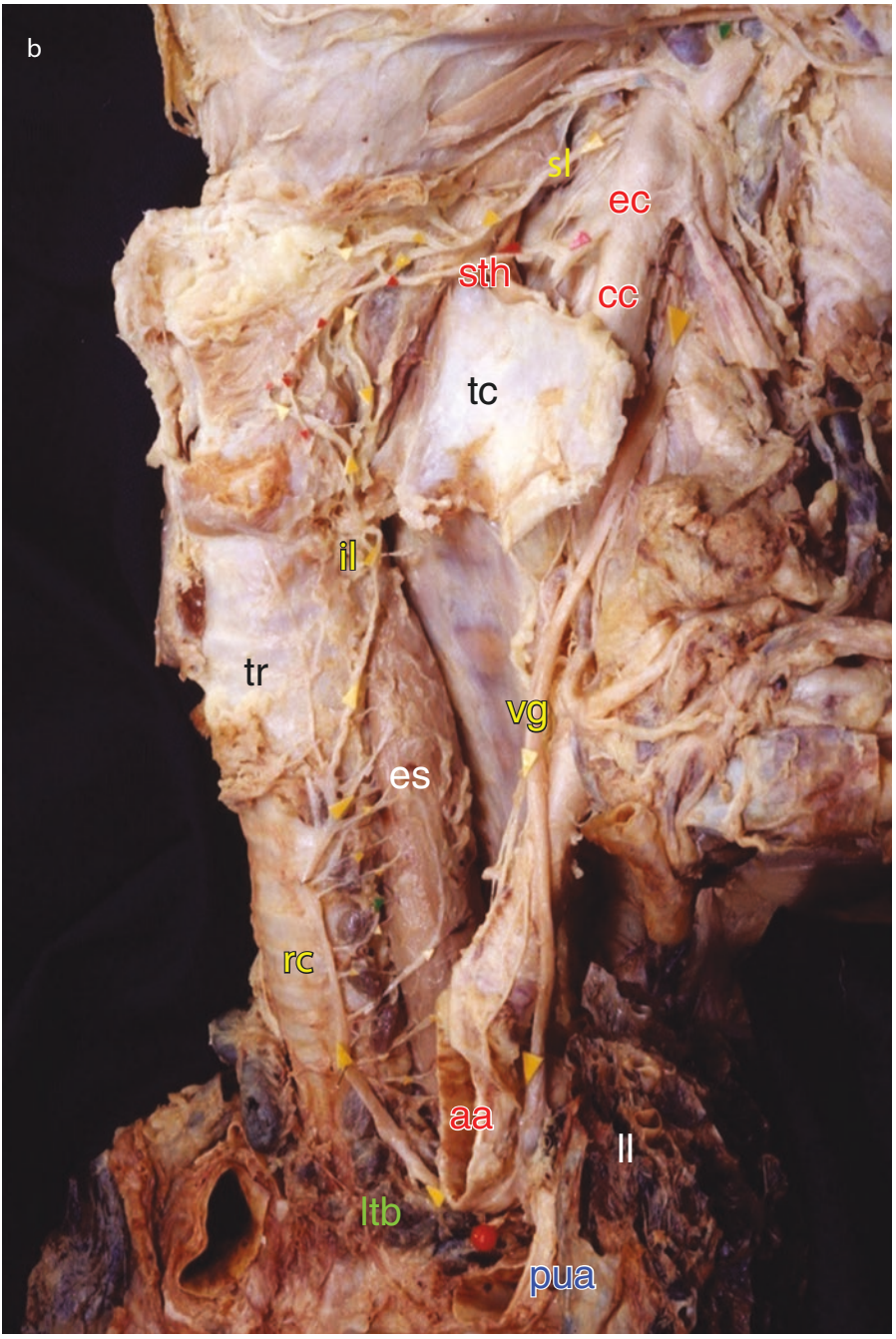

Fig. 2.12 (continued)

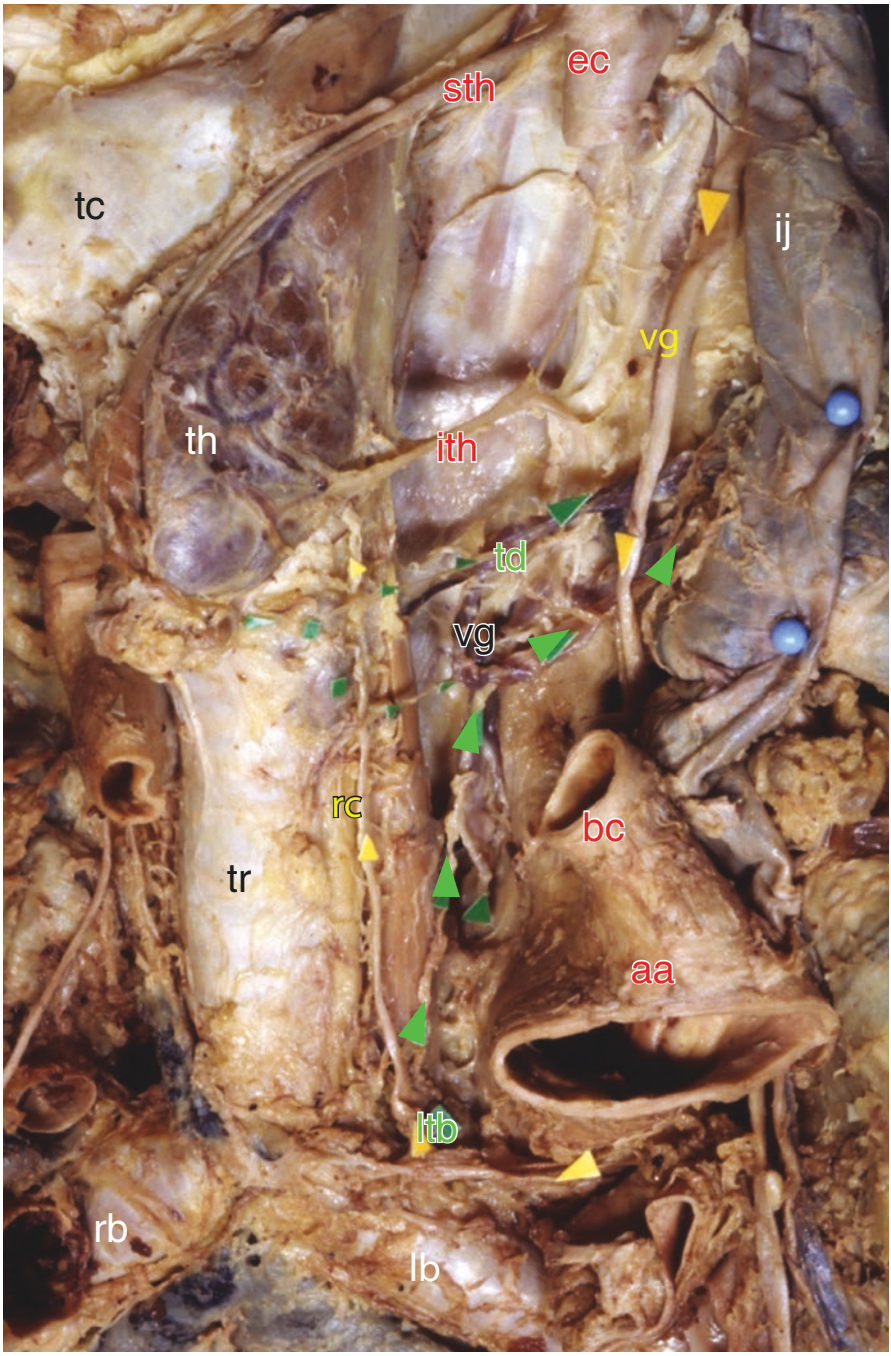

Fig. 2.13 Lymph vessel draining into the thoracic duct. The left paratracheoesophageal area was dissected after removal of the great vessels. The left paratracheal lymph chain is poorly developed. A lymph vessel (green arrowheads), which originates from the left tracheobronchial node, ascends almost vertically and drains into the terminal portion of the thoracic duct (Specimen 8, male). Yellow arrowheads: vagus and recurrent laryngeal nerves

Interestingly, there is also a third pathway from the left tracheobronchial nodes which runs slightly obliquely and drains into the terminal portion of the thoracic duct (Fig. 2.13). In addition to the abovementioned typical paratracheal lymphatics of the esophagus, there are also atypical lymph vessels which drain into the thoracic duct on both the left and right sides.

There is a recess close to the esophageal hiatus of the diaphragm between the thoracic surface of the diaphragm and the esophagus. Lymph nodes at the lower end of the thoracic esophagus are sometimes situated within this recess. In Fig. 2.14 [11] a large node is located within the recess adjacent to the left margin of the esophagus. In addition to the connections with the esophageal lymphatics, this node has a transverse communication with the nodes between the esophagus and inferior vena cava on the upper surface of the diaphragm. An even more critical communication is seen between this node and the left gastric lymphatics (Fig. 2.14). These findings indicate that the lymph nodes adjacent to the left margin of the esophagus at the level of the hiatus serve as a relay station from the lymphatics of the lower mediastinum to those of the upper abdomen.

2.1.2 Lymphatics of the Stomach

Rouvière divided the stomach lymphatics into four territories according to the four gastric branches of the coeliac trunk, as shown (Fig. 2.15) in his classic scheme [Rouvière's Fig. 83; 1]: left gastric, right gastric, right gastroepiploic, and left gastroepiploic territories. The lymphatics from these four territories run along their accompanying artery to the coeliac nodes. The left and right lymphatics of the lesser curvature can be typically seen as in Fig. 2.16 [14]. In this figure additional lymphatic chains are seen along the accessory left gastric artery and the proper hepatic artery; interestingly, they form a figure 8-like shape between the liver and the lesser curvature.

From the right gastroepiploic territories, the right gastroepiploic vein follows an oblique descending route on the anterior surface of the pancreas head and drains into the superior mesenteric vein (Fig. 2.17) [15]. The question is what do the lymphatics of the greater curvature do? Do they ascend to the coeliac nodes or descend to the superior mesenteric nodes? Minute dissection reveals that lymph vessels of the right gastroepiploic territory do not follow the right gastroepiploic artery to reach the coeliac nodes, but rather they accompany the right gastroepiploic vein to reach the superior mesenteric nodes (Fig. 2.18) [16].

Although the lymphatics along the right gastric artery typically follow the hepatic artery and drain into the coeliac nodes, they are also connected to the cystic lymphatics. Some cystic lymphatics drain into a node which is located within the middle level at the free margin of the lesser omentum (Fig. 2.19) [17, 18]. This node was already noted as the "ganglion de l'hiatus" by Rouvière (1932) [1], and was recognized as the "nodus foraminus" or the "node of anterior border of omental foramen" in Terminologia Anatomica (1998 [5]). As this node is located at the free margin of the lesser omentum, it can serve as a relay station between the anterior

Fig. 2.14 Huge superior diaphragmatic node close to the left esophageal margin. With the diaphragm cut and opened, the continuation of the esophagus from the mediastinum to the abdominal cavity can be seen. Note the unusually large node (superior diaphragmatic node) in the recess between the left margin of the esophagus and the diaphragm. From this node, numerous connections with a variety of nodes are seen. Particularly noteworthy are those connections to the coeliac lymphatics via gastric lymphatics (lower green arrowheads) (Specimen 9, male)

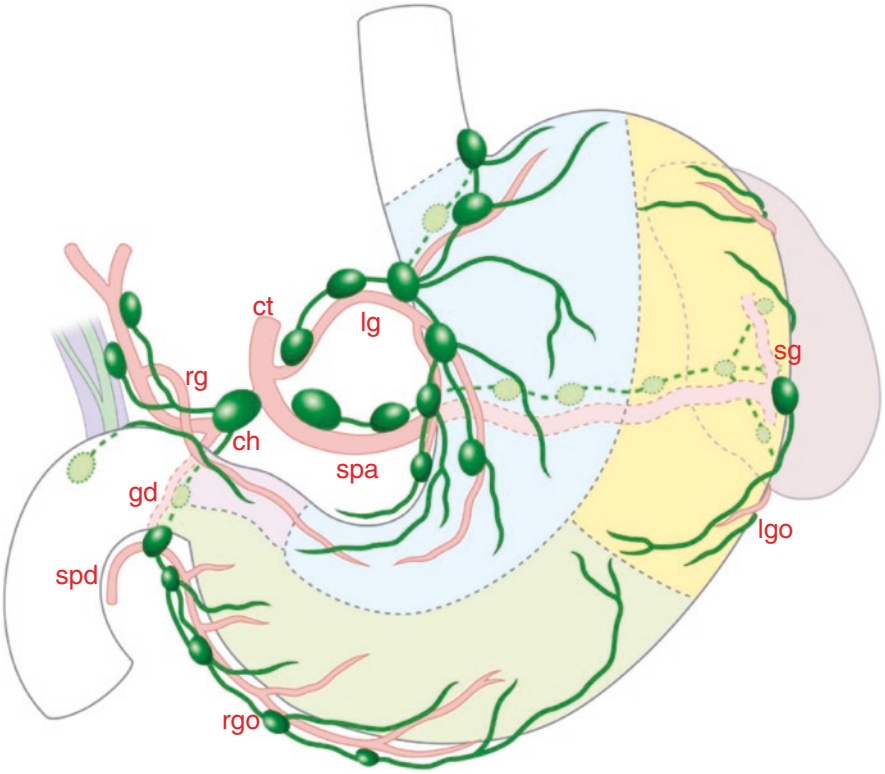

Fig. 2.15 Classical scheme of gastric lymphatics by Rouvière. Rouvière (taken from Fig. 83; 1932 [1]) divided the gastric lymphatics into four lymphatic territories with reference to the distribution of arterial branches of the coeliac trunk

and posterior lymphatics within the lesser omentum. In the same specimen as Fig. 2.19 lymph vessels from the nodus foraminus are connected with those of the posterior pancreas head and drain finally into the interaorticocaval nodes (Fig. 2.20) [17, 18]. These two illustrations suggest that some lymphatics of the lesser curvature may be relayed via the nodus foraminus and the nodes of the posterior pancreas head and drain into the interaorticocaval nodes.

Regarding atypical pathways in relation to variant arteries, the following lymphatic connections will be noted. On the posterior wall of the fundus of the stomach the posterior gastric artery, which originates from the splenic artery, is often observed (62%, Suzuki et al.) [19]. Along this atypical artery, lymphatics descend and drain into the splenic lymphatic chain (Fig. 2.21).

The left inferior phrenic artery often gives off a branch to the cardiac notch of the stomach (about 50%, Sato et al. [20]) (Fig. 2.22) [21]. Some lymph vessels from the cardioesophageal area run along the branch and the stem of the left inferior phrenic artery and then descend along the stem to finally drain into the coeliac nodes, superior mesenteric nodes, or into the nodes along the upper margin of the left renal vein (Fig. 2.23) [15].

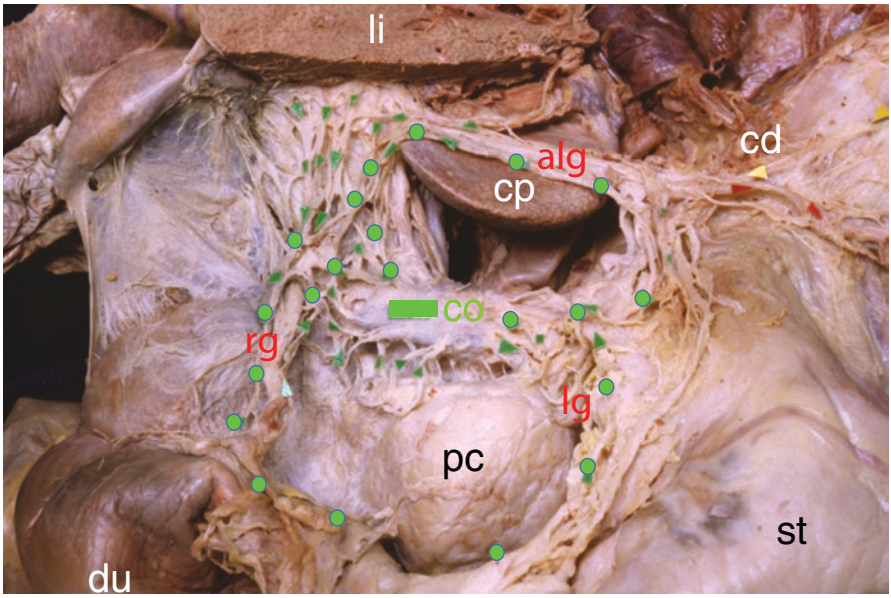

Fig. 2.16 Lymphatics along the coeliac arterial branches. The arterial branches of the coeliac trunk between the lesser curvature and the liver form a figure 8-like shape. Lymphatics along these vessels are shown with green markers. The coeliac node is indicated by the green rectangle (Specimen 10, male)

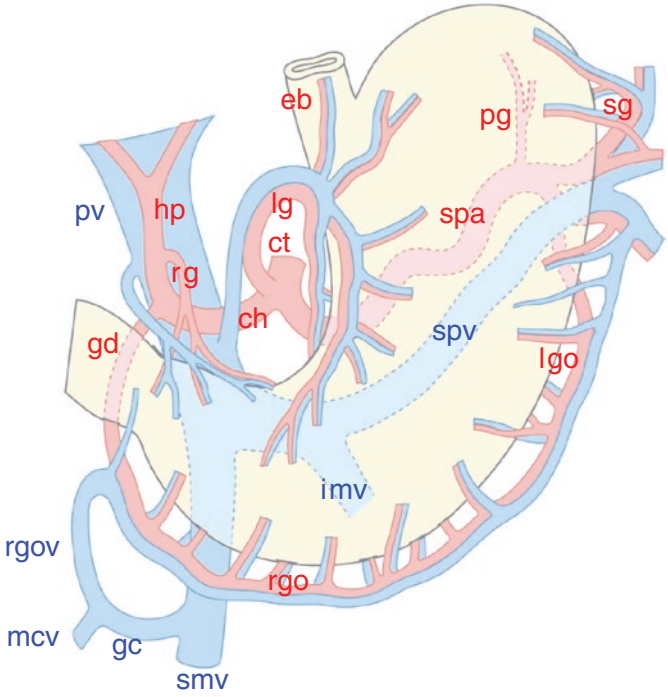

Fig. 2.17 The veins of the stomach and their relation to the arteries. Note the difference in the course between the right gastro-omental artery and vein

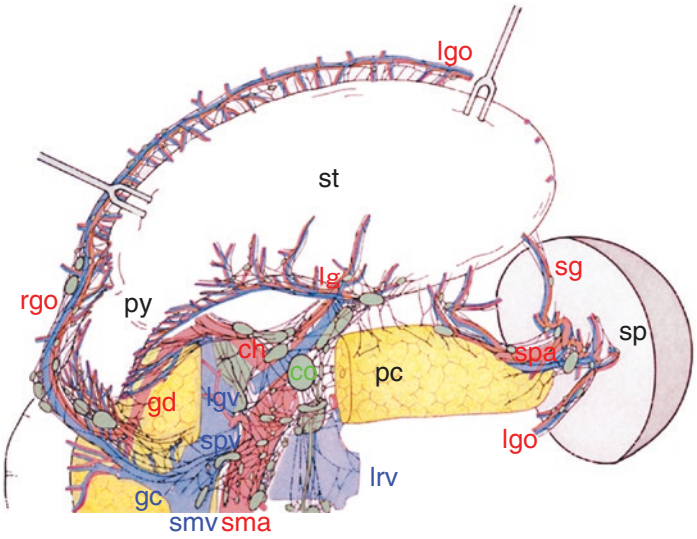

Fig. 2.18 Dissection of the stomach and pancreas. The stomach was reflected and the neck of the pancreas was cut, then the lymph vessels of the stomach were traced to the origins of the coeliac and superior mesenteric arteries. Lymphatic vessels along the right greater curvature run along the superior mesenteric vein to reach the superior mesenteric nodes (taken from Fig. 6 of Deki [16])

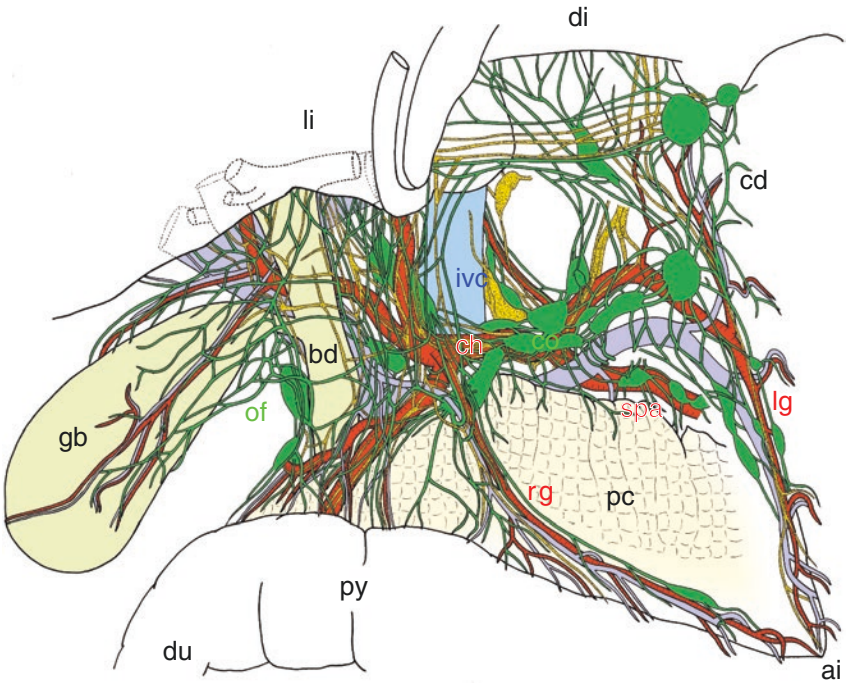

Fig. 2.19 Lymphatics of the lesser curvature, liver and gallbladder. Connections of the lymphatics of the stomach and the hepatic pedicle are shown. Note the omental foramen node (node of the anterior border of the omental foramen [5]) (taken from Fig. 1 of Ito et al. [17])

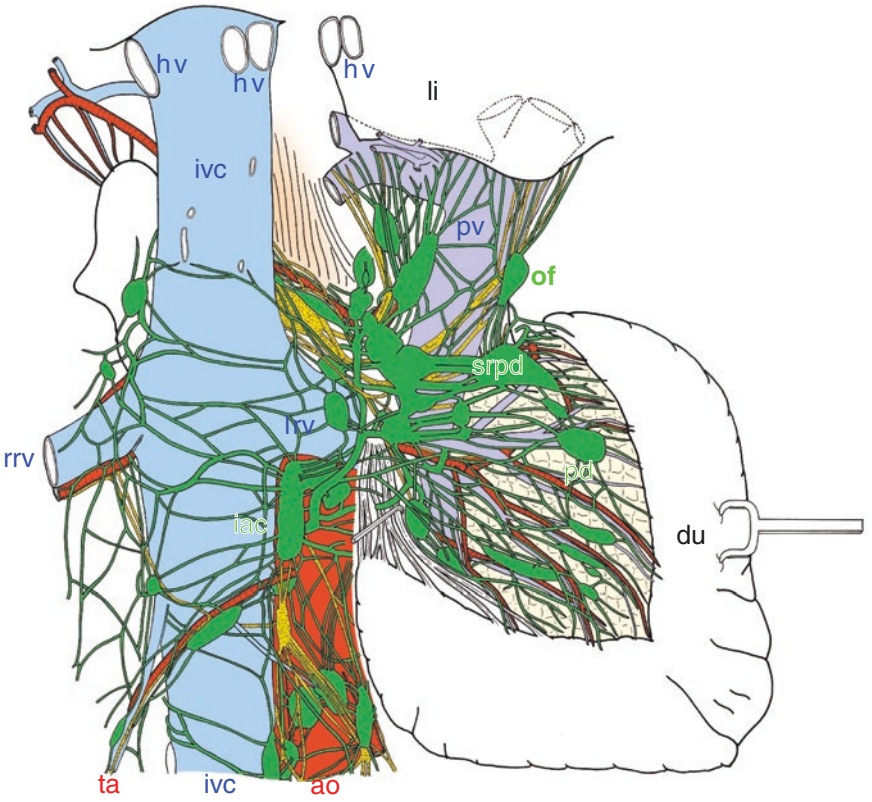

Fig. 2.20 Lymphatics of the pancreas head. The pancreas has been reflected to the left (same specimen as in Fig. 2.19). Dissection showing the omental foramen node connecting with the lymphatics behind the pancreas head and then with the para-aortic nodes (taken from Fig. 2 of Ito et al. [17])

In the lymphatic arrangement of the stomach, two points should be made: (1) Although the general emphasis is placed on the lymphatics that reach the coeliac nodes, it is important to note that in addition to those well-known lymphatic chains, there are also atypical chains which run to the superior mesenteric lymphatics. (2) Also noteworthy are those lymphatics that run along the atypical arteries, such as the posterior gastric artery and the left inferior phrenic artery.

2.1.3 Lymphatics of the Colon

The lymphatics of the colon generally follow the colic arteries; thus, a comprehensive understanding of the arterial arrangement is crucial. There are two major arteries supplying the colon, the superior and inferior mesenteric arteries (Fig. 2.24) [22]. From the superior mesenteric artery, the ileocolic, right colic, and middle colic arteries originate and these supply the caecum, ascending colon, and transverse

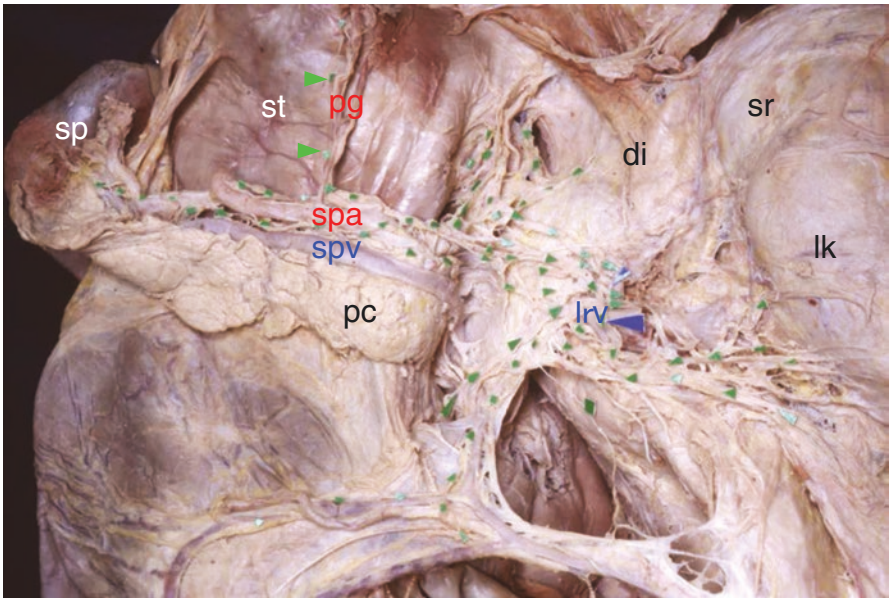

Fig. 2.21 Lymphatics along the posterior gastric artery. The stomach, spleen, and pancreas body and tail have been reflected to the right to reveal the lymphatics along the posterior gastric artery (green arrowheads) which drain into nodes of the splenic artery (Specimen 11, male)

colon, respectively. From the inferior mesenteric artery, the left colic, sigmoid, and the superior rectal arteries originate.

The colic arteries of the superior and inferior mesenteric arteries bifurcate close to the colon and form an arterial arcade, termed the marginal artery. From the marginal artery numerous vasa recta originate and supply the colic wall. Many lymph nodes lie alongside the vasa recta and marginal artery. These are paracolic lymph nodes. Along the colic arteries lie intermediate nodes. These are termed according to the name of the accompanying colic artery. The principal lymph nodes near the origin of the mesenteric arteries are termed the superior and inferior mesenteric nodes (Fig. 2.24).

A typical lymphatic arrangement of the right hemicolon is shown in Fig. 2.25 [taken from Fig. 8 of Sato and Sato, 23]. In this figure three points should be noted: (1) As the superior mesenteric vein is located alongside and to the right of the superior mesenteric artery, lymph vessels of the right hemicolon first cross the superior mesenteric vein and then move to the arterial side. (2) In this specimen, the right colic artery is well developed and forms a common stem with the artery of the right colic flexure (hepatic flexure). In general however, the presence of the right colic artery is somewhat unpredictable. A distinct right colic artery is

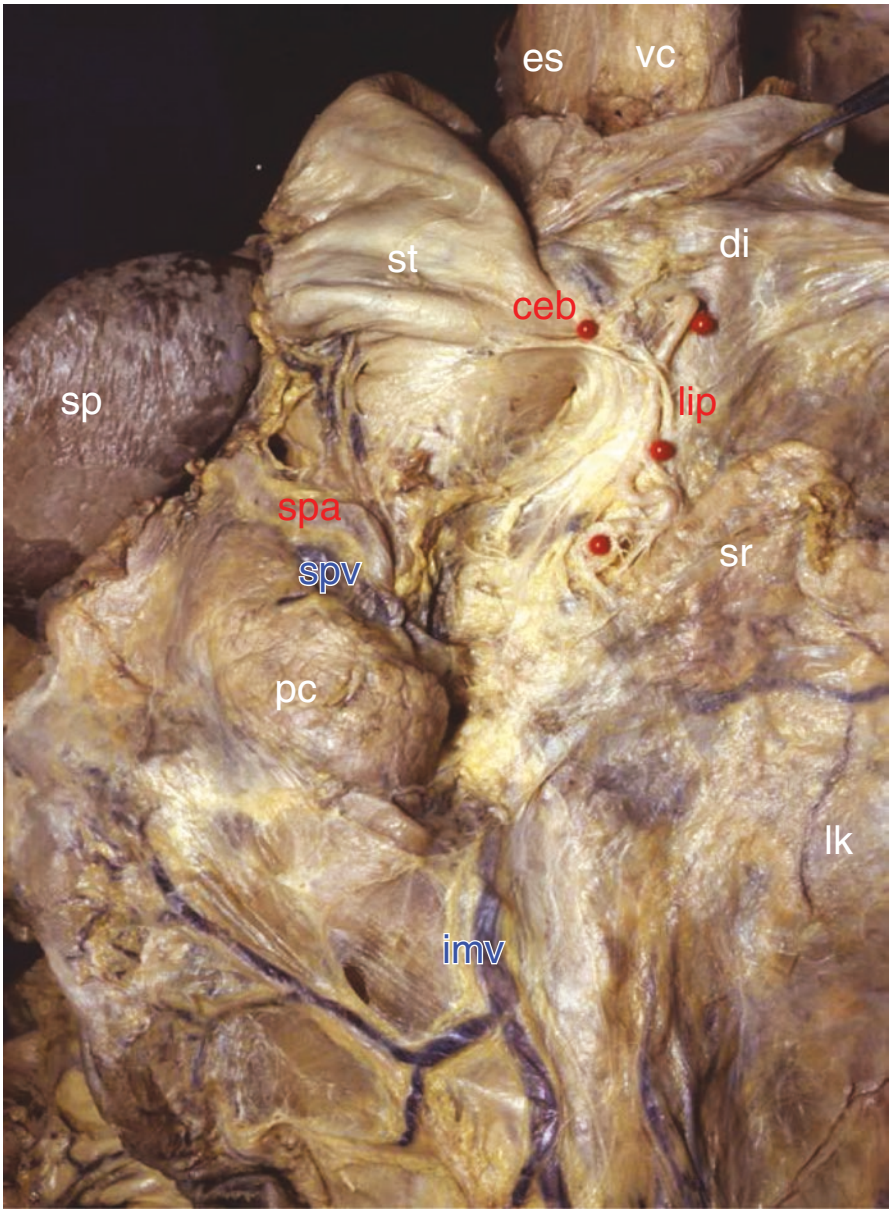

Fig. 2.22 Left inferior phrenic artery and its cardioesophageal branch. The stomach, spleen, and pancreas body and tail have been reflected to the right to reveal the left inferior phrenic artery and its cardioesophageal branch (red pins) (Specimen 12, male)

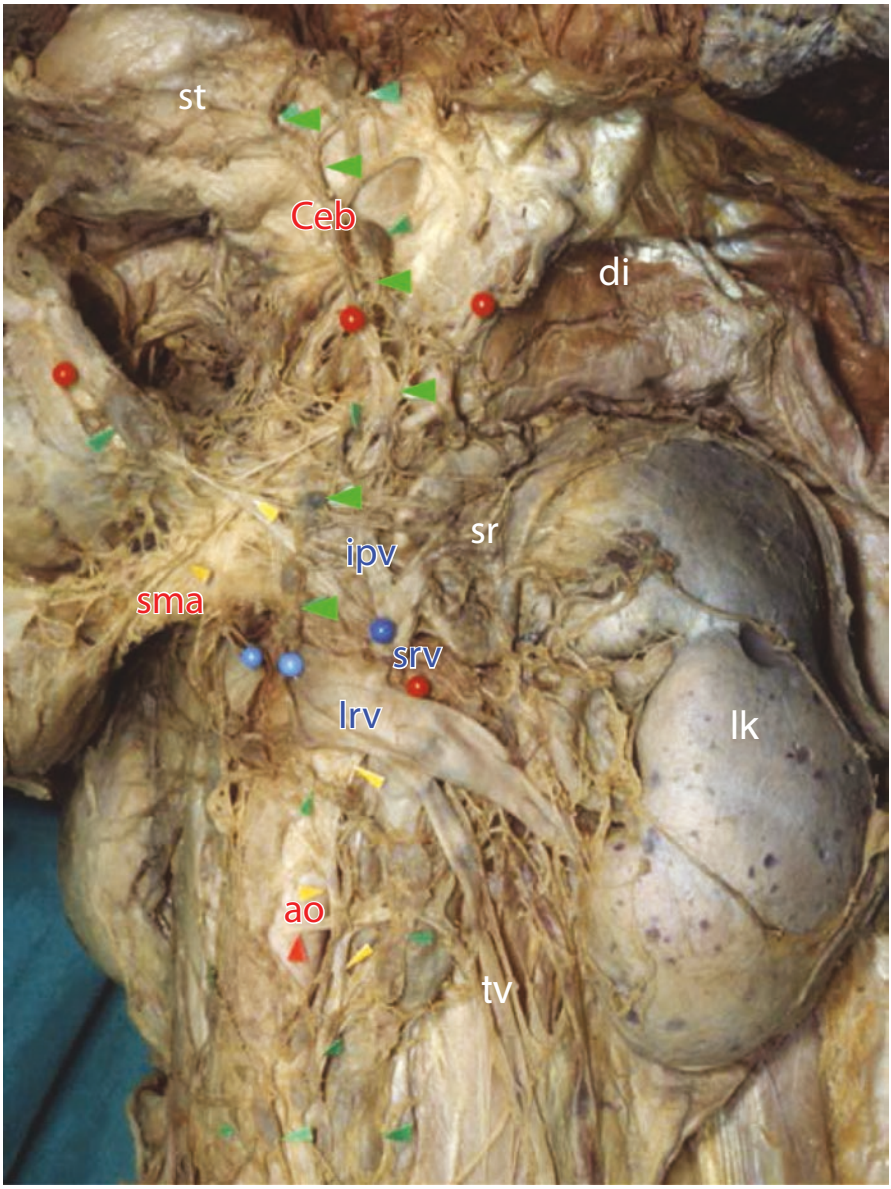

Fig. 2.23 Lymphatics along the left inferior phrenic artery. A lymph vessel (green arrowheads) from the cardia runs along the cardio-esophageal branch of the left inferior phrenic artery and descends along this artery, then finally drains into the superior mesenteric nodes (Specimen 13, male)

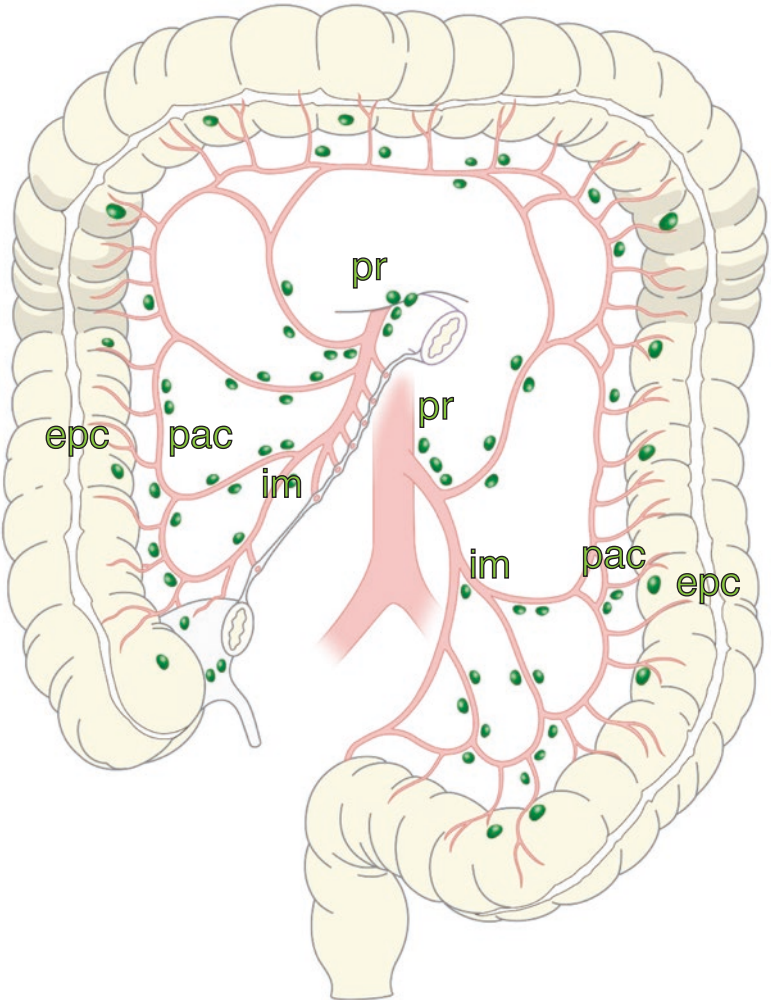

Fig. 2.24 Manner of lymph node distribution of the large intestine. This scheme shows the lymph node distribution in relation to the superior and inferior mesenteric arteries and their colic branches (taken from Fig. 11-4 of Slanetz and Herter [22])

observed in only about one-third of specimens [24], and therefore the ascending colon is often supplied via the marginal artery from the ileocolic and middle colic arteries. Based on this arterial arrangement, numerous lymphatics of the right colon tend to gather to the ileocolic and middle colic nodes. The anterior and posterior ileocolic nodes are shown in Fig. 2.26a, b [25]. (3) Arteries of the

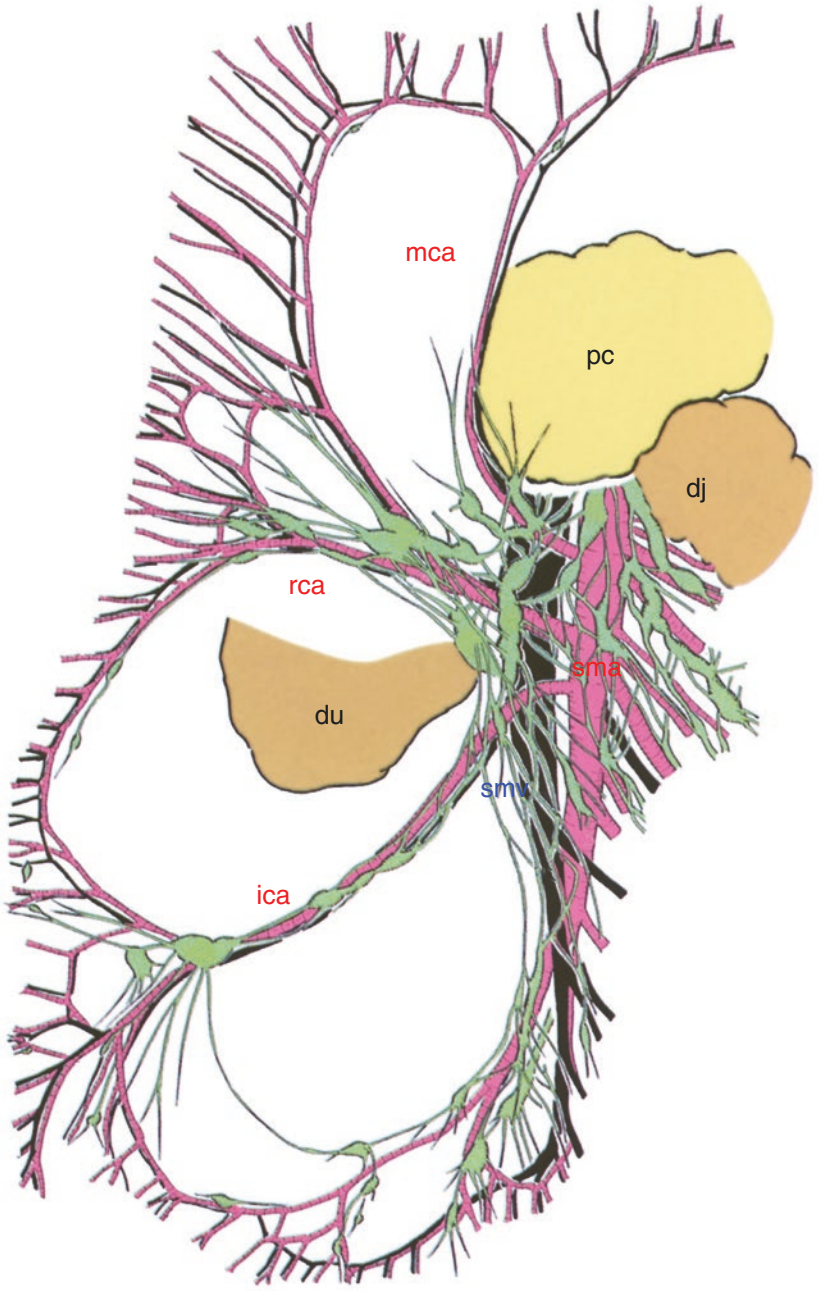

Fig. 2.25 Lymphatics along the superior mesenteric vessels. Note the complex lymphatic arrangement adjacent to the superior mesenteric artery and vein (taken from Fig. 8 of Sato and Sato [23])

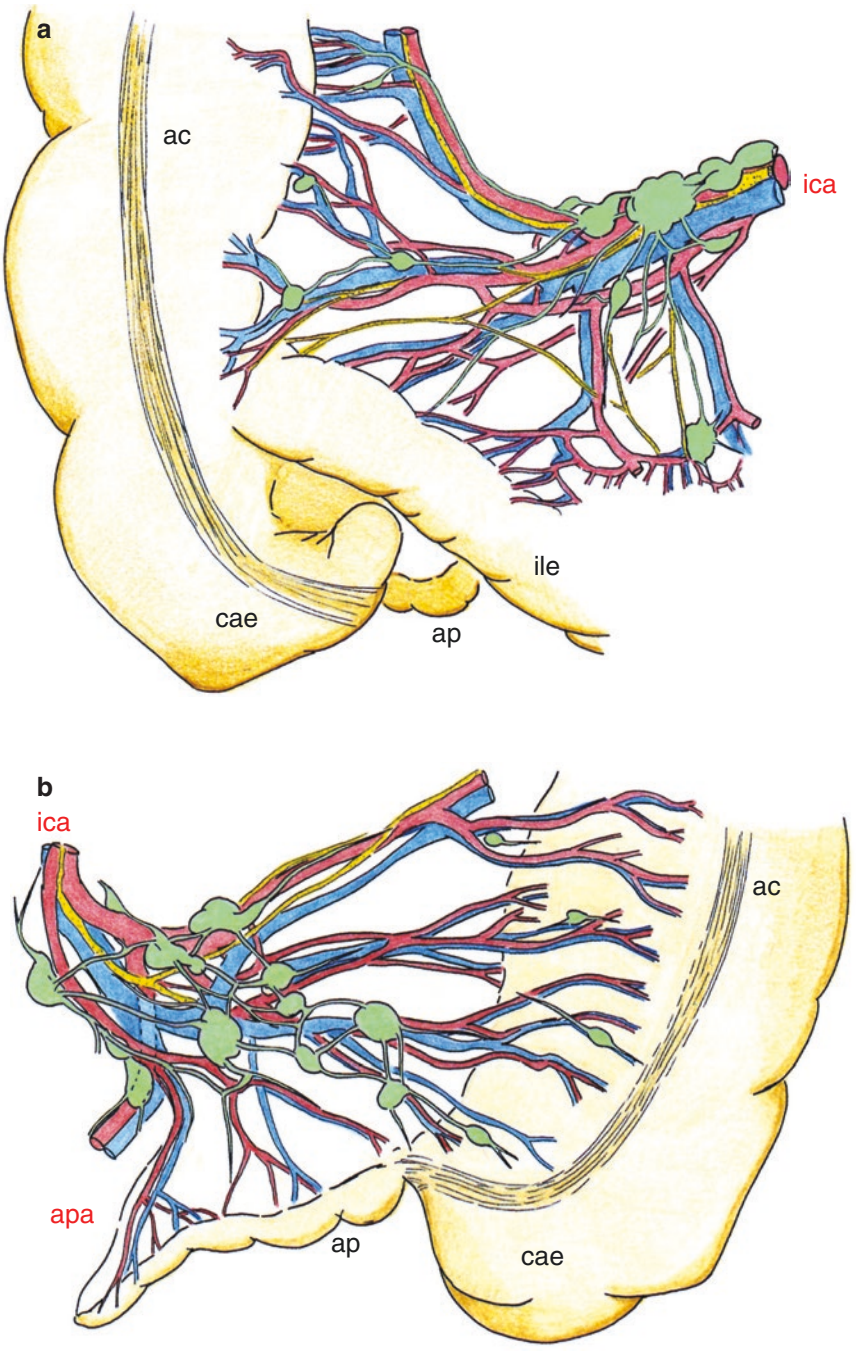

Fig. 2.26 Lymphatics of the caecum. (**a**) Anterior view; (**b**) Posterior view (taken from Figs. 5 and 6 of K. Sato [25])

transverse colon are complex. In French textbooks of anatomy, the arteries of the transverse colon are classified into three types [26]: (a) artery of the right colic flexure, (b) artery of the transverse colon, and (c) artery of the left colic flexure. In the specimen of Fig. 2.25, the middle colic artery reached the middle part of the transverse colon; unfortunately however during dissection, the paracolic branch was not traced to the left colic flexure.

Regarding the typical left colic flexure, from the inferior mesenteric artery, the upper left colic artery reaches the marginal artery which joins that from the superior mesenteric artery. This segment of the marginal artery is termed Riolan's anastomosis. The major stem of the inferior mesenteric artery sends numerous sigmoid arteries before continuing as the superior rectal artery (Fig. 2.27) [taken from Fig. 2.10 of Sato and Sato, 23]. Well-developed lymphatics along the sigmoid arteries ascend along the stem of the inferior mesenteric artery to reach the lymphatics surrounding the abdominal aorta. These lymphatics gather at the origin of the inferior mesenteric artery and reach not only the lateral aortic lymph nodes, but also the interaorticocaval lymph nodes. Lymphatics of the colon tend to gather at the lymph nodes surrounding the abdominal aorta below the left renal vein.

2.1.4 Lymphatics of the Rectum

Lymphatic pathways of the rectum are roughly classified into superior, lateral, and inferior pathways (Fig. 2.28) [27]. The latter, the inferior pathway, which originates from the anal canal and runs subcutaneously to reach the superficial inguinal nodes, will not be demonstrated in this chapter.

The superior pathway ascends along the superior rectal artery (Fig. 2.29). Regarding the manner of drainage into the para-aortic nodes, the ascending lymph vessels from the rectum not only concentrate around the origin of the inferior mesenteric artery but also these vessels are vertically scattered between the level of the left renal vein and the bifurcation of the aorta (Fig. 2.30) [28]. In addition, also within this region, numerous horizontal communications are noted.

The lateral pathway typically runs along the middle rectal artery. The typical middle rectal artery is shown in Fig. 2.31 [29]. This artery, however, is often absent, and thus it is only rather rarely observed (22%, Sato and Sato) [30]; without this guiding artery, it is difficult to trace lymph vessels from the rectum. However, in a rather rare dissection in the absence of the middle rectal artery, we were able to trace a lymph vessel of the rectum (Fig. 2.32) [31].

The lateral lymph vessels do not always run along the organ-supplying branches to reach the stem of the internal iliac artery, but rather they tend to run lateralward to drain into the interiliac nodes near the obturator nerve (Fig. 2.32) [31]. To reach

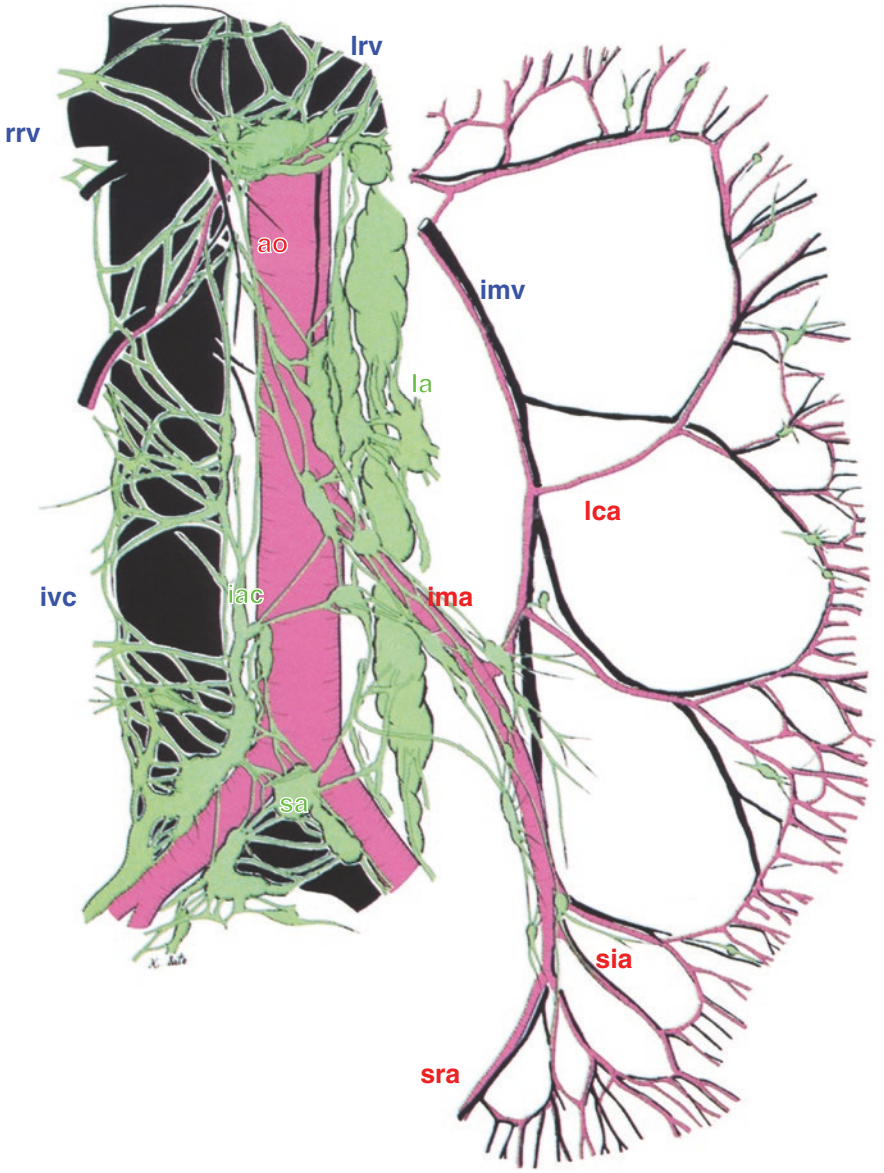

Fig. 2.27 Lymphatics along the inferior mesenteric vessels. Note the intimate relationship between these lymphatics and the para-aortic nodes (taken from Fig. 10 of Sato and Sato [23])

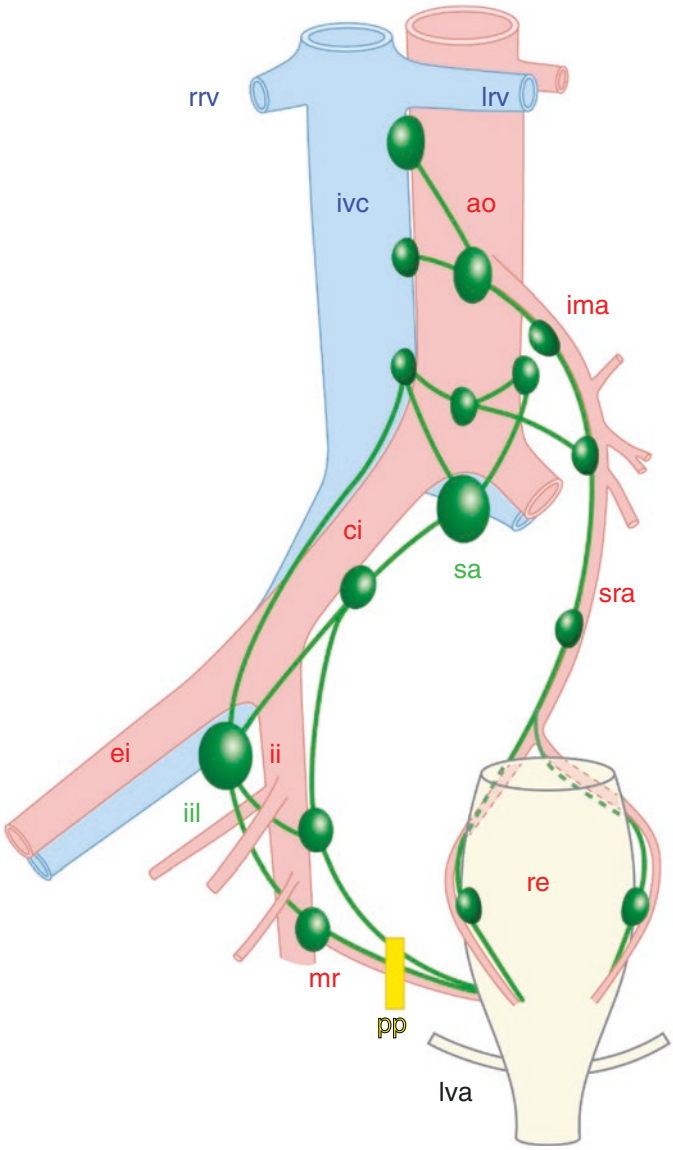

Fig. 2.28 Lymphatic pathways of the rectum. The scheme of the relationship of the superior and lateral lymphatic pathways of the rectum to the surrounding structures (K Sato [25])

the interiliac nodes, the lymph vessels must cross the cord of umbilical artery, which originates from the internal iliac artery, run alongside the urinary bladder, and ascend on the posterior wall of the rectus abdominis muscle to reach the navel. Lymph vessels originating from the upper region of the pelvic organs pass over the cord of umbilical artery, while those from the lower region pass under the cord

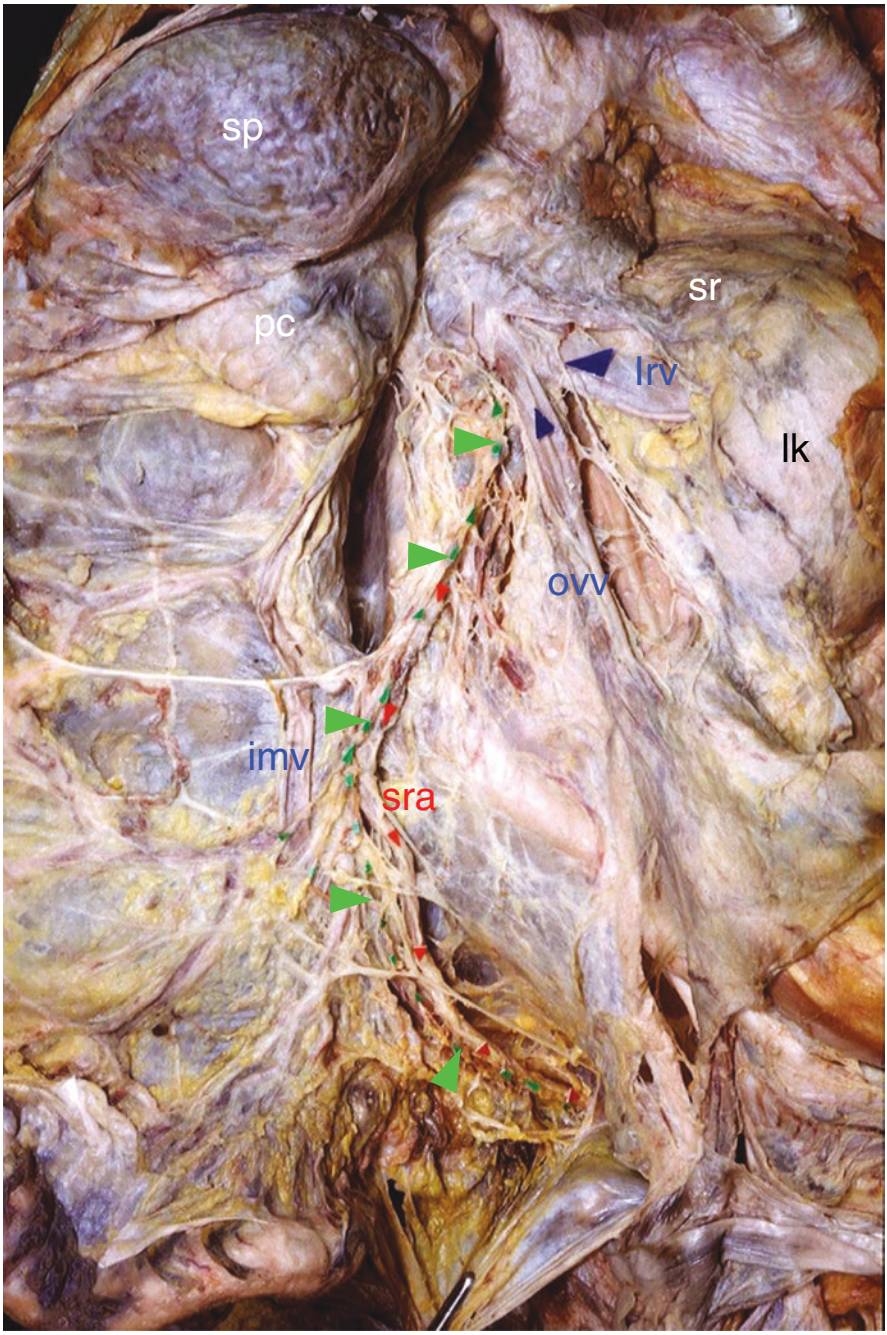

Fig. 2.29 Ascending lymph vessel from a female rectum. As viewed from the front, the stomach, spleen, pancreas body and tail, and the descending and sigmoid colon have been reflected to the right, showing an ascending lymph vessel (green arrowheads) along the superior rectal artery/inferior mesenteric artery (Specimen 14, female)

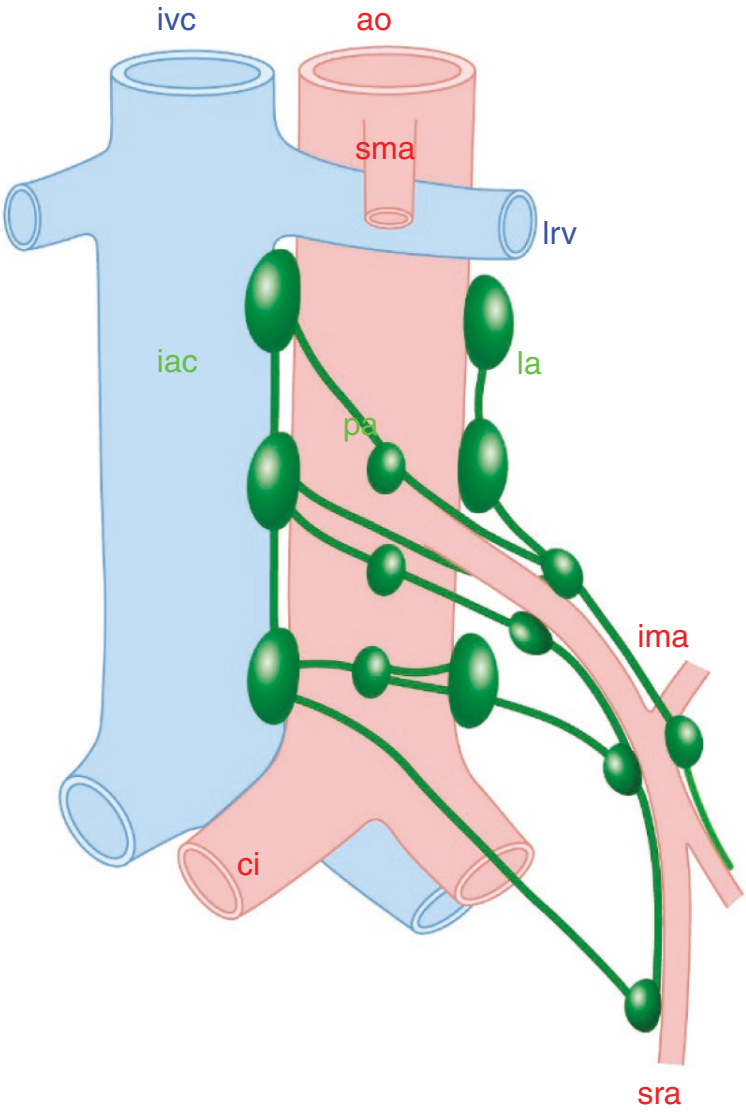

Fig. 2.30 Ascending rectal lymphatics to the abdominal aorta. The distribution manner of the ascending lymph vessels along the superior rectal artery and the inferior mesenteric artery to the abdominal aorta is shown (K Sato [25])

(Fig. 2.33) [29]. Another critical relationship of the lateral pathway is the positional relationship to the pelvic plexus. Many lymph vessels from the upper portion of the rectum cross over the pelvic plexus as shown in Fig. 2.34 [32]. However, as shown in Fig. 2.31, the middle rectal artery pierces the pelvic plexus which indicates that some lymph vessels of the lower rectum also pass through the pelvic plexus.

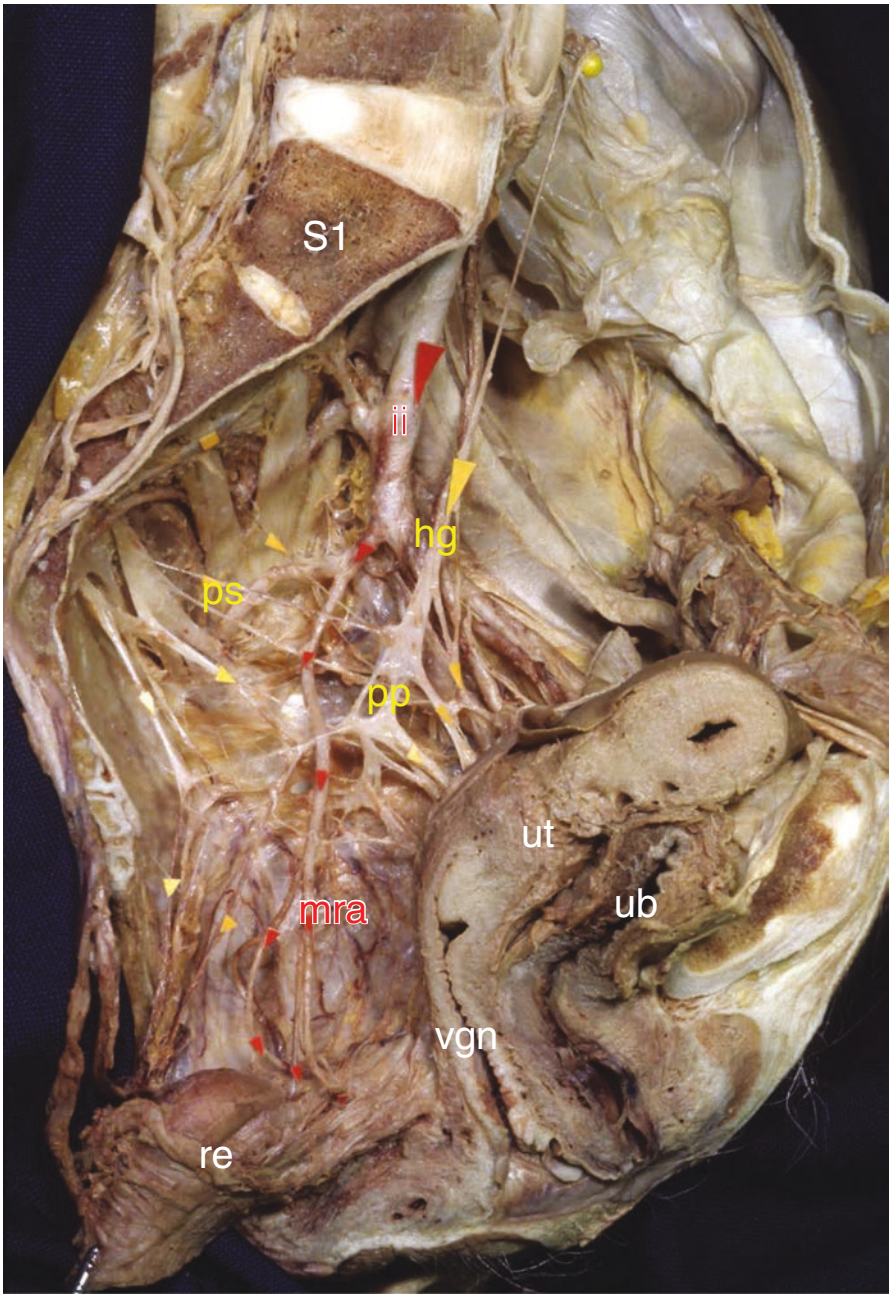

Fig. 2.31 Female middle rectal artery course. The left half of the median-sectioned female pelvis is seen from the right. The rectum has been pulled posteriorly. The typical middle rectal artery originates from the initial part of the internal pudendal artery which is a branch of the internal iliac artery. This middle rectal artery pierces the pelvic plexus and reaches the rectum (Specimen 15, female)

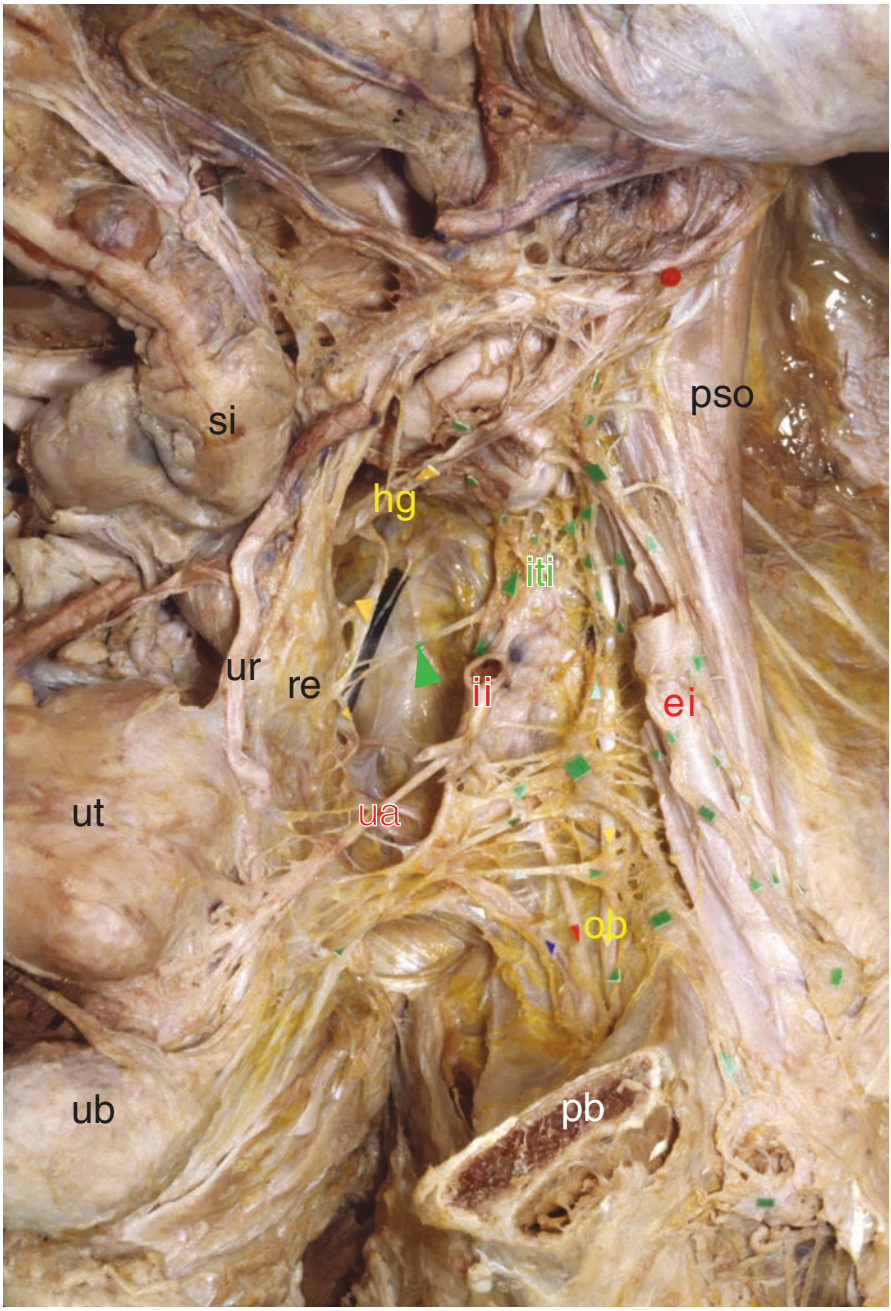

Fig. 2.32 Rectal lymphatics reaching the interiliac lymphatics. Transitional portions of the left common, external and internal iliac arteries have been removed. Although in this specimen the middle rectal artery was not present, a lymph vessel (green arrowheads) from the rectum to the interiliac lymphatics was dissected (Specimen 16, female)

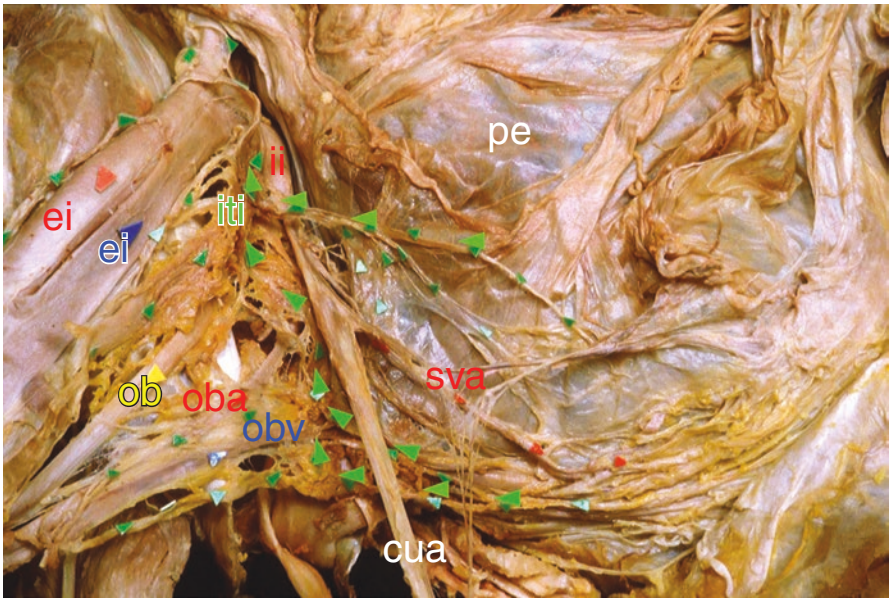

Fig. 2.33 Relationship of the pelvic lymphatics and the umbilical artery. After removal of the hip bone, the right half of a female pelvis was dissected from the outside. The external iliac artery and the cord of the umbilical artery were shifted slightly lateralward. Note that the lymph vessels of higher origin (light green arrowheads) cross over the cord of the umbilical artery, while those of lower origin (dark green arrowheads) cross under the cord (Specimen 17, female)

In addition to the lateral pathway, some lymph vessels run posteriorly and drain into the lymphatics along the lateral sacral artery to reach the lymphatics along the common iliac nodes (Fig. 2.35) [32]. This figure shows that the lymph vessel pierces the fascial membrane which unites the right and left hypogastric nerves (interhypogastric fascia).

The iliac lymphatics are typically observed medial to, lateral to, and anterior to the iliac arteries and veins. In addition to these lymphatics, minute dissection after cutting the united portions of the three iliac arteries revealed that many lymph vessels (light green arrowheads) wind around and behind the arteries to connect with the iliac lymphatics (Figs. 2.35 and 2.36 [32]). This clarifies that the iliac lymphatics are not simply single layer lymphatics, but rather they are lymphatics which surround the iliac vessels.

2.1.5 Lymphatics Surrounding the Abdominal Aorta (Ganglions Abdomino-Aortiques, Rouvière)

The medial groups of the right and left common iliac lymph chains converge at the subaortic nodes. As shown in Fig. 2.36, the subaortic node receives the right and left medial groups of the common iliac chains on the one hand, but on

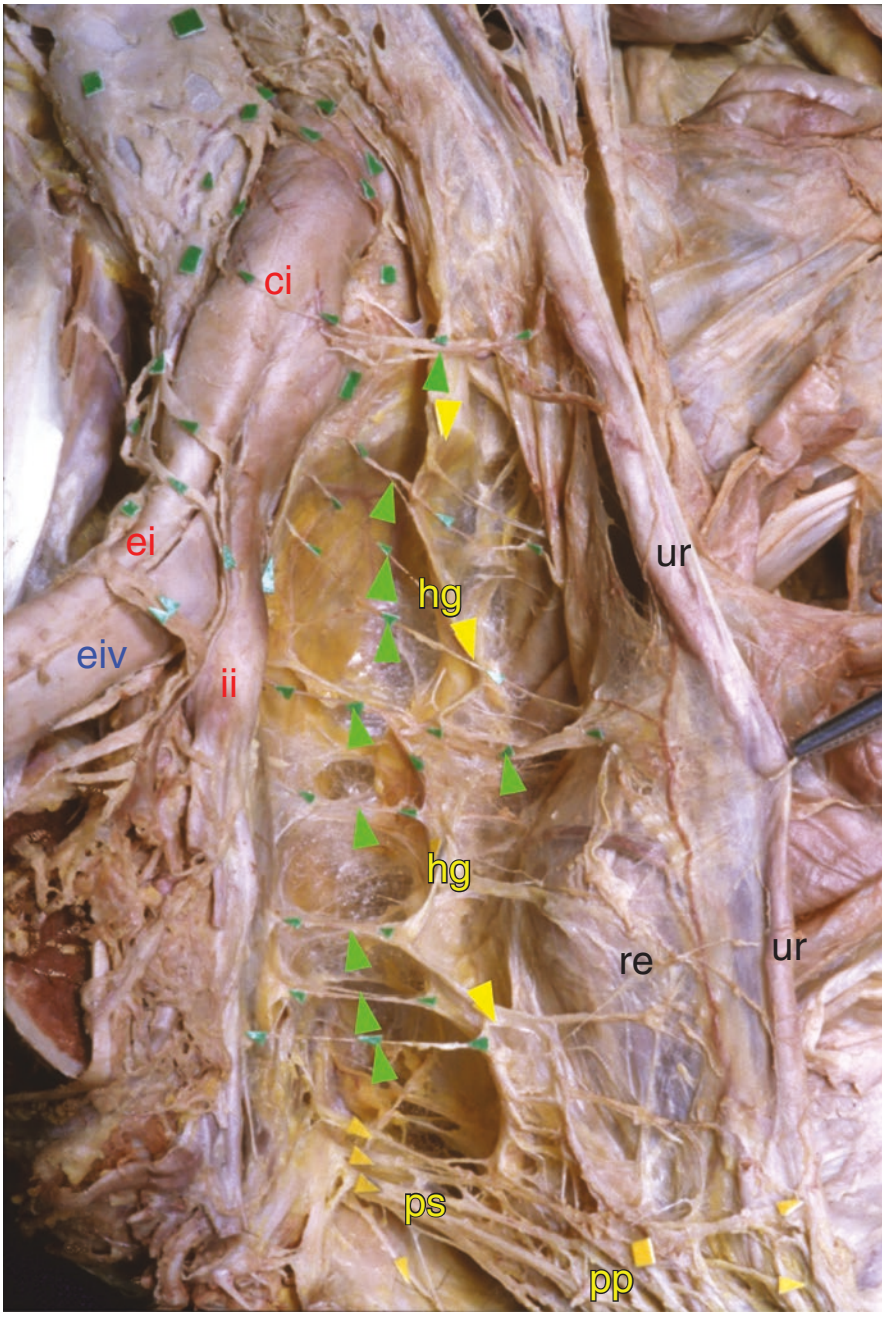

Fig. 2.34 Relationship between the lymphatics and nerves in a female pelvis. In a female pelvis, the rectum and the right ureter have been shifted to the left. The right hypogastric nerve and pelvic plexus are wrapped by fascial structures, and several lymph vessels (green arrowheads) cross over them (dissection video photograph: Specimen 18, female)

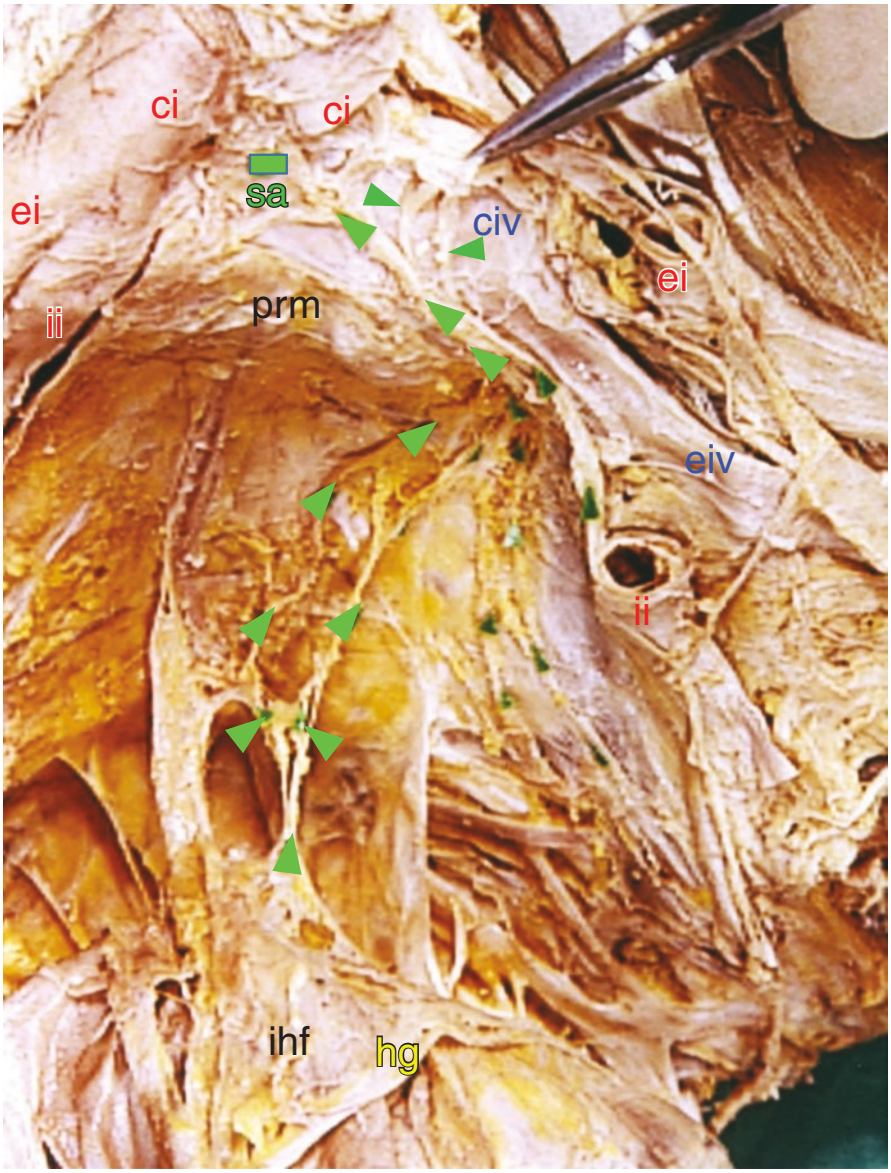

Fig. 2.35 Female pelvic lymphatics (seen from above). The rectum and fascia which unite the right and left hypogastric nerves, are shifted anteriorly. A lymph vessel (green arrowheads) from the rectum pierces the fascia to reach the anterior surface of the sacrum and finally, via the left common iliac lymphatics (light green arrowheads), it drains into the subaortic node (dissection video photograph: Specimen 18, female)

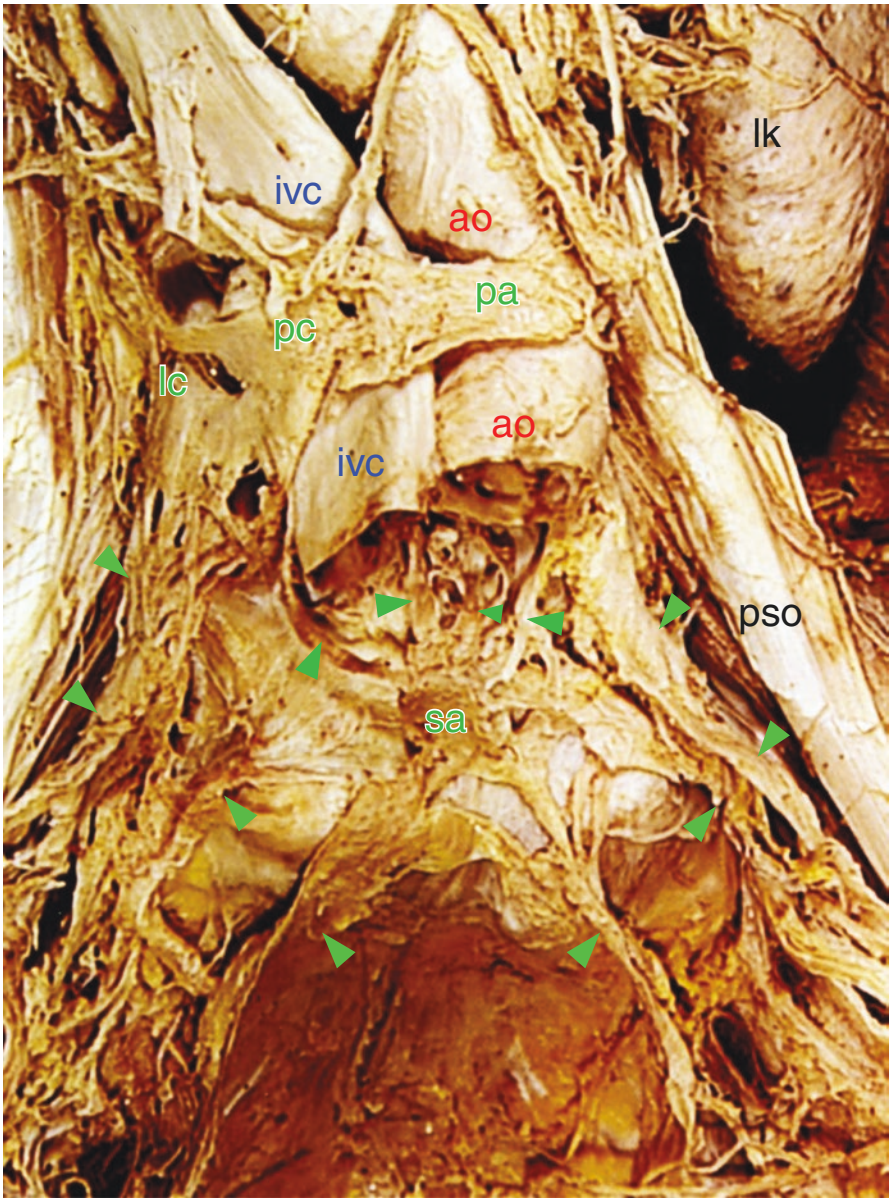

Fig. 2.36 Para-aortic lymphatic chains. Bilateral iliac arteries and veins and also the lower ends of the aorta and inferior vena cava have been removed. The subaortic node receives the right and left medial iliac chains (light green arrowheads) and sends three thick vessels of the major chains of the para-aortic lymphatics (lateral aortic, interaorticocaval, and lateral caval chains) (dark green arrowheads) (dissection video photograph: Specimen 18, female)

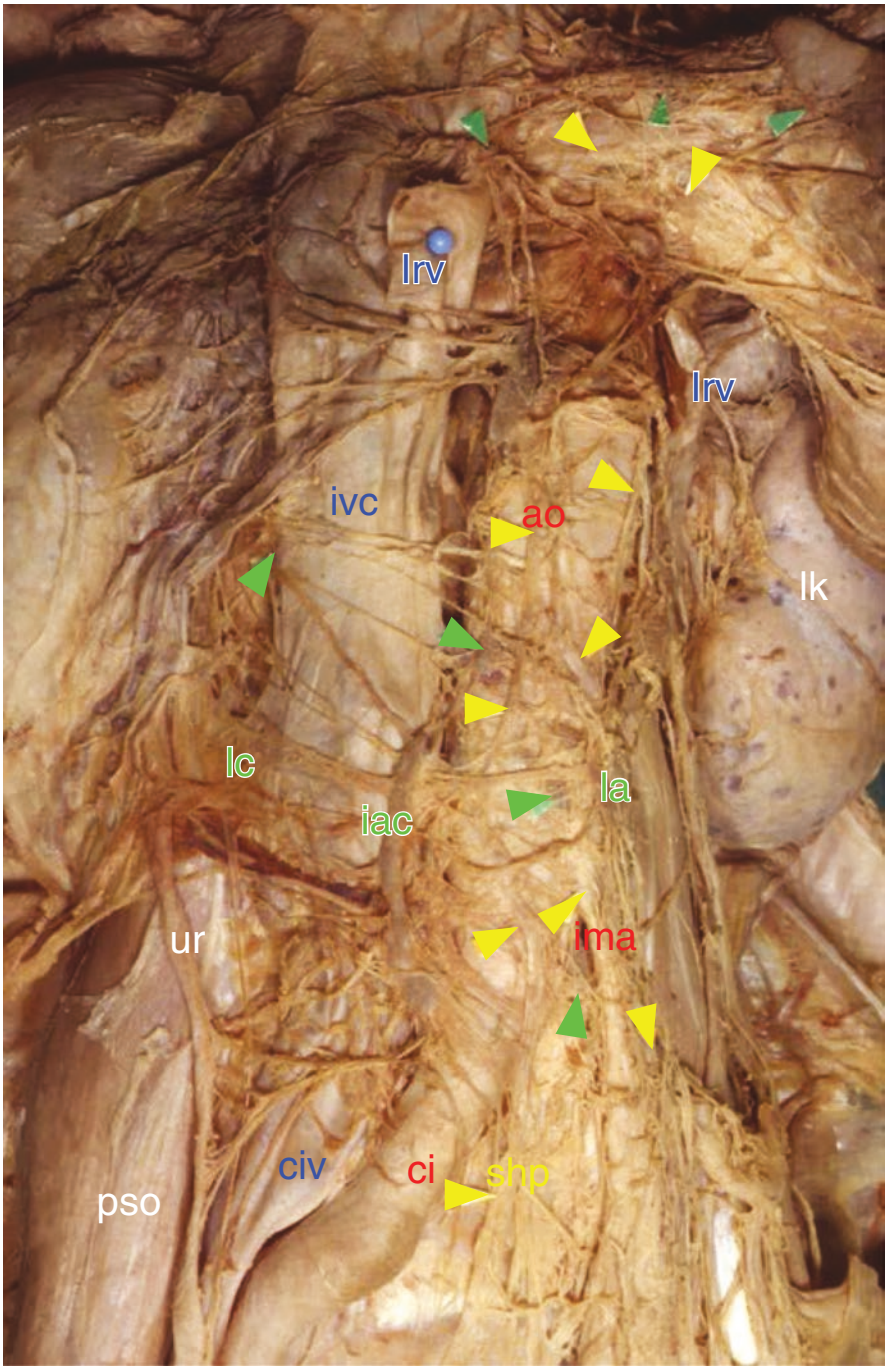

Fig. 2.37 Well-developed lymphatics around the aorta and the inferior vena cava. These lymphatics (green arrowheads) intermingle with the autonomic nerves (yellow arrowheads) (Specimen 19, male)

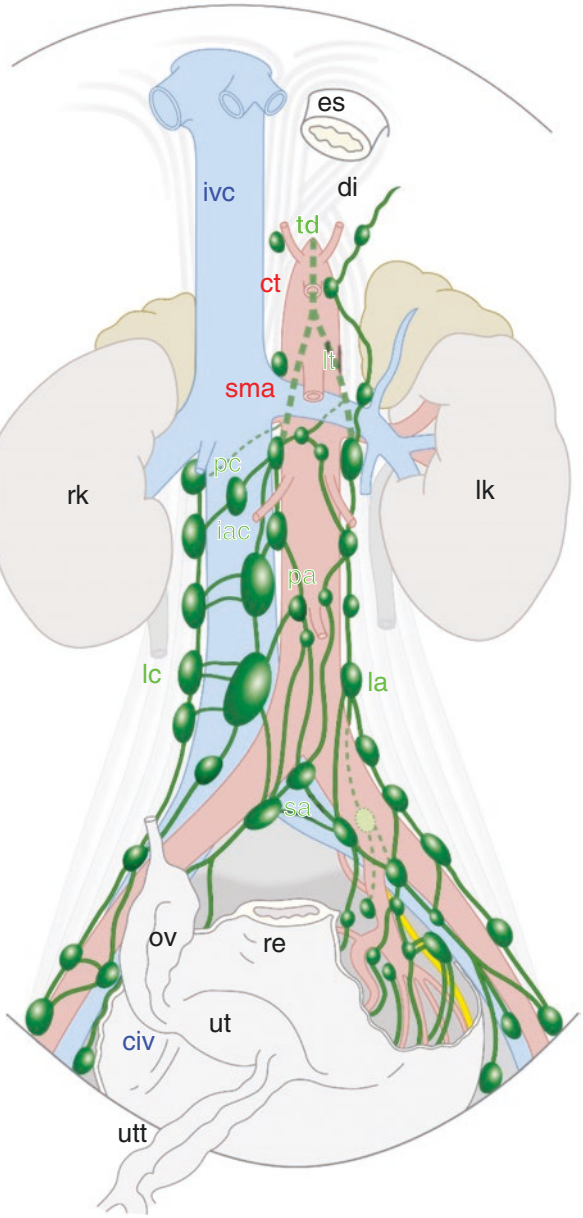

Fig. 2.38 Para-aortic lymphatics. This excellent scheme is taken from a textbook of anatomy of the lymphatic system (Rouvière) [1]

the other hand it sends three thick lymph vessels to the lateral aortic, interaorticocaval, and lateral caval lymph chains. In other words, the subaortic node is not only the ending point of the iliac chains but also the beginning point of the para-aortic chains. The left lateral common iliac chain continues to the lateral

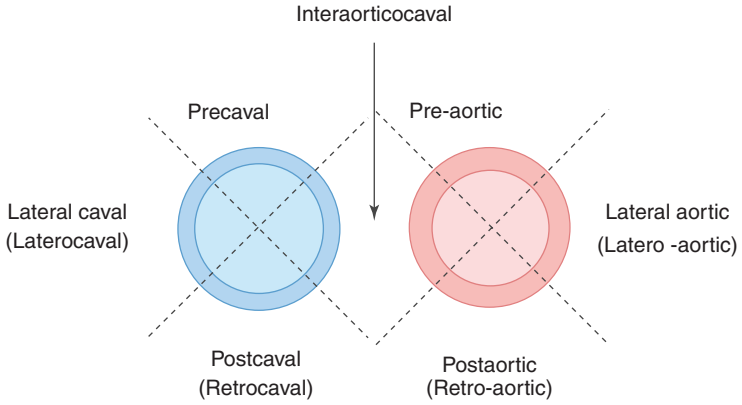

Fig. 2.39 Para-aortic node classification. Scheme showing a cross-section classification of the para-aortic nodes (Japanese Classification of Gastric Cancer [3]). Terms within parentheses are taken from Rouvière [1]

aortic chain, while the right corresponding chain is connected to the lateral caval chain (Fig. 2.36). The three lymph chains are connected to each other in front of as well as behind the two great vessels, and many nodes are detected in this communication network (Figs. 2.36 and 2.37 [33]). Therefore, the abdominal aortic nodes can be schematically subdivided into seven nodes: lateral aortic (latero-aortic), preaortic, retroaortic (postaortic), interaorticocaval, precaval, retrocaval (postcaval), and lateral caval (laterocaval) nodes (Fig. 2.38) [1], (Fig. 2.39) [3].

Accordingly, the abdominal aortic nodes are not simple para-aortic nodes, rather they are actually para-aorticocaval nodes. However, the paracaval chain gradually joins the para-aortic chain near the level of the left renal vein, and shifts posteriorly to eventually drain into the thoracic duct (Fig. 2.38). After removal of the abdominal aorta, the retroaortic lymphatics can be seen (Fig. 2.40 [32]). At about the level of the renal blood vessels, the para-aortic lymphatics gather to form two major lymphatic trunks, the lateroaortic trunk and the interaorticocaval trunk. These two trunks form the left and right lumbar trunks which unite to form the thoracic duct (Figs. 2.38 and 2.40). It has been described in textbooks that at the gathering point of the two trunks, in other words, the origin of the thoracic duct, the duct appears dilated (cisterna chili). However, in our dissections, this dilatation formation is rather rare, as seen in Fig. 2.40.

Another critical problem is the relationship of the para-aortic and inferior mesenteric chains to the autonomic nerve plexus (Fig. 2.37). Descending nerves from the coeliac plexus mainly join the inferior mesenteric plexus. Below the origin of the inferior mesenteric artery, the right and left lumbar splanchnic nerves, which originate from the lumbar parts of the sympathetic trunks, unite to form the superior hypogastric plexus. This plexus divides again into the right and left hypogastric nerves which join the pelvic plexuses. The para-aortic lymphatics are closely related to these nerve networks surrounding

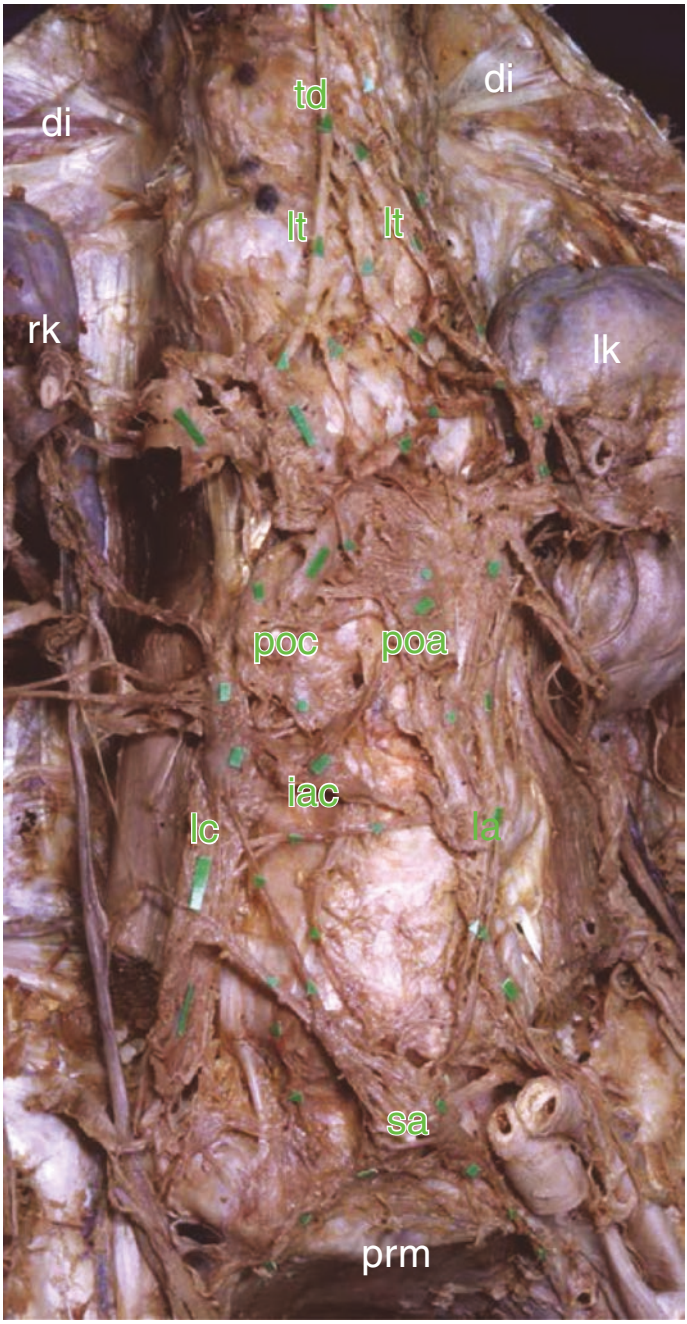

Fig. 2.40 Para-aortic lymphatics and the formation of the thoracic duct. After the removal of the abdominal aorta, the postaortic nodes and their communications with other lymphatics can be seen. As the aortic hiatus of the diaphragm has been opened, the formation of the thoracic duct is seen slightly superior to the kidneys (Specimen 20, male)

the lower abdominal aorta (Fig. 2.37). The intimate relationship of these nerves and lymphatics is very critical in rectal cancer surgery from the viewpoint of urinary and sexual functions.

2.2 Conclusion

In this chapter a pictorial demonstration of actual dissection findings of the lymphatics of the esophagus, stomach, colon, and rectum were described. In those descriptions, the following regional features of the arrangement of the lymphatics were included.

Regarding the lymphatics of the esophagus, the right ascending chain is generally more well developed than the left chain which runs anterior to and close to the left recurrent laryngeal nerve. Some esophageal lymph vessels may drain into the thoracic duct. Lymphatics of the lower thoracic esophagus continue to the gastric lymphatics via the superior diaphragmatic nodes close to the esophagus.

The lymphatics of the stomach typically run along the branches of the coeliac trunk to reach the coeliac nodes. The lymph vessels run along the right gastroepiploic blood vessels; however, they do not accompany the gastroepiploic artery, rather they run along the corresponding vein to reach the superior mesenteric nodes.

The lymphatics of the colon are divided into two pathways: that from the right hemicolon drains into the superior mesenteric nodes, whereas that from the left hemicolon reaches the inferior mesenteric nodes.

Regarding the lymphatics of the rectum, in addition to the superior (ascending) lymphatics along the superior rectal artery, the lateral (middle) lymphatics are critical. The lateral lymphatics first drain into the iliac nodes and/or presacral nodes and finally reach the subaortic nodes.

Drawings and photographs of actual dissections have been included to facilitate ease of understanding to achieve overall comprehension and to contribute to the precise knowledge of lymphatics. It is hoped that these additions will substantially contribute to the wide-encompassing significance of the lymphatics—a key to optimal surgical performance.

Acknowledgments I'm deeply indebted to all of my colleagues, and, in particular, Prof. K. Sato, Prof. H. Sakamoto, Dr. H. Deki, and Dr. M. Ito, for their expert dissection skills to make such remarkable figures possible. I also wish to thank Mr. M. Kohga for his excellent artistic skills to create meaningful precise schemes.

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