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TEACHING ANATOMY

Pictorial dissection review of the lymphatic pathways from the gallbladder to the abdominal para-aortic lymph nodes and their relationships to the surrounding structures

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Abstract
Purpose This photographic review of actual dissections was compiled to demonstrate the various lymphatic pathways and their relationships to the surrounding structures to facilitate the development of QOL surgical procedures.
Methods For the purpose of demonstration, three male adult specimens, prepared with 10 % formaldehyde solution injected through the femoral artery and preserved in 60 % alcohol solution, were used. Dissection was carried out in typical fashion without the use of dyes or a microscope. The dissection results were recorded in sketches, photographs and video recording.
Results Two major lymphatic pathways from the gallbladder are demonstrated: (a) the left oblique pathway to the celiac nodes, and (b) the right descending pathway to the superior retropancreaticoduodenal node (Rouvière). A third and minor pathway to the superior mesenteric nodes is suggested.
Conclusions These three pathways finally reach the para-aortic (lumbar) lymph nodes. The importance of the interaorticocaval nodes at the level of the left renal vein should be emphasized, in particular the significance of the nodes of the right descending pathway, from the viewpoint of surgical treatment of cancer of the gallbladder and the pancreas head.

Keywords Lymphatic pathway of gallbladder · Lymph node of epiploic foramen · Interaorticocaval lymph nodes · Relationships between lymphatics and nerves of posterior pancreas head · Lymphatics in cancer surgery

Introduction

To design optimal QOL procedures for cancer operations, it is critical to study the regional lymphatics and their pathways to the main lymphatics as well as the relationships to other structures, especially those to the autonomic nerves. For over a century, lymphatics have been recognized to be of significant importance. Numerous famous textbooks have included suggested lymphatic pathways [1, 2, 9–11, 14, 15], while these works have been of great educational value, unfortunately the illustrations are relatively basic and lacking clarity and, thus, it is difficult to apply these suggested pathways to the novel QOL medical procedures of today. Therefore, we want to provide clear detailed illustrations and photographs to offer a precise basis upon which new procedures can be designed.

For the past 15 years, we have made video recordings of actual detailed dissection procedures investigating the lymphatics and autonomic nerves of regions typically affected by cancer [16–18]. These dissection recordings have allowed view of structural relationships promoting overall comprehension of topography for use in education, as well as for the design of novel QOL techniques. Here, we present photographs from the actual dissection recordings of the descending lymphatics from the gallbladder to the abdominal para-aortic nodes (lumbar nodes;

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Terminologia Anatomica 1998 [5]) and then finally, to the thoracic duct.

Findings

Probable descending lymphatic pathways

First, we will consider the probable expected pathways for the descending lymphatics from the gallbladder. As lymphatics in general accompany the organ's pedicle (duct and vascular vessels), the expectation for these gallbladder lymphatics would be that they follow these structures. Although there are three possible pathways for the gallbladder lymphatics to reach the para-aortic lymph nodes, the first two are the main pathways: (a) that from the gallbladder along the hepatic artery to the celiac lymph nodes, (b) that which first descends along the bile duct and then runs on the posterior surface of the pancreas head, and (c) the lesser known pathway which descends along the portal vein to reach the superior mesenteric vein and then enters the superior mesenteric nodes.

Demonstration of the lymphatic pathways from the gallbladder

A rich lymphatic plexus is seen on the gallbladder neck; however, the typical cystic nodes are not seen. Lymphatics run along the cystic artery and hepatic artery to reach the nodes around the celiac trunk and then they descend to the para-aortic nodes which are located along the left and right margins of this vessel at the level of the left renal vein.

Some of the cystic lymphatics descend along the right margin of the common bile duct and reach a lymph node at the area which is slightly above the upper margin of the pancreas head. This is the node of epiploic foramen of Rouvière [15] (node of anterior border of omental foramen [5]). Lymphatics from this node will be shown.

In Fig. 1, a small node is detected along the left margin of the portal vein near the angle formed by this vessel and the splenic vein. This node is provisionally called the *preportal node* (Ito et al. [6]).

The hepatic veins have been cut at their entry into the inferior vena cava, and the liver, hepatic pedicle, pancreas head and duodenum have been reflected to the left. On the posterior surface of the portal vein, numerous lymph vessels with some lymph nodes are seen. On the posterior pancreas, head numerous lymph vessels relayed by many lymph nodes run transversely to converge at the interaorticocaval area (Fig. 2).

At the crossing of the portal vein and the upper margin of the pancreas head, there is a large node group that was called by Rouvière, the superior group of the retropancreaticoduodenal nodes [15]. Lymph vessels from the epiploic foramen node drain into this node group, directly or via a large adjacent node on the posterior surface of the pancreas. From the retropancreaticoduodenal node group numerous lymph vessels drain into the interaorticocaval nodes (intermediate lumbar nodes [5]) just above and below the left renal vein.

Gallbladder lymphatics gather at the cystic node, which is located at the neck of the gallbladder. This node is sometimes called as the node of the cystic neck. From this node, several lymph vessels descend to reach the epiploic foramen node at the right margin of the bile duct (Fig. 3).

The hepatic pedicle and pancreas head have been reflected, as in Specimen 1. In this case, lymph vessels on the posterior surface of the hepatic pedicle and on the posterior pancreas head are well developed. From the epiploic foramen node, a few lymph vessels drain into the superior retropancreaticoduodenal node of Rouvière. From this Rouvière's node, several lymph vessels run to the interaorticocaval lymphatics just above and below the left renal vein. In addition, lymph vessels from the lower end of the epiploic foramen node first drain into the superior retropancreaticoduodenal node and then into the posterior pancreaticoduodenal nodes before reaching the interaorticocaval nodes at the level of the left renal vein. In this specimen, the superior retropancreaticoduodenal node is not as well developed as in Specimen 1, and in fact, some lymph vessels from the lower end of the epiploic foramen node directly drain into the posterior pancreaticoduodenal nodes and then into the interaorticocaval nodes (Fig. 4).

As in Specimens 1 and 2, the posterior lymphatics of the hepatic pedicle and pancreas head are well developed; they converge to the large superior retropancreaticoduodenal node. From this node, several lymph vessels run to the interaorticocaval nodes above and below the left renal vein (Fig. 5).

The lymphatic network has been carefully removed and the autonomic nerve plexus has been dissected. At the right side of the root of the superior mesenteric artery, the right celiac ganglion can be seen. From this ganglion, rather thick hepatic branches ascend along the bile duct and portal vein to reach the porta hepatis. From these branches, numerous twigs are distributed to the posterior surface of the pancreas head. In general, the nerve plexus is located deep to the lymphatic network, thereby suggesting a more intimate relationship between the pancreas surface and the nerve plexus (Fig. 6).

Discussion

Cystic node (node of the gallbladder neck)

It has been said that the cystic node is found in almost all specimens (47/50, 94 %) [20]. In his textbook, Kutsuna [11]

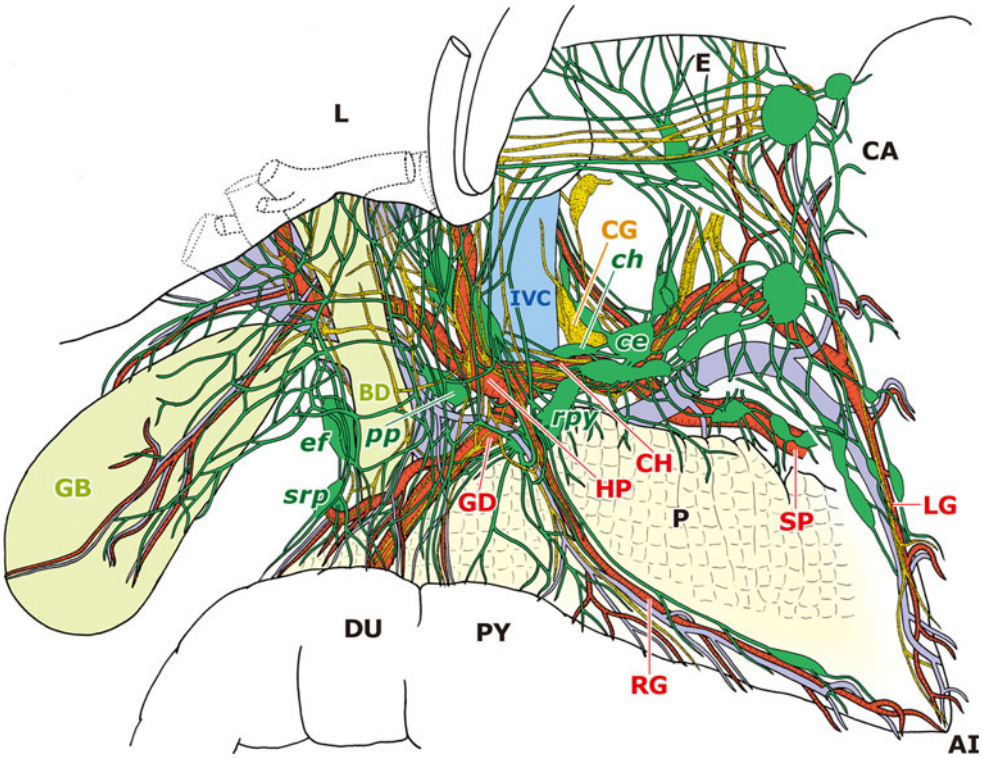

Fig. 1 *Anterior view* of the dissection of a male adult subject (specimen 1) [6]. Illustration of dissection findings of the lymphatics surrounding the gallbladder in Specimen 1 (male) after removal of the lesser omentum (*anterior view*). AI angular incisure, BD bile duct, CA cardia, CG celiac ganglion, CH common hepatic artery, DU duodenum, E esophagus, GB gallbladder, GD gastroduodenal artery, HP hepatic artery proper, IVC inferior vena cava, L liver, LG left gastric artery, P pancreas, PY pylorus, RG right gastric artery, SP splenic artery, *ce* celiac node, *ch* common hepatic node, *ef* node of epiploic foramen (node of anterior border of omental foramen), *pp* preportal node, *rpy* retropyloric node [6], *srp* superior retropancreaticoduodenal node (Rouvière)

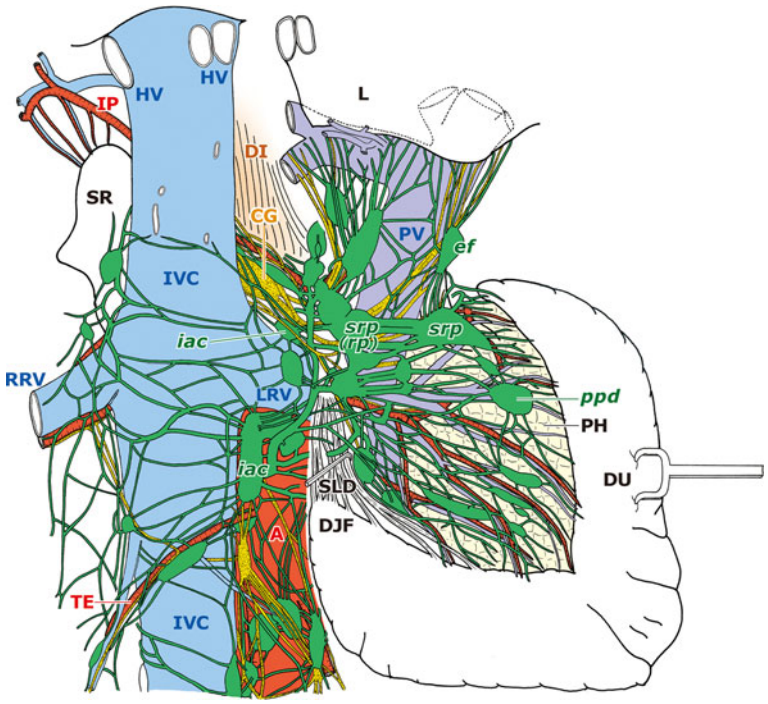

Fig. 2 *Posterior view* of the pancreas head and hepatic pedicle of specimen 1 [6]. Illustration of dissection findings of the lymphatics surrounding the gallbladder in Specimen 1 after cutting the hepatic veins and reflection of the pancreas head to the *left* (*posterior view*). A, abdominal aorta; CG, celiac ganglion; DI, diaphragm; DJF, duodenojejunal flexure; DU, duodenum; HV, hepatic vein; IP, inferior phrenic artery; IVC, inferior vena cava; L, liver; LRV, left renal vein; PH, pancreas head; PV, portal vein; RRV, right renal vein; SLD, suspensory ligament of duodenum; SR, suprarenal gland; TE testicular artery; *ef* node of epiploic foramen (node of anterior border of omental foramen), *iac* interaorticocaval node (intermediate lumbar node), *ppd* posterior pancreaticoduodenal node, *rp* retroportal node [6], *srp* superior retropancreaticoduodenal node (Rouvière) *srp* superior retropancreaticoduodenal node (Rouvière)

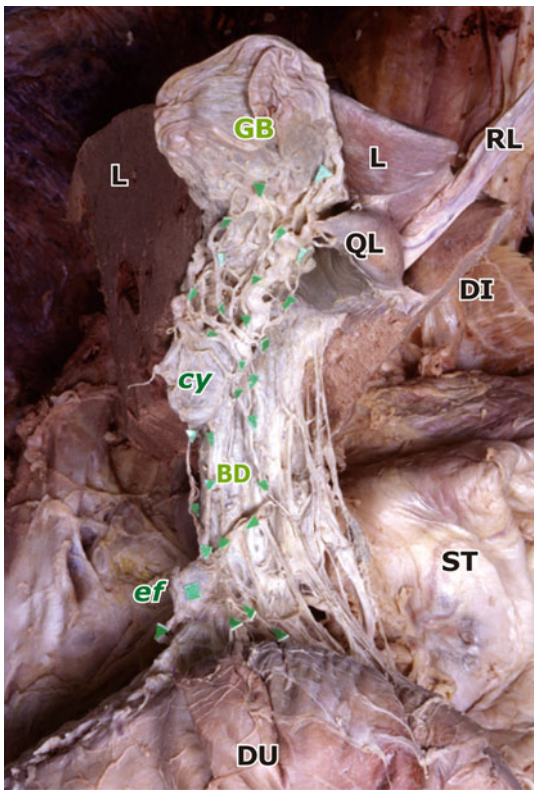

Fig. 3 *Anterior view* of the dissection of a different male specimen (specimen 2) [19]. Dissection photograph of the lymphatics of the gallbladder in Specimen 2 after the gallbladder was reflected upwards to show the cystic node (male) [19]. BD, bile duct; DI, diaphragm; DU, duodenum; GB, gallbladder; L, liver; QL, quadrate lobe; RL, round ligament of liver; ST, stomach; *cy* cystic node, *ef* node of epiploic foramen (node of anterior border of omental foramen)

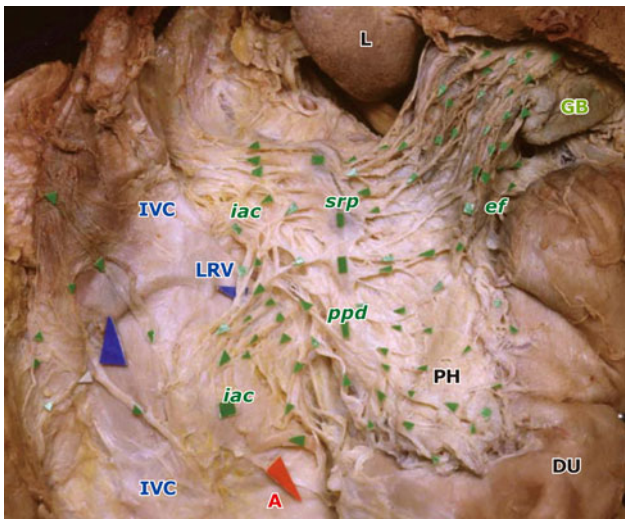

Fig. 4 *Posterior view* of the pancreas head and hepatic pedicle (specimen 2) [19]. Dissection photograph of the lymphatics of the gallbladder in Specimen 2, after reflection of the pancreas head to the *left* (*posterior view*) (see also Fig. 2) [19]. A, abdominal aorta; DU, duodenum; GB, gallbladder; IVC, inferior vena cava; L, liver; LRV, left renal vein; PH, pancreas head; *ef* node of epiploic foramen (node of anterior border of omental foramen), *iac* interaorticocaval node (intermediate lumbar node), *ppd* posterior pancreaticoduodenal node, *srp* superior retropancreaticoduodenal node (Rouvière)

described that this node is always found. However, in his illustration in the same textbook, there is no cystic node in the drawing. Ito et al. [6] found a cystic node in only 1 of 4 specimens. Therefore, a careful statistical study with many specimens is necessary to clarify the true frequency of this node.

Descending pathways

It is important to consider the descending pathways of the cystic lymphatics. In general, lymphatics of a certain organ run along the duct from the organ and/or along the corresponding blood vessels. From the viewpoint of accompanying structures, two main pathways of gallbladder lymphatics are possible: (a) a pathway along the cystic and hepatic arteries to reach the area surrounding the celiac trunk (left oblique pathway), and (b) a pathway descending along the cystic duct and common bile duct to reach the posterior surface of the pancreas head, and join the retropancreatic lymphatics (right longitudinal pathway). In the illustration of Kutsuna (Fig. 312) in Nishi's atlas [13], only the first pathway is shown. Interestingly, in Rouvière's textbook (Fig. 84 [15]) both pathways are shown. Therefore, we need to determine which pathway is dominant. In the case of the second pathway, it will be important to determine what relationship it has with the lymphatics of the posterior pancreas head. In addition, it must be clarified how this pathway reaches the para-aortic lymph nodes from the posterior surface of the pancreas head.

Kutsuna [11], in his textbook, described that the second pathway is dominant; however, no illustration or detailed statistics were included. However, Rouvière [15] provided a beautiful illustration of the second pathway and discussed that this pathway is dominant. Rouvière described the node of the epiploic foramen (his ganglion de l'hiatus), located within the lesser omentum at the free margin along the common bile duct. He emphasized the importance of this node as an intermediary node within the second pathway. This node was first officially recognized in *Terminologia Anatomica* in 1998 [5] as "nodus foraminalis" (node of the anterior border of the omental bursa). Ito et al. [6] found the typical version of this node in only 1 of 4 specimens; however, in the other three specimens the lymphatics directly connected to the upper group of the superior retropancreaticoduodenal nodes of Rouvière, not via the epiploic foramen node.

Lymphatics of the head of the pancreas

Regarding the lymphatics of the head of the pancreas, there are numerous varied means of classification and terms. The

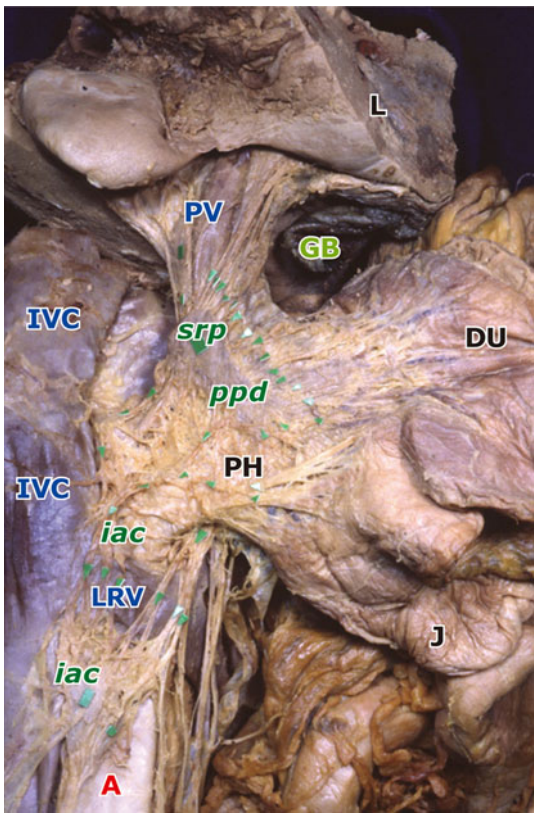

Fig. 5 Lymphatics on the *posterior surface* of the pancreas head (specimen 3, male) [19]. Dissection photograph of the lymphatics of the posterior pancreas head and the *posterior surface* of the hepatic pedicle. The pancreas head and liver were reflected to the *left* after cutting the hepatic veins. A, abdominal aorta; DU, duodenum; GB, gallbladder; IVC, inferior vena cava; J, jejunum; L, liver; LRV, left renal vein; PH, pancreas head; PV, portal vein; *iac* interaorticocaval node (intermediate lumbar node), *ppd* posterior pancreaticoduodenal node, *srp* superior retropancreaticoduodenal node (Rouvière)

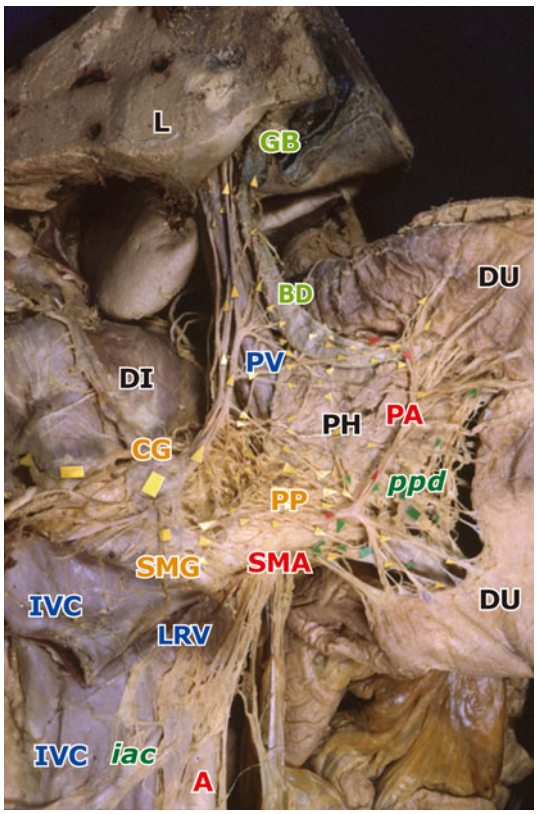

Fig. 6 Relationships between the lymphatics and the autonomic nerve plexus on the posterior surface of the pancreas head (specimen 3) [19]. The celiac ganglion and its distribution to the posterior surface of the pancreas head and to the liver were dissected, after removal of the lymphatics of the posterior pancreas head. A, abdominal aorta; CG, celiac ganglion; DI, diaphragm; DU, duodenum; GB, gallbladder; IVC, inferior vena cava; L, liver; LRV, left renal vein; PA, posterior pancreacoduodenal arcade; PH, pancreas head; PP, pancreatic plexus; PV, portal vein; SMA, superior mesenteric artery; SMG, superior mesenteric ganglion; *iac* interaorticocaval node (intermediate lumbar node), *ppd* posterior pancreaticoduodenal node

generally accepted terminology of the nodes of the pancreas head [5] simply considers superior and inferior description and gives no consideration to the anterior and posterior subdivisions. However, the detailed study of Deki and Sato [4] shows the importance of the consideration of the difference between the anterior and posterior node drainage. The lymphatics from the upper third of the anterior pancreas head drain into the celiac nodes, while those of the lower two-thirds drain into the superior mesenteric nodes. However, the posterior lymphatics drain into the interaorticocaval nodes. Therefore, it is imperative that the classification of these nodes is more specific to include anterior and posterior divisions.

Retropancreaticoduodenal nodes of Rouvière

The pancreaticoduodenal nodes of the posterior group are divided into upper and lower groups ([5], Japanese classification of gastric carcinoma [8] and general rules for the study of pancreatic cancer of Japan [7]). Rouvière emphasized the importance of the node along the upper margin of the pancreas head, and termed it as the superior retropancreaticoduodenal node (ganglion rétro-duodéno-pancréatique supérieur) [15]. Based on its importance and critical intermediary location in hepatobiliary lymph drainage, this node should be stressed and it seems important to designate this node by a specific term, so that it might be readily recognized by those performing hepatopancreaticobiliary surgical procedures.

In Fig. 2, there are two large nodes along the upper margin of the posterior pancreas head. The right node, located at the crossing of the bile duct and pancreas upper margin, directly receives lymph vessels from the node of the epiploic foramen. The left node, located behind the portal vein (principal retroportal node of Ito et al. [6]), receives lymph vessels from the posterior pancreas head,

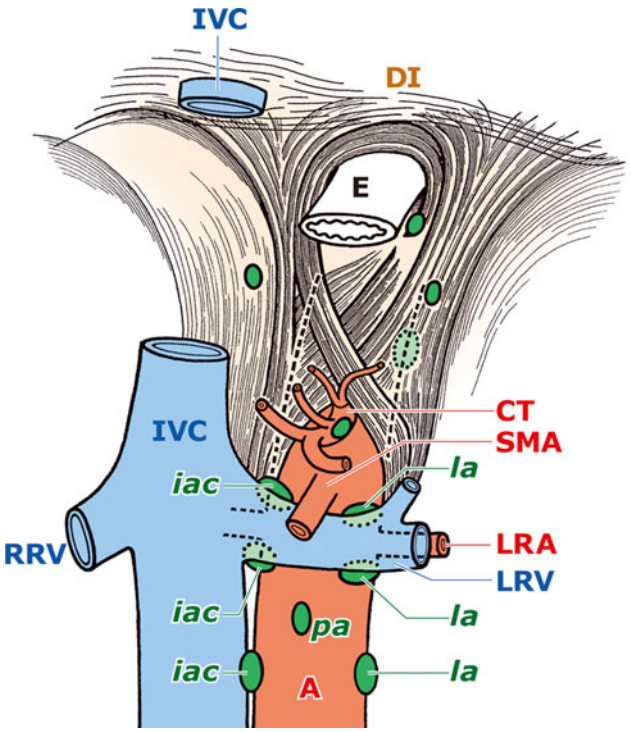

Fig. 7 A scheme from the Japanese classification of gastric carcinoma, showing the upper para-aortic nodes with reference to the left renal vein [8]. A, abdominal aorta; CT, celiac trunk; DI, diaphragm; E, esophagus; IVC, inferior vena cava; LRA, left renal artery; LRV, left renal vein; RRV, right renal vein; SMA, superior mesenteric artery; *iac* interaorticocaval node (intermediate lumbar node), *la* latero-aortic node (lateral aortic node), *pa* pre-aortic node

the above-mentioned right node and also from liver lymphatics. In another specimen of Ito et al. [6] these two nodes were fused. These nodes also received lymphatics of the posterior pancreas head; in addition, the left node received lymphatics from along the portal vein.

Interaorticocaval nodes

From these critical nodes lymphatics originate to reach the interaorticocaval nodes just above and below the left renal vein, as already illustrated back in the eighteenth century by Mascagni [12]. The point to be emphasized is the fact that the left renal vein is a critical structure. Abdominal para-aortic nodes at the bifurcation of the aorta surround not only the aorta, but also the inferior vena cava. However, the ascending lymphatics gradually converge around the aorta because these lymphatics finally drain into the thoracic duct, which is located behind the aorta. The four angles at the crossing corners of the left renal vein and aorta are important areas of lymphatics conversion before reaching the thoracic duct. Figure 7, taken from the Japanese classification of gastric carcinoma [8] (English language journal version [3]), shows the para-aortic nodes and emphasizes the importance of the latero-aortic and interaorticocaval nodes which lie immediately above and below the left renal vein. These nodes are the final collecting nodes for lymphatics from the upper abdominal organs before reaching the thoracic duct. Regarding the pathways from the gallbladder lymphatics, the left pathway runs via the celiac nodes and descends to the para-aortic nodes of both groups. However, the right pathway runs via the epiploic foramen node and superior retropancreaticoduodenal node of Rouvière to drain primarily into the interaorticocaval nodes.

Pathways along the portal vein to the superior mesenteric nodes

We studied the right and left pathways along the bile duct; interestingly at the liver hiatus, three ducts pass through. The final duct is the portal vein. Therefore, the lymphatics along the portal vein are the next pathways to elucidate. In the article and figures of Ito et al. [6; see Figs. 1, 3, 4], there is a small node (node F) located in front of the portal vein, just above the angle between this vein and the splenic vein. This node receives many thin lymph vessels from the porta hepatis and the gallbladder neck. They provisionally termed this node as the "principle portal node". From this node, several lymph vessels descend along the portal vein and the left margin of the superior mesenteric vein to reach lymph nodes surrounding the superior mesenteric artery. This pathway, which includes node F, may be termed as the "mesenteric pathway" and it is likely to be a minor pathway due to the compression of the immediate surrounding structures. To date, this pathway has not been recognized in the literature.

Conclusion

In conclusion, lymphatic pathways from the gallbladder may be classified into three descending pathways (two major and one minor): (a) left oblique pathway to the celiac nodes, (b) right longitudinal pathway to the superior retropancreaticoduodenal nodes (Rouvière), and (c) intermediate mesenteric pathway. The first and second pathways are the major pathways. It is important to note that the second pathway finally reaches the interaorticocaval nodes just above and below the left renal vein.

Note: Some of the above figures, as well as the figures taken from the dissection DVD, were presented at the European Association of Clinical Anatomy meeting in Padova in 2011 [18].

Conflict of interest The authors declare that they have no conflict of interest.

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