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Pathways of lymph node involvement in upper abdominal malignancies: evaluation with high-resolution CT

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Abstract. The aim of this study was to enhance our understanding of the pathways of lymphatic spread of primary carcinomas in the upper abdomen by recognizing the development, configuration, and frequency of nodal enlargement in discrete anatomic regions. The study included 417 patients with histologically confirmed carcinomas (CC) of the stomach (n = 267), liver (n = 98), gallbladder (n = 25), and bile ducts (n = 27). All patients were studied by high-resolution CT and tumor extension to the lymph nodes of the subperitoneal space was clearly identified in 59 patients [33 with CC of the stomach, 8 with CC of the gallbladder, 3 with CC of the bile ducts, and 15 with hepatocellular carcinoma (HCC)]. In 47 of 59 patients this extension was confirmed by surgery or aspiration biopsy. Three discrete anatomic groups of lymph nodes were recognized producing a relatively distinct CT configuration when involved: (a) the hepatoduodenal seen in 49 patients; (b) the peripancreatic demonstrated in 33 patients; and (c) the aortocaval recognized in 16 patients. These groups of lymph nodes can be seen individually involved or in combination. Recognition of involvement of these nodes is important for correct diagnosis and staging of upper abdominal malignancies. The development of this involvement follows the natural flow of lymph via the lesser omentum to the retroperitoneal space.

Key words: Abdomen – Neoplasms – CT – Lymphatic system – Anatomy – Metastases – Omentum

Introduction

Peritoneal reflections – ligaments, mesenteries, and omenta – are well-known routes for spread of malignancies in the abdomen [1]. The role of CT for detection of this spread is well established. Recent reports confirm the ability of high-resolution CT to evaluate complex anatomic regions and structures such as the porta hepatis and lesser omentum [2–4]. Yet, there are few reports dealing with lymph node involvement at specific anatomic locations due to tumor extension in the upper abdomen, and these are limited to the perihepatic and hepatoduodenal region [5]. Furthermore, CT is not particularly sensitive in detecting all histologically positive nodes, unless they present an anteroposterior dimension of more than 10 mm and heterogeneous contrast enhancement [6]. However, lymph node enlargement at specific anatomic locations as well as the sequence of their involvement facilitate the diagnosis of lymphatic spread of disease which is important for staging, treatment, and prognosis. Therefore, we reviewed our cases of common upper abdominal malignancies examined by high-resolution CT to evaluate those with enlargement of the hepatoduodenal, peripancreatic and aortocaval lymph nodes. These groups of nodes represent steps of the lymphatic route for spread of carcinomas of the stomach, liver, gallbladder, and bile ducts utilizing the lymph vessels of the gastrohepatic ligament (GHL) and hepatoduodenal ligament (HDL) to the extraperitoneal space.

Methods

Medical records and CT examinations of 417 patients with histologically confirmed carcinomas (CC) of the stomach (n = 267), liver (n = 98), gallbladder (n = 25), and bile ducts (n = 27) collected over a period of 9 years were reviewed. Histologic confirmation of the primary lesion was obtained by surgery, endoscopy, needle aspiration or liver biopsy. The CT criteria of adenopathy were those established by previous authors [3, 6, 7], but these were slightly modified for our study as follows:

1. Discrete soft tissue nodule(s) with an anteroposterior diameter of more than 1.2 cm along the HDL (hepatoduodenal nodes – node of the foramen of Winslow)

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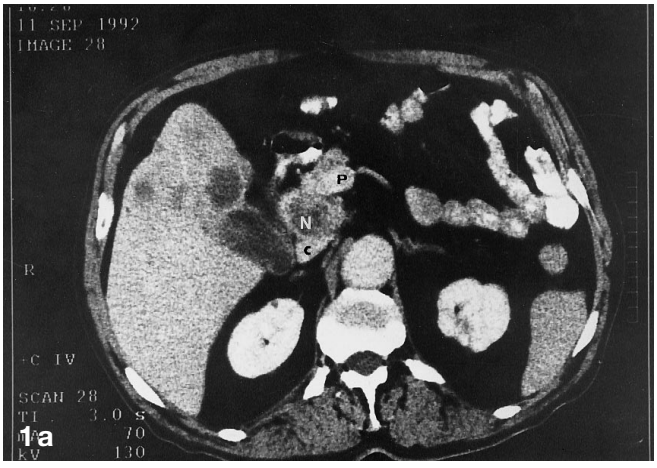
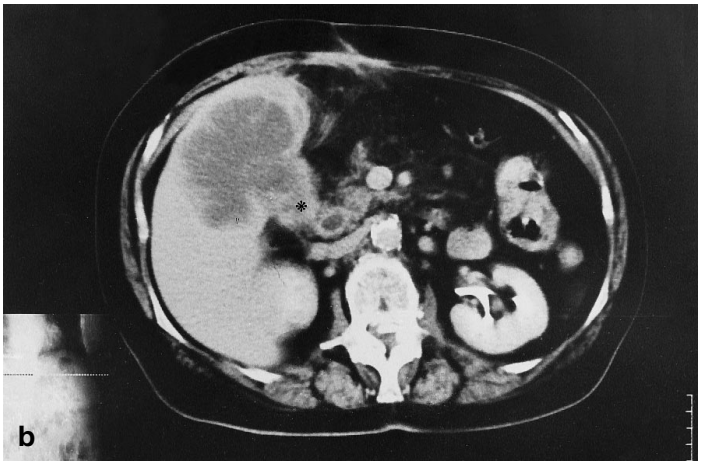
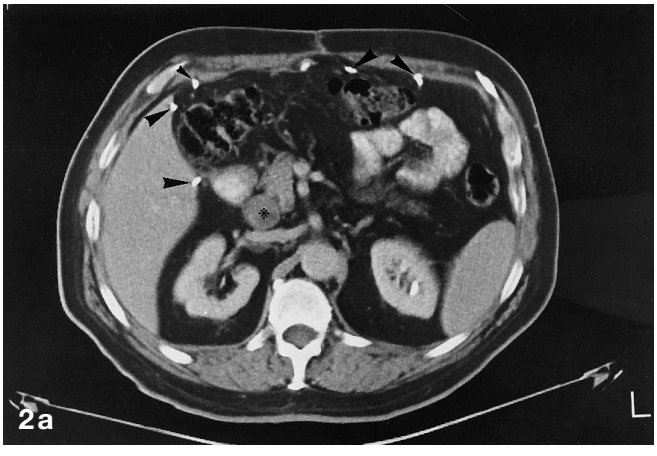
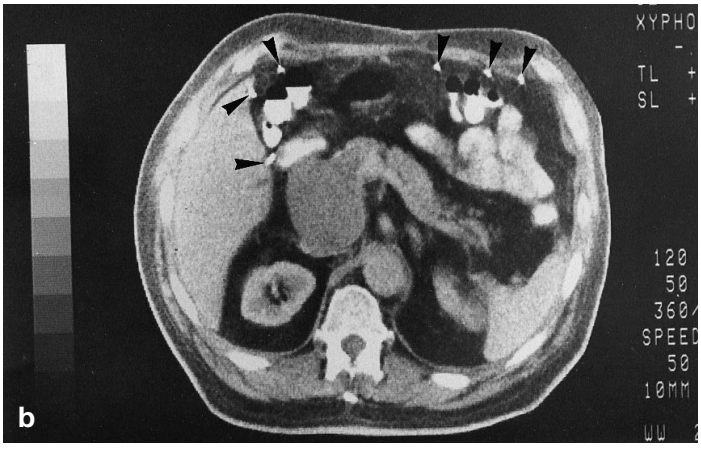








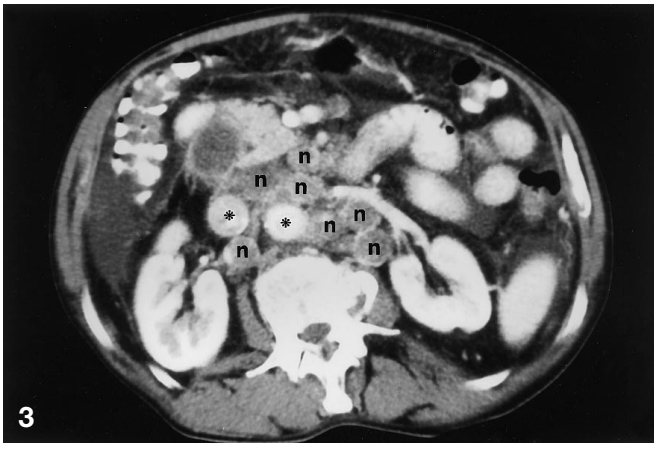


Fig. 1 a, b. Hepatoduodenal (step-I) involvement. **a** Gallbladder confirmed carcinoma (CC) with intrahepatic metastases in a 78-year-old man. Contrast-enhanced CT shows discrete involvement of the node of the foramen of Winslow *(N)* in the hepatoduodenal ligament (HDL) between portal vein *(P)* and inferior vena cava *(C)*. The node measures 2.8 cm and demonstrates inhomogeneous enhancement. **b** Cholangiocarcinoma infiltrating liver in a 67-year-old woman. Contrast-enhanced CT shows diffuse infiltration of the hepatoduodenal ligament (HDL; *asterisk*) causing effacement of its normal anatomic structures. In both cases histologic confirmation of tumor extension was obtained by aspiration biopsy

Fig. 2 a, b. Peripancreatic (step-II) involvement. Hepatocellular carcinoma in a 63-year-old man treated with regional chemotherapy (*arrowheads* point to surgically placed catheters). **a** CT at the level of the superior mesenteric artery shows an abnormal pancreaticoduodenal node *(asterisk)*. **b** CT at the same level 1 year later. Typical configuration of further enlargement of pancreaticoduodenal nodes simulating carcinoma of the head of the pancreas

Fig. 3. Aortocaval–retroperitoneal (step-III) involvement. Carcinoma of the stomach in a 65-year-old man. Contrast-enhanced CT scan through the level of the left renal pedicle demonstrates pathologically enlarged retroperitoneal nodes *(n)* between the aorta *(asterisk)* and the inferior vena cava *(asterisk)* simulating lymphoma. Aspiration biopsy disclosed adenocarcinoma probably from the stomach subsequently confirmed by endoscopy where an ulcerated lesion was found at the lesser curve near the gastroesophageal junction

and around the pancreas (peripancreatic nodes) demonstrating heterogeneous contrast enhancement
2. Round or oval soft tissue nodules > 1.3 cm in diameter, discrete or matted together with or without contrast enhancement, at the level of the renal vessels (aortocaval nodes) and > 0.6 cm in the retrocrural space (retrocrural nodes)
3. Diffuse soft tissue thickening effacing the anatomy of the HDL and/or the head of the pancreas

Due to the long duration (9 years) and the retrospective nature of this study, no uniform imaging parameters were available. However, all patients were examined on high-resolution scanners, capable of rapid data aquisition for dynamic and/or helical scanning. The scanners were the Somatom DR3 (Siemens, Erlangen, Germany), CT/T 9800 (GE Medical Systems, Milwaukee, Wis.), and SR7000 (Philips Medical Systems, Best, The Netherlands). Contiguous axial sections were obtained

Table 1. Number of patients per step of lymph node involvement

Primary carcinoma	No. of patients	Step I (hepatoduodenal)	Step II (peripancreatic)	Step III (aortocaval)	Combination
Stomach	33	23	18	13	18[a]
Gallbladder	8	8	3	–	3
Bile ducts	3	3	–	–	–
Liver	15	15	12	3	11[a]
Total no. of patients	59	49	33	16	32

[a] Three patients in each of these two groups demonstrated all three steps

with slice thickness of 3 or 5 mm at 3- to 5-mm intervals in all cases. Pre- and post-contrast scans were obtained routinely unless contraindicated. Rapid-sequence dynamic scans were obtained after an intravenous bolus injection of 100 mL of contrast material at 2 mL/s with interscan intervals of 2–3 s. Finally, the last 3 years of helical scanning was also employed in selected cases with 5-mm collimation, 5-mm/s table speed, and 3-mm reconstruction index. A total of 150 mL of nonionic contrast material (iopromide, Ultravist, Shering, Berlin, Germany) was injected using power injector at 4 mL/s.

Histologic confirmation of the extension was available within 2 weeks from diagnosis in 47 patients, from surgical specimens in 19, and from aspiration biopsy in 28. In 12 patients no surgery or biopsy was performed. Nevertheless, gross enlargement of regional lymph nodes (> 3 cm) seen on CT at the time of diagnosis in 6 patients, unlikely for reactive lymphadenopathy, or the development of regional lymph node enlargement within a follow-up of 8 months in 6 patients, were considered clinically sufficient evidence for tumor extension. Therefore, these cases were included in this report.

Abdominal CT examinations were independently reviewed by three experienced radiologists (S. E., N. V., E. Z.) in order to detect specifically if tumor extension was present along the lesser omentum to the lymph nodes in the subperitoneal space. Only cases in which there was unanimous agreement of the findings were included. Lymph node extension was classified into three recognizable anatomic steps:

1. Hepatoduodenal (step I), which involves the nodes in the HDL in the form of either discrete nodal involvement – usually of the node of Winslow – or diffuse nodal infiltration (Fig. 1)
2. Peripancreatic (step II), which involves the peripancreatic nodes – pancreaticoduodenal, celiac, superior mesenteric – and frequently gives the confusing appearance of pancreatic CC (Fig. 2)
3. Aortocaval (step III), which simulates retroperitoneal lymphoma because it involves extensively the nodes in the retroperitoneum (Fig. 3).

Results

Of the 417 patients included in this review, 358 had no evidence of lymph node enlargement. Surgical exploration of the nodes in the HDL and the peripancreatic region was performed in 53 of these patients and was also negative. However, lymph node involvement could not be excluded in the remaining 305 patients in whom surgical exploration was not performed.

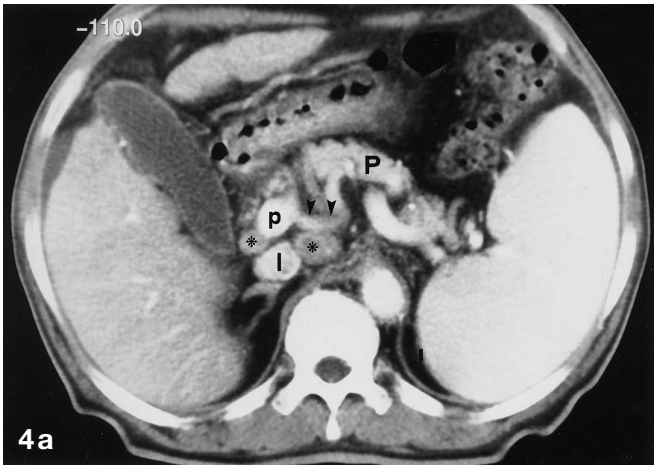
Table 2. Extralymphatic manifestations in patients with gastric confirmed carcinoma per step of lymph node involvement

Step[a]	Jaundice	Liver metastases	Ascites
I		1	
II	5	1	1
III		3	2

[a] In patients with two or three coexisting groups of lymph node involvement the case was assigned to the more advanced step

Fifty-nine patients demonstrated lymph node extension to one or more anatomic regions. Extension to the lymph nodes in the HDL (hepatoduodenal or step-I extension) was seen in 49 patients. Extension to the lymph nodes around the pancreas (peripancreatic or step-II extension) was demonstrated in 33 patients and extension to the nodes in the retroperitoneum initially at the level of the left renal vein (aortocaval or step-III extension) in 16. Twenty-six patients demonstrated a combination of lymph node involvement in two anatomic locations (Fig. 4), and in 6 cases all three groups of lymph nodes were involved, either at presentation or during follow-up examinations (Fig. 5). Table 1 summarizes the frequency that a particular group of nodes was involved in relation to the underlying malignancy in these 59 patients.

There were 33 patients (12.3 %) with gastric CC demonstrating lymph node extension. The hepatoduodenal group of nodes (step I) was involved in 23, the peripancreatic (step II) in 18, and the aortocaval (step III) in 13 patients. More extensive disease was related to two or even three groups of nodal involvement in 18 patients (Fig. 6). Histologic confirmation of involvement was obtained from surgical speciments in 11 (8 from the hepatoduodenal and 3 from the peripancreatic group) and by aspiration biopsy in 14 patients (6 from the hepatoduodenal, 5 from the peripancreatic, and 3 from the aortocaval group). In 2 of these 14 patients pancreatic carcinoma and diffuse retroperitoneal lymphoma were the initial diagnostic impression, respectively. The correct diagnosis of gastric CC was suggested only after aspiration biopsy of the lymph node extension and confirmed by endoscopic biopsy in both cases.



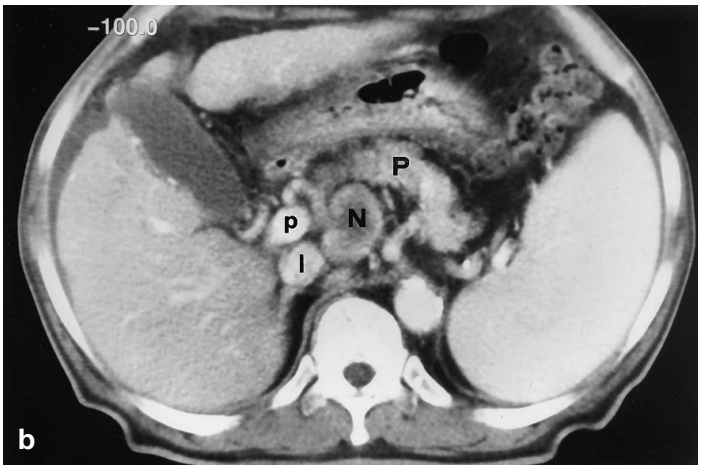
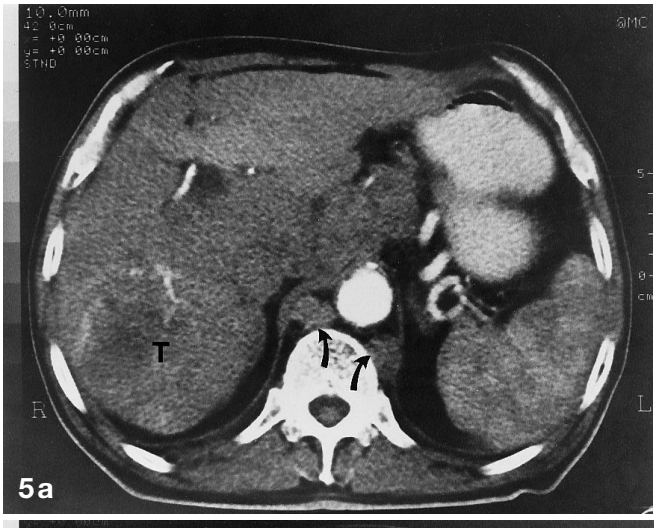


Fig. 4a, b. Hepatocellular carcinoma in a 70-year-old man demonstrating hepatoduodenal (step-I) and peripancreatic (step-II) lymph node involvement. **a** Contrast-enhanced helical-CT scan at the level of the HDL. *Arrowheads* point to the origin of the common hepatic artery. The cystic node *(asterisk)* near the neck of the gallbladder and the node of the foramen of Winslow *(asterisk)* in the portocaval space are clearly seen to be pathologically enlarged and enhanced. **b** Two centimeters lower, an abnormal posterior pancreaticoduodenal node *(N)* is demonstrated. *p* Portal vein; *I* inferior vena cava; *P* pancreas



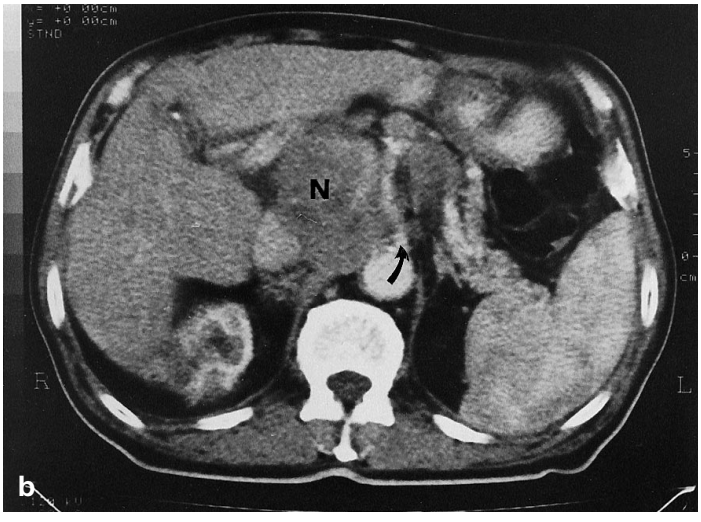
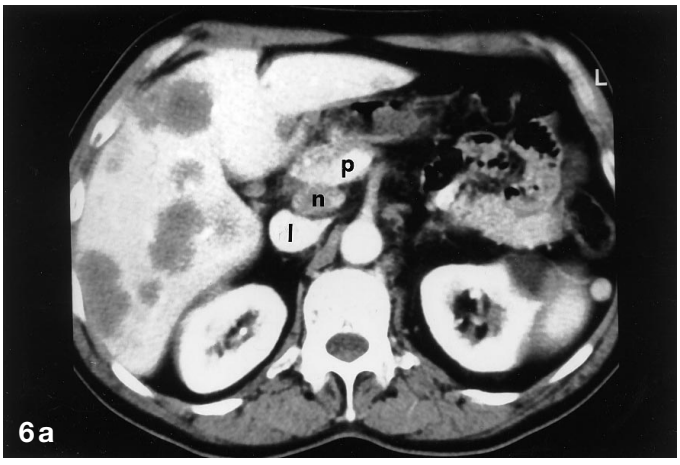
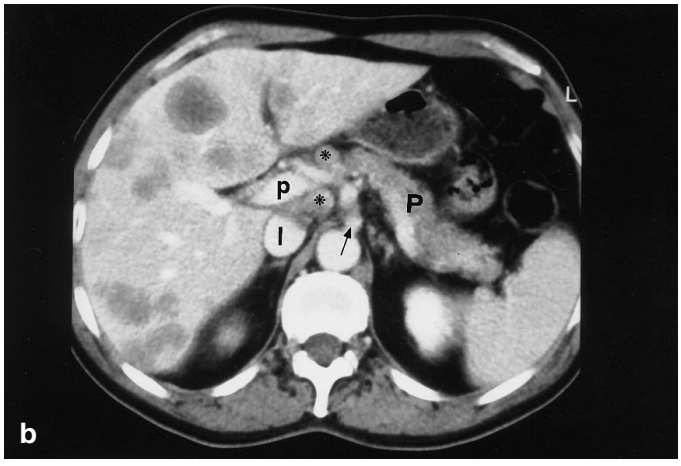
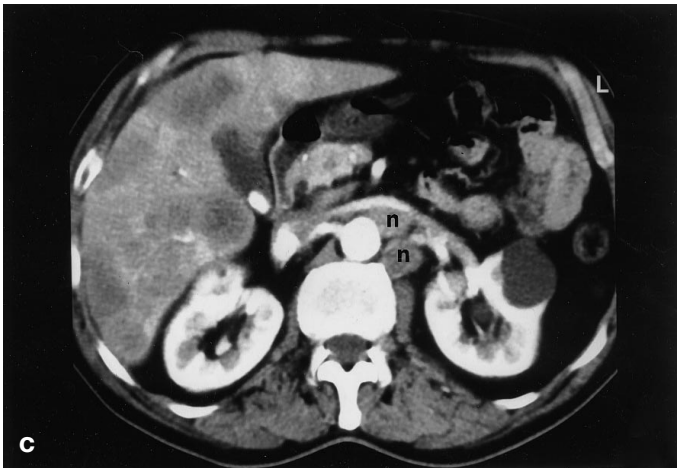


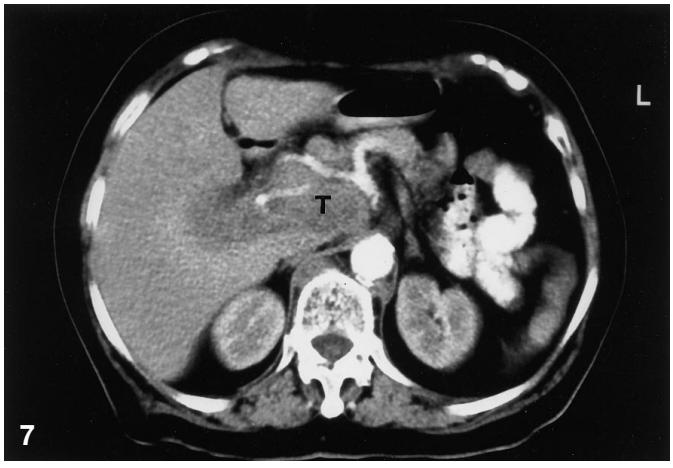
Fig. 5. Hepatocellular carcinoma in a 71-year-old male demonstrating all three steps of lymph node extension at presentation. **a** Contrast-enhanced CT at the level of the liver hilus. The tumor *(T)* causes diffuse infiltration of the lesser omentum and enlargement of the retrocrural nodes *(arrows)*. **b** Three centimeters lower. Enlarged nodes *(N)* around the head of pancreas and superior mesenteric artery *(arrow)*. **c** At the level of the right renal hilus. Multiple pathologically enlarged retroperitoneal nodes *(n)* matted together around the aorta *(asterisk)* and inferior vena cava *(asterisk)*. Histologic confirmation of extension of the primary lesion was obtained by aspiration biopsy from the "pancreatic" lesion and retroperitoneal nodes

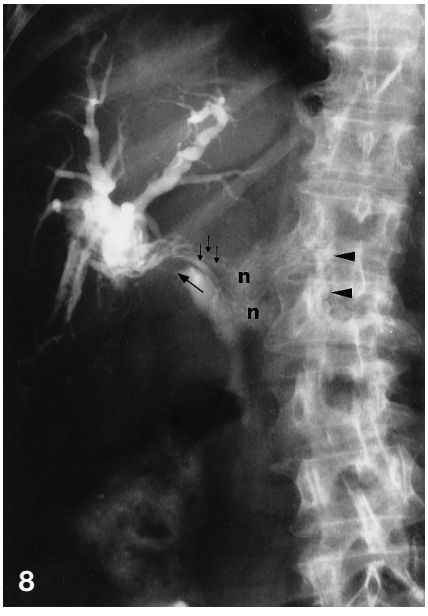
In 28 patients with gastric CC the pattern of nodal extension was present at diagnosis, whereas in 5 patients it developed between 3 and 6 months from diagnosis of the primary lesion. Bile duct obstruction with jaundice was seen in 5 patients and was always associated with step-II extension. Table 2 summarizes the incidence of bile duct obstruction, liver metastases, and ascites associated with lymph node extension in patients with gastric CC.











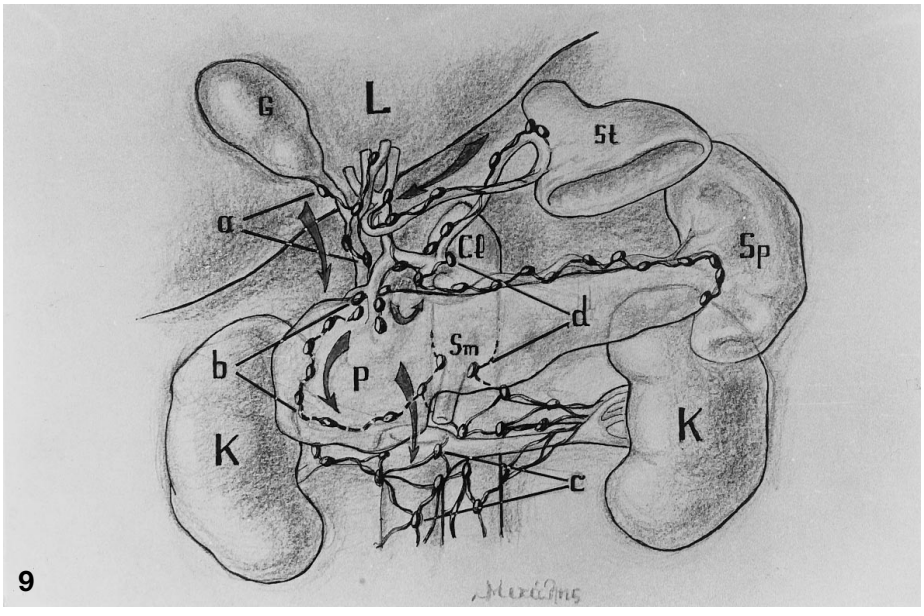


Fig. 6 a–c. Advanced CC of the stomach in a 60-year-old man with liver metastases demonstrating the hole spectrum of lymph node extension. **a** Contrast-enhanced helical scan at the level of the portocaval space shows an abnormal Winslow node *(n)*. **b** Two centimeters cephalad, two descrete peripancreatic lymph nodes *(asterisk)* are visualized around the celiac artery *(arrow)*. **c** CT scan at the level of the left renal vein on the same study demonstrates enlarged retroperitoneal lymph nodes *(n)*. *p* Portal vein; I inferior vena cava; *P* pancreas

Fig. 7. Gallbladder CC in a 65-year-old woman with jaundice simulating pancreatic carcinoma. Contrast-enhanced helical CT at the level of the origin of the celiac artery shows a tumor mass *(T)* in the anatomic region of the head of the pancreas diffusly infiltrating the HDL and effacing the tissue planes. Histologic confirmation of extension of gallbladder CC to the hepatoduodenal and peripancreatic nodes was obtained by aspiration biopsy of the apparent "pancreatic" mass

There were 8 patients (32%) with gallbladder CC and tumor extension to lymph nodes. The hepatoduodenal lymph nodes (step-I extension) were seen involved in all ceses, either in the form of discrete enlargement of the node of the foramen of Winslow (6 patients; Fig. 1) or in the form of diffuse nodal infiltration. In 3 patients with more advanced disease a coexisting involvement of the peripancreatic lymph nodes (step-II extension) was also observed. In fact, in 1 patient with jaundice and coexisting step-II extension, an erroneous diagnosis of pancreatic carcinoma with HDL extension was made. The correct diagnosis was possible only after aspiration biopsy from the apparent "pancreatic" mass (Fig. 7). Histologic confirmation of the HDL adenopathy was obtained by aspiration biopsy in two more patients and from surgical specimens in 4 patients. In the remaining patient in this group a step-I extension developed within 8 months from a post-surgical biopsy. No aortocaval (step-III) extension was seen among patients in this group.

In the 3 patients (11%) with cholangiocarcinoma, only hepatoduodenal extension was seen (Fig. 1b). This extension was in the form of diffuse nodal infiltration in all patients, and in all patients lymph node involvement was histologically confirmed (two from surgical specimen, one from aspiration biopsy).

Finally, there were 15 patients (15.3%) with hepatitis-B-related HCC and nodal dissemination. A step-I extension was demonstrated in all patients (11 with the discrete form). Nine patients demonstrated a coexisting peripancreatic (step-II) lymph node extension, and in 3 patients all three steps of extension were visualized (Fig. 5). Histologic confirmation of tumor extension was obtained from surgical specimen in 2 (from the hepatoduodenal group) and aspiration biopsy in 10 patients (4 from the hepatoduodenal, 5 from the peripancreatic, and 1 from the aortocaval group).

Discussion

Communications between abdominal lymph nodes via efferent lymph vessels coursing within peritoneal reflections can explain extensive abdominal nodal dissemination of a neoplastic disease once the regional nodes of organs afflicted with a malignancy are involved.

◀ **Fig. 8.** Inadvertent visualization of the lymphatic vessels tracing the lymphatic route from the hilus of the liver to the cisterna chyli during a transhepatic cholangiogram in a patient with gallbladder CC infiltrating the common hepatic duct *(arrow)*. Efferent lymphatic vessels draining the gallbladder and common hepatic duct enter the HDL *(arrows)*. In this serendipitous lymphangiogram the hepatoduodenal lymph nodes *(n)* from where efferent lymphatics empty into the cisterna chyli *(arrowheads)* bypassing the peripancreatic lymph nodes are visualized faintly

Fig. 9. Drawing of lymphatic drainage in the abdomen. *Arrows* point to the natural flow of lymph. *L* liver; *st* stomach; *G* gallbladder; *sp* spleen. *P* pancreas; *K* Kidneys; *cl* celiac artery; *Sm* superior mesenteric artery; *a* hepatoduodenal nodes; *b* pancreatoduodenal nodes; *c* aortocaval nodes; *d* celiac and superior mesenteric nodes

The lesser omentum provides an important natural pathway for communication of regional lymph nodes of the stomach with the nodes where the deep lymphatic system of the liver and the lymph vessels of the gallbladder and bile ducts empty (Fig. 8) [8]. Among these nodes, which extend along the HDL, the node of the foramen of Winslow is frequently involved and easily recognized [4, 9]. Grossly, efferent lymph vessels from the nodes in the HDL empty into the peripancreatic (pancreaticoduodenal, celiac, superior mesenteric) nodes from where efferent lymphatics empty into the aortocaval nodes, near the renal pedicle, in the retroperitoneum (Fig. 9). This implies that hepatoduodenal, peripancreatic, and aortocaval nodes represent intermediary steps of lymph flow from the regional nodes of the stomach, duodenum, liver, gallbladder, bile ducts, and pancreas to the cisterna chyli [10, 11].

In this report we searched for tumor extension along the lesser omentum to the hepatoduodenal, peripancreatic, and aortocaval group of lymph nodes. This might explain why size criteria for nodal enlargement slightly exceed those reported in the literature [4, 6], since 1.3 cm for HDL and 1.5 cm for retroperitoneal nodes were the smallest dimensions encountered for discrete nodes being part of a distinct pattern. Lymph node involvement of the aforementioned groups of nodes was encountered in 59 of 417 patients with histologically confirmed malignancies of organs in the upper abdomen.

This nodal involvement is not disease specific. It can be seen less frequently in lymph node metastases from other primary CC, such as colon or breast [12], as well as inflammatory diseases, notably chronic viral hepatitis [13]. In our series, however, nodal involvement was clearly demonstrated on CT in 12.3% of 267 patients with CC of the stomach (33 patients), 32% of 25 patients with CC of the gallbladder (8 patients), 11% of 27 patients with CC of the bile ducts (3 patients), and 15.3% of 98 patients with HCC (15 patients). Moreover, involvement of the peripancreatic and aortocaval group of lymph nodes can be confused with more commonly encountered malignancies, such as CC of the pancreas and diffuse retroperitoneal lymphoma, respectively, because of similar configuration in the same anatomic location [14]. This confusing configuration was seen at presentation in 2 patients with gallbladder CC and 1 patient with CC of the stomach, and in 2 patients, one from each case, pancreatic carcinoma was initially diagnosed both clinically and radiologically. The correct diagnosis was made only after aspiration biopsy in both instances. A false diagnosis of retroperitoneal lymphoma was also made in a case of gastric CC presenting with diffuse retroperitoneal adenopathy. The gastric lesion was subsequently recognized at endoscopy after aspiration biopsy from the retroperitoneal lymph nodes indicating metastatic adenocarcinoma. A more extensive differential diagnosis of the "pancreatic" mass or the diffuse retroperitoneal adenopathy would have included nodal dissemination of a malignancy demonstrating a peripancreatic or aortocaval extension.

In patients with gallbladder or HCC peripancreatic extension was not seen without concurrent involvement

of the hepatoduodenal lymph nodes. The same was also true in 8 patients with CC of the stomach, whereas in 6 patients (3 with gastric and 3 with HCC) the entire chain of hepatoduodenal, peripancreatic, and aortocaval lymph nodes were involved, indicating that these three steps represent a continuum of nodal involvement corresponding with the course of lymphatic drainage (Fig. 9). However, there were 7 patients with CC of the stomach who exhibited extension to the peripancreatic (step II) and aortocaval (step III) lymph nodes without involvement of the nodes in the HDL (step I) and, even more surprisingly, 3 more patients with CC of the stomach who demonstrated an isolated step-III pattern. There are several explanations to answer this apparent paradox. Firstly, we can hypothesize that HDL lymphadenopathy might be present in the first 7 patients but not identifiable on CT. It is well known that CT understages tumor extension especially in thin, debilitated patients. However, 5 of the 7 patients developed a peripancreatic and aortocaval extension a few months after either total or partial gastrectomy and there was no reference in the operative report of infiltration of the HDL nodes, for which the surgeon was specifically asked to look. Secondly, the presence or the development of peripancreatic or aortocaval nodal dissemination without involvement of the HDL nodes, although exceptional, is possible for two reasons. One reason is that lymph vessels not infrequently bypass some nodes and empty directly into lymph nodes further away, thus causing enlargement of groups of nodes which are not in actual contiguity [11]. Certainly, the patients who demonstrated a peripancreatic and aortocaval extension had the bulk of retroperitoneal adenopathy around the celiac and superior mesenteric artery and at the level of the renal hilus (Figs. 5, 6). Furthermore, surgical manipulations in the 5 patients with CC of the stomach might have mobilized these direct lymphatic communications bypassing the more "natural" lymphatic dissemination.

The other reason has to do with the anatomy of the GHL. Anatomically, the GHL joins the lesser curvature of the stomach with the left lobe and hilus of the liver and, also, it is a conduit from the gastroesophageal junction to the retrocrural (extraperitoneal) space [15], thus facilitating the spread of malignancies from the stomach to the hilus of liver, but also to the retrocrural space. Interestingly enough, the 3 patients with CC of the stomach who developed only an aortocaval extension and 1 of the 2 patients with HCC demonstrating involvement of all three groups of lymph nodes had, in addition, significant enlargement of the retrocrural nodes (Fig. 5 a).

Extension to the hepatoduodenal lymph nodes (step I) was the most frequently encountered. It was seen in 49 patients and was followed by the peripancreatic (step II) extension seen in 33 patients. Involvement of the aortocaval nodes (step III) was identified in 16 patients. This order of frequency relates to the natural flow of lymph in the vessels of the lesser omentum. A more advanced pattern was associated with more advanced stages of the disease. Therefore, complications such as jaundice, ascites, and liver metastases were mostly related to the two more advanced steps.

In conclusion, nodal dissemination of primary CC of the organs in the upper abdomen frequently involves lymph nodes in the HDL, the peripancreatic region, and the retroperitoneum. These nodes represent steps of the natural flow of lymph from the regional nodes of these organs to the cisterna chyli via lymph vessels in the lesser omentum. The differential diagnosis of enlargement of these groups of lymph nodes, separately or in combination, should include tumor extension from an occult carcinoma of the above organs. Conversely, in all patients with CC of the organs in the upper abdomen, these anatomic regions should always be searched for documentation of tumor extension and staging. Finally, selective involvement of the peripancreatic and aortocaval lymph nodes (steps II and III) can occur and mimic other common malignancies, such as pancreatic carcinoma and retroperitoneal lymphoma.

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