Acknowledgements

I have been extraordinarily fortunate to have worked with some of the most talented and outstanding academic radiologists in the country, who have served as exceptional mentors and role models. Dr. David Panicek first inspired me to think about variants and pitfalls in abdominal imaging, and he did his best to make me write plain and understandable English. Dr. Hedvig Hricak and Dr. Alexander Margulis selflessly provided advice and guidance when I moved to San Francisco in 1997, and I consider myself lucky to have worked with them. Dr. Ronald Arenson continues to be the fairest and most supportive Chair that one could hope to have. Without their influence and assistance, this book would not exist – and I am deeply indebted to them all. In addition, I would like to specifically thank Drs. Peter Callen, Peter Cooperberg, Diego Ruiz, and Judy Yee for their graciousness in sharing images from their case material for reproduction in this book.

CASE 1 Pseudolipoma of the inferior vena cava

Imaging description

Pseudolipoma of the inferior vena cava refers to the apparent presence of a fatty mass in the lumen of the inferior vena cava as it passes through the diaphragm from the liver into the right atrium. The appearance is a partial volume artifact due to a layer of fat that sits above the caudate lobe next to the inferior vena cava. The cava deviates to the midline as it passes from the liver into the right atrium, and depending on local anatomy and the phase of respiration, the fat above the caudate lobe can be partial volumed in such a way that it appears to be within the vessel (Figure 1.1) [1].

Importance

Pseudolipoma of the inferior vena cava may be mistaken for a true fat-containing tumor of the inferior vena cava, such as a lipoma or liposarcoma [2], resulting in unnecessary follow-up investigations and patient anxiety.

Typical clinical scenario

Pseudolipoma of the inferior vena cava has a reported frequency of 0.5% at abdominal CT [3], but this seems far higher than I would have expected based on my clinical experience. While pseudolipoma of the inferior vena cava can be seen in anyone, it is commoner in cirrhosis, presumably because there is a greater degree of anatomic distortion and potential for partial volume artifact due to shrinkage of the liver and greater deviation of the inferior vena cava as it passes through the diaphragm in these patients (Figure 1.2).

Differential diagnosis

Theoretically, a true lipoma or liposarcoma could arise as a primary intraluminal caval mass, but this has not been reported. Venous invasion by locally aggressive angiomyolipoma may cause a fatty tumor thrombus in the cava [4], but the presence of a renal mass with contiguous spread into the cava is distinctive and should not result in confusion with a pseudolipoma.

Teaching point

The appearance of fat in the lumen of the inferior vena cava as it passes through the diaphragm is a normal variant due to partial volume artifact and does not require additional testing.

REFERENCES

1 Han BK, Im JG, Jung JW, Chung MJ, Yeon KM. Pericaval fat collection that mimics thrombosis of the inferior vena cava: demonstration with use of multi-directional reformation CT. *Radiology* 1997; **203**: 105–108.

2 Perry JN, Williams MP, Dubbins PA, Farrow R. Lipomata of the inferior vena cava: a normal variant? *Clin Radiol* 1994; **49**: 341–342.

3 Miyake H, Suzuki K, Ueda S, et al. Localized fat collection adjacent to the intrahepatic portion of the inferior vena cava: a normal variant on CT. *Am J Roentgenol* 1992; **158**: 423–425.

4 Moulin G, Berger JF, Chagnaud C, Piquet P, Bartoli JM. Imaging of fat thrombus in the inferior vena cava originating from an angiomyolipoma. *Cardiovasc Intervent Radiol* 1994; **17**: 152–154.

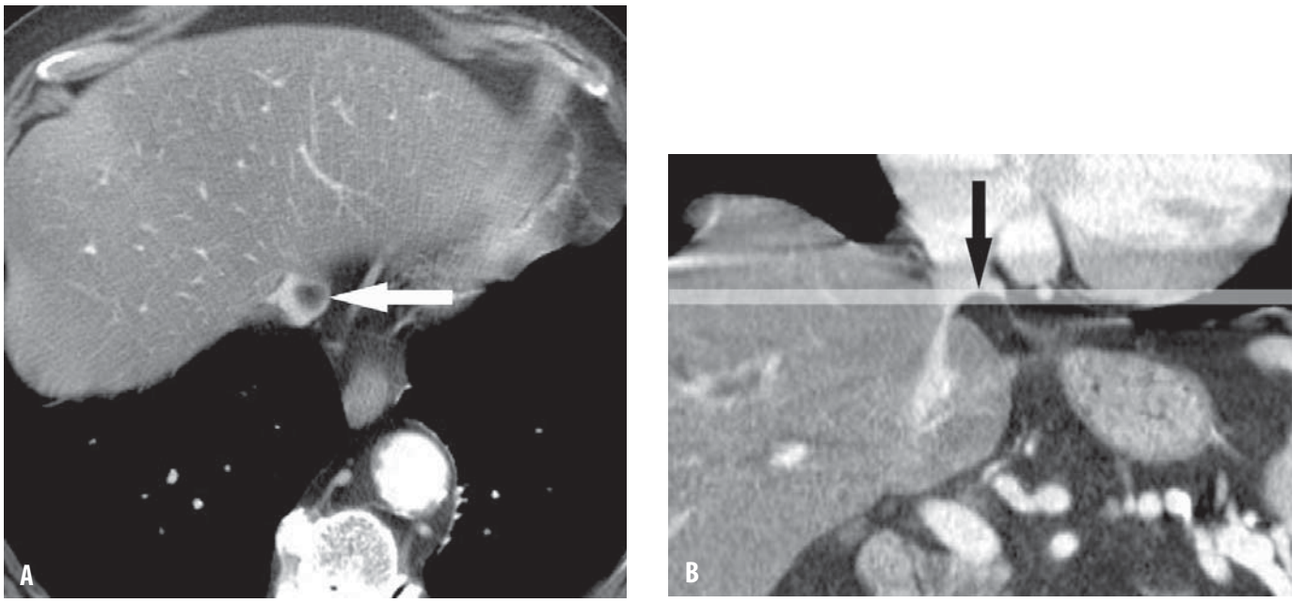

Figure 1.1 **A.** Axial contrast-enhanced CT image in a 70 year old man with prostate cancer shows an apparent fatty mass (arrow) in the lumen of the inferior vena cava as it passes through the diaphragm. **B.** Coronal reformatted CT image demonstrates the mechanism of this partial volume artifact; fat (arrow) above the caudate lobe is partial volumed into the lumen of the cava on the corresponding axial section (at the level indicated by the shaded rectangle).

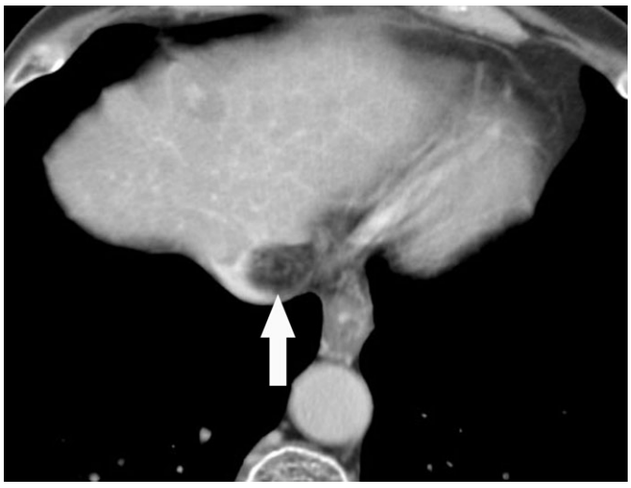

Figure 1.2 Axial contrast-enhanced CT image in a 67 year old woman with alcoholic cirrhosis (note the irregular liver contour) shows a pseudolipoma (arrow).

CASE 2 Superior diaphragmatic adenopathy

Imaging description

The superior diaphragmatic (or cardiophrenic or epicardiac) lymph nodes are in the mediastinum, but are routinely included on the upper slices of abdominal CT or MRI studies because they lie on the superior surface of the diaphragm in the fat adjacent to the heart. They are divided into anterior (paracardiac) and lateral (juxtaphrenic) groups [1, 2]. The anterior group lies posterior to the lower sternum. The lateral group abuts the entrance of the phrenic nerve into the diaphragm, adjacent to the inferior vena cava on the right and the cardiac apex on the left. The normal superior diaphragmatic lymph nodes are usually small and often not visible by CT imaging. Pathological enlargement is generally defined as a short axis diameter greater than 5 mm [2, 3], although some use a short axis threshold of 8 or 10 mm [4, 5]. Enlarged superior diaphragmatic nodes are seen as nodular soft tissue structures lying just superior to the diaphragm and posterior to the sternum, adjacent to the cardiac apex, or abutting the supradiaphragmatic inferior vena cava (Figure 2.1).

Importance

The superior diaphragmatic lymph nodes receive lymph from the peritoneal cavity and the anterosuperior part of the liver. Enlargement of these nodes may be seen in:

Liver disease. In practice, cirrhosis and chronic hepatitis [6] are probably the commonest causes of superior diaphragmatic adenopathy. In chronic hepatitis, the degree of nodal enlargement (but not the level of serum liver enzymes) correlates with disease severity on biopsy [7].

Peritoneal disease. The principal peritoneal cause of superior diaphragmatic adenopathy is ovarian cancer. In general, studies of these nodes do not have a histopathological standard of reference because these nodes are not easily accessible for tissue sampling and outcome is used as an alternative endpoint. In the case of ovarian cancer, superior diaphragmatic nodes greater than 5 mm in short axis diameter confer a worse prognosis [3] and are presumably metastatic in nature (Figure 2.2).

Other malignancy. Superior diaphragmatic adenopathy may also be seen in other cancers, with widespread, hepatic (Figure 2.3), or peritoneal spread. In at least some oncologic settings, it is possible that superior diaphragmatic adenopathy is reactive rather than metastatic. For example, in patients with resectable hepatic metastases from colorectal cancer, superior diaphragmatic nodes greater than 5 mm in short axis diameter do not confer a worse prognosis, which may indicate they are reactive and not metastatic [8]. With the greater utilization of PET, more data on the likely pathological basis of superior diaphragmatic adenopathy may emerge.

Typical clinical scenario

The identification of superior diaphragmatic adenopathy should prompt a careful search for hepatic or peritoneal disease (Figures 2.4 and 2.5). Reactive superior diaphragmatic adenopathy in cirrhosis or chronic hepatitis is frequently accompanied by portal, portacaval, or retroperitoneal adenopathy (which I call "liver pattern adenopathy") [7].

Differential diagnosis

The appearance of superior diaphragmatic adenopathy is usually distinctive, although occasionally large nodal deposits may be difficult to distinguish from pleural or pulmonary masses (Figure 2.6).

Teaching point

Superior diaphragmatic adenopathy can be a useful diagnostic clue to hepatic and peritoneal disease.

REFERENCES

1 Williams PL, Warwick R. *Gray's anatomy*, 38th edition. Edinburgh, London, Melbourne, New York: Churchill Livingstone, 1995; 1624.

2 Aronberg DJ, Peterson RR, Glazer HS, et al. Superior diaphragmatic lymph nodes: CT assessment. *J Comput Assist Tomogr* 1986; **10**: 937–941.

3 Rouviere H. *Anatomy of the human lymphatic system: a compendium.* Ann Arbor, MI: Edwards Brothers, 1938; 86–88.

4 Holloway BJ, Gore ME, A'Hern RP, et al. The significance of paracardiac lymph node enlargement in ovarian cancer. *Clin Radiol* 1997; **52**: 692–697.

5 Graham NJ, Libshitz HI. Cascade of metastatic colorectal carcinoma from the liver to the anterior diaphragmatic lymph nodes. *Acad Radiol* 1995; **2**: 282–285.

6 Wechsler RJ, Nazarian LN, Grady CK, et al. The association of paracardial adenopathy with hepatic metastasis found on CT arterial portography. *Abdom Imaging* 1995; **20**: 201–205.

7 Dodd GD 3rd, Baron RL, Oliver JH 3rd, et al. Enlarged abdominal lymph nodes in end-stage cirrhosis: CT-histopathologic correlation in 507 patients. *Radiology* 1997; **203**: 127–130.

8 Zhang XM, Mitchell DG, Shi H, et al. Chronic hepatitis C activity: correlation with lymphadenopathy on MR imaging. *Am J Roentgenol* 2002; **179**: 417–422.

9 Aslam R, Coakley FV, Williams G, et al. Prognostic importance of superior diaphragmatic adenopathy at computed tomography in patients with resectable hepatic metastases from colorectal carcinoma. *J Comput Assist Tomogr* 2008; **32**: 173–177.

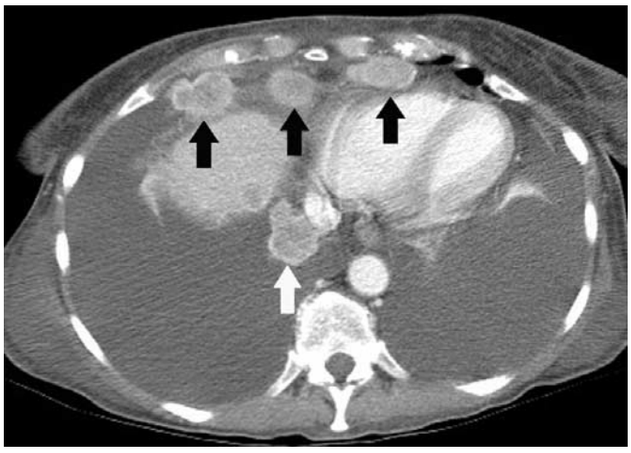

Figure 2.1 Axial contrast-enhanced CT image in a 55 year old woman with advanced ovarian cancer shows marked superior diaphragmatic adenopathy involving both the anterior or paracardiac (black arrows) and lateral or juxtaphrenic (white arrow) groups of nodes.

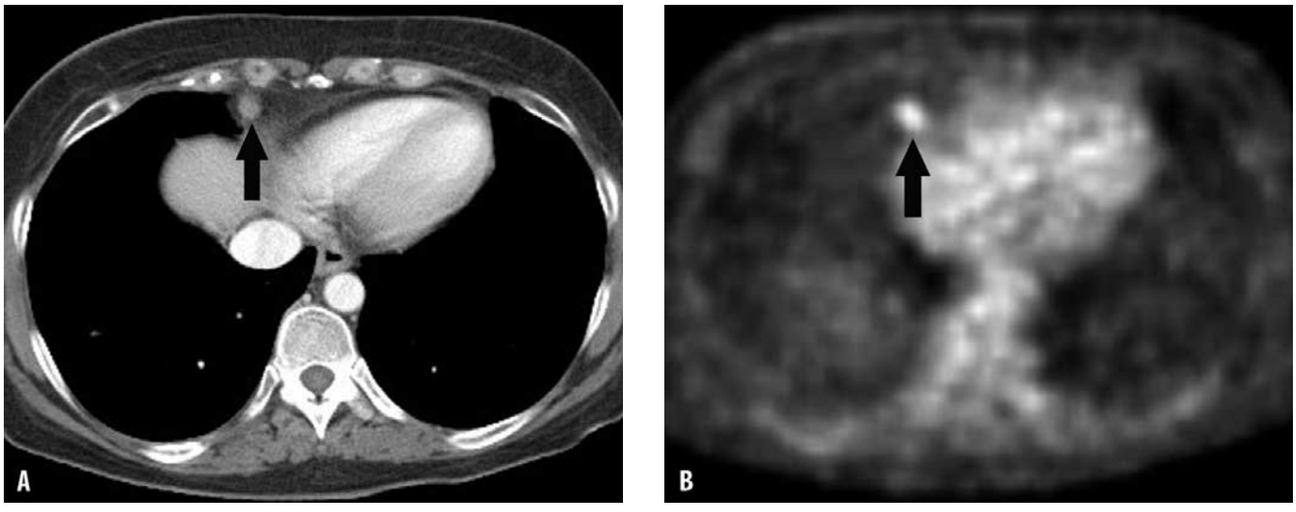

Figure 2.2 A. Axial contrast-enhanced CT image in a 48 year old woman with ovarian cancer shows superior diaphragmatic adenopathy (arrow). **B.** Axial FDG PET image shows increased uptake in the node (arrow), confirming the metastatic nature of the enlargement.

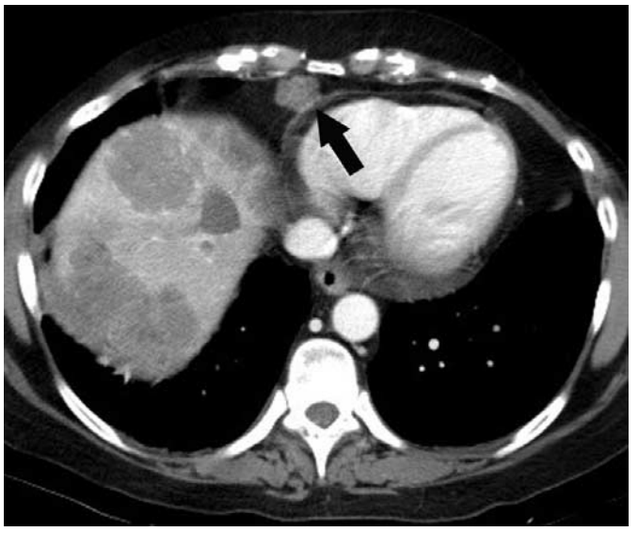

Figure 2.3 Axial contrast-enhanced CT image in a 72 year old woman with breast cancer metastatic to the liver shows malignant-appearing superior diaphragmatic adenopathy (arrow).

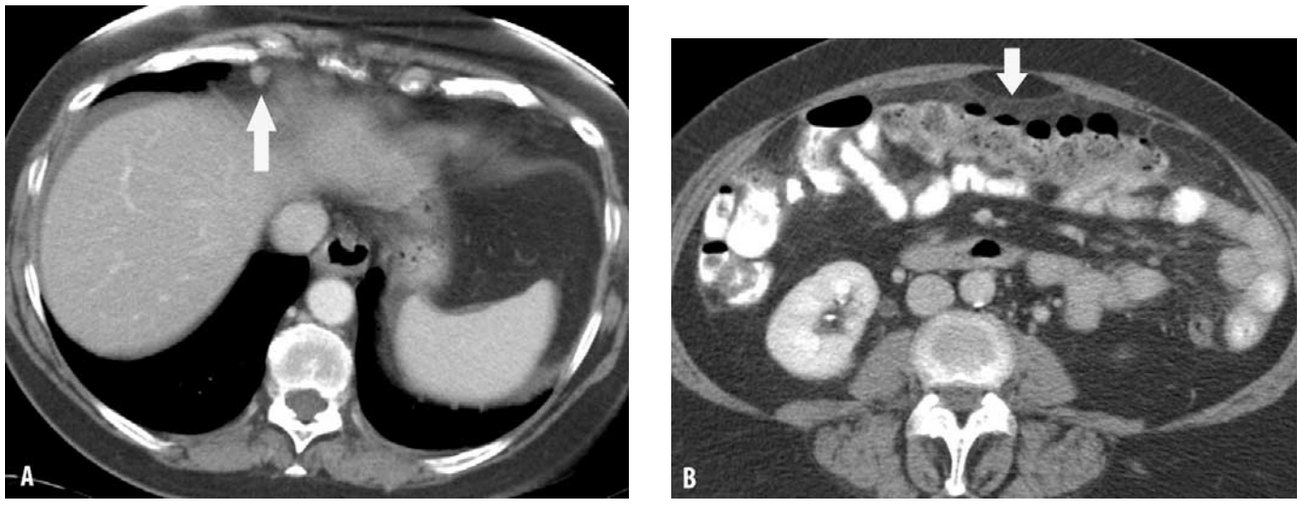

Figure 2.4 A. Axial contrast-enhanced CT image in a 62 year old woman with newly diagnosed ovarian cancer shows superior diaphragmatic adenopathy (arrow). **B.** Axial contrast-enhanced CT image at a more inferior level shows subtle infiltration (arrow) of the greater omentum. This is particularly concerning for peritoneal spread, given the co-existence of superior diaphragmatic adenopathy. Malignant infiltration of the omentum was confirmed at surgery.

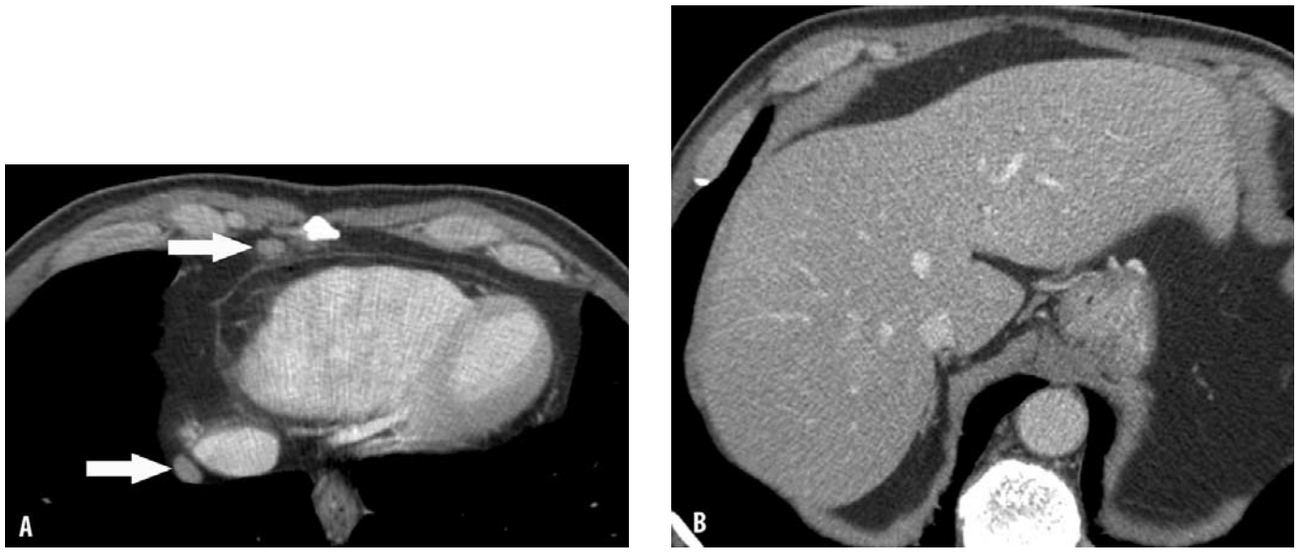

Figure 2.5 A. Axial contrast-enhanced CT image in a 58 year old man with chronic hepatitis C shows superior diaphragmatic adenopathy (arrows). **B.** Axial contrast-enhanced CT image at a more inferior level shows a relatively large left hepatic lobe, but a smooth liver surface. Biopsy showed grade 3 inflammatory change and stage 3 fibrosis but no definite cirrhosis. Superior diaphragmatic adenopathy can be an indicator of clinically important liver disease even when the liver appears relatively normal at imaging.

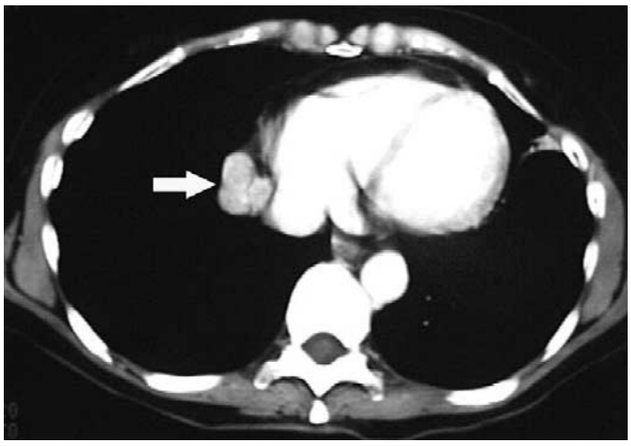

Figure 2.6 Axial contrast-enhanced CT image in a 56 year old woman with ovarian cancer shows an enlarged paracaval superior diaphragmatic node (arrow). This could potentially be confused for a pleural or pulmonary mass.

CASE 3 Lateral arcuate ligament pseudotumor

Imaging description

The diaphragmatic crura fuse with each other medially to form the single midline median arcuate ligament, behind which the aorta passes from the thorax into the abdomen. Laterally, the crura extend in front of the psoas muscles as the paired medial arcuate ligaments, which provide a ligamentous attachment for the diaphragm. The medial arcuate ligament is classically described as attaching to the transverse process of L1, although a dissection study suggests it actually attaches to the transverse process of L2 [1]. More laterally still, the crura continue in front of the quadratus lumborum muscles as the paired lateral arcuate ligaments, which pass from the spinal attachment to the 12th rib. Prominent lateral arcuate ligaments may be seen as distinct soft tissue nodules of 1 cm or more in diameter in continuity with the diaphragm and projecting into the posterior pararenal space of the retroperitoneum on cross-sectional imaging (Figure 3.1) [2].

Importance

A prominent lateral arcuate ligament may simulate a retroperitoneal mass, or suggest peritoneal metastases in the hepatorenal pouch (if right-sided).

Typical clinical scenario

Nodular projections into the retroperitoneum due to prominent lateral arcuate ligaments were seen in 5 of 100 unselected CT scans, and were bilateral in 3 patients [2]. No particular association with age, sex, or respiratory position has been described.

Differential diagnosis

The usual appearance of the lateral arcuate ligaments is that of soft tissue nodules anterior to the lower posterior ribs. When paired, the bilateral symmetric arrangement allows for easy differentiation from disease [3]. When unilateral, band-like curvilinear continuity with the diaphragm is a useful clue. Occasionally, a pleural metastasis deep in the costophrenic recess may be difficult to distinguish from the lateral arcuate ligament, although correlation with prior imaging or PET scan may clarify (Figure 3.2).

Teaching point

An apparent tumor implant abutting the diaphragm anterior to the lower posterior ribs is likely to represent a prominent lateral arcuate ligament.

REFERENCES

1 Deviri E, Nathan H, Luchansky E. Medial and lateral arcuate ligaments of the diaphragm: attachment to the transverse process. *Anat Anz* 1988; **166**: 63–67.

2 Silverman PM, Cooper C, Zeman RK. Lateral arcuate ligaments of the diaphragm: anatomic variations at abdominal CT. *Radiology* 1992; **185**: 105–108.

3 Panicek DM, Benson CB, Gottlieb RH, Heitzman ER. The diaphragm: anatomic, pathologic, and radiologic considerations. *Radiographics* 1988; **8**: 385–425.

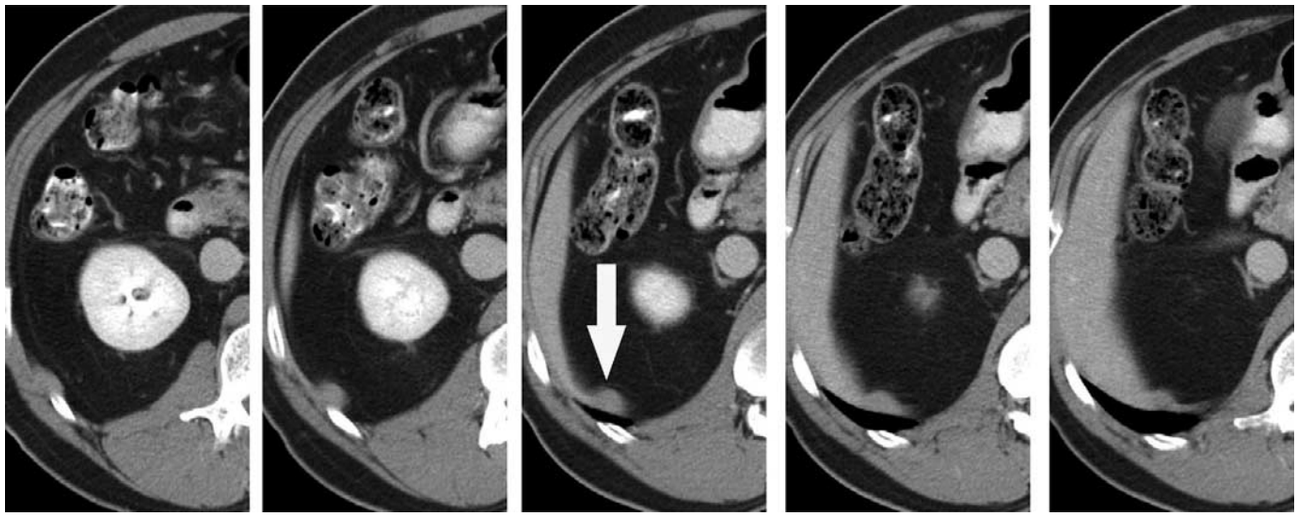

Figure 3.1 Montage of five axial contrast-enhanced CT images arranged from superior to inferior and obtained in a 50 year old man with abdominal pain. The central image shows a soft-tissue nodule (arrow) adjacent to the liver that mimics a peritoneal implant, but curvilinear continuity with the diaphragm on serial images confirms the structure is the lateral arcuate ligament.

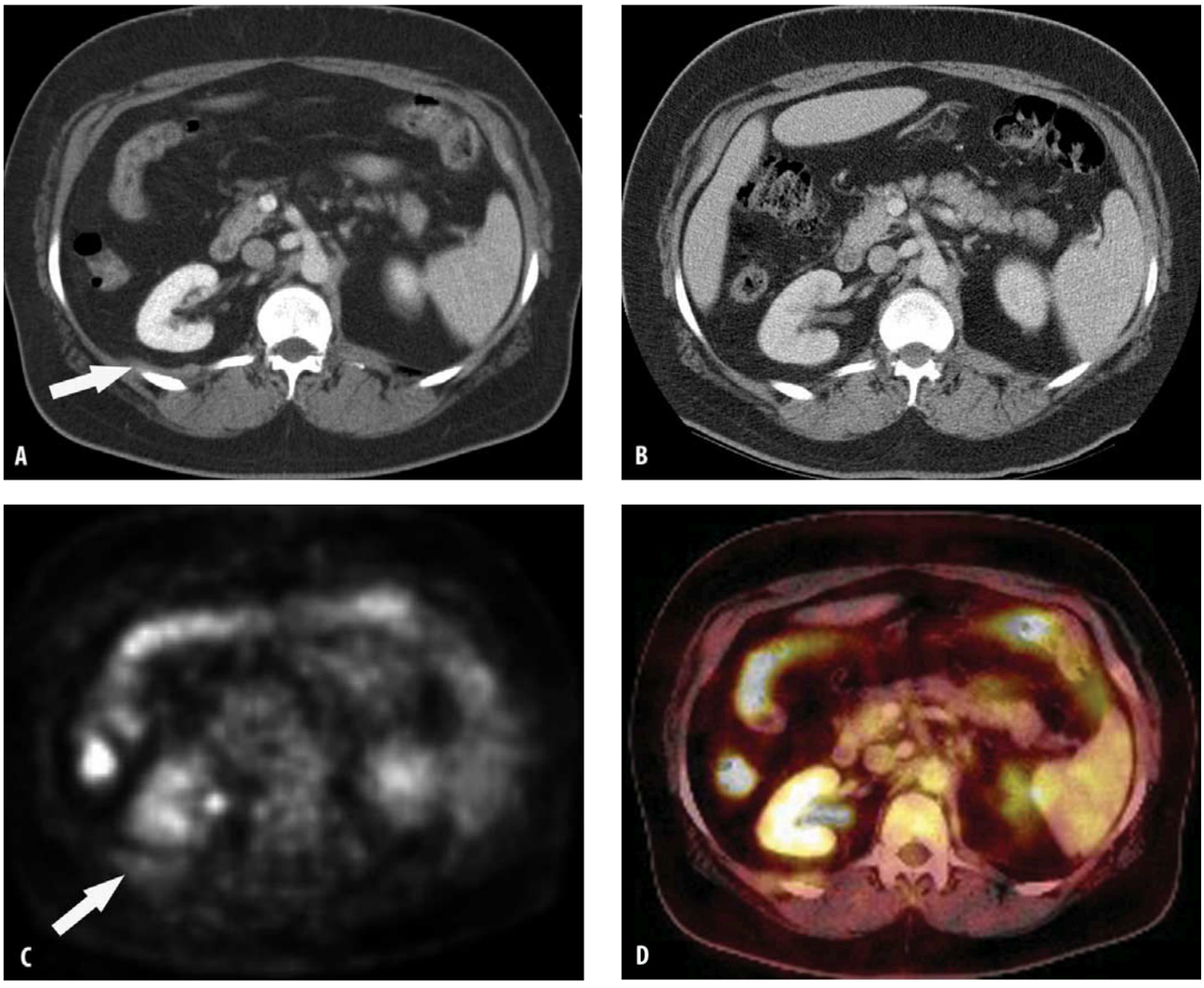

Figure 3.2 **A.** Axial contrast-enhanced CT image in a 46 year old man with recurrent malignant thymoma. A plaque-like focus of soft-tissue thickening (arrow) abutting the front of the lower right ribs resembles a prominent lateral arcuate ligament. **B.** Axial contrast-enhanced CT image performed five years before does not show the plaque-like focus of soft-tissue thickening. **C.** Axial PET image at the corresponding level shows increased FDG uptake (arrow) in the soft-tissue thickening. **D.** Fused PET/CT image verifies the increased uptake is within the soft-tissue thickening, confirming the diagnosis of a pleural metastasis deep in the costophrenic recess. Occasionally, such a metastasis may be difficult to distinguish from the lateral arcuate ligament.

CASE 4 Diaphragmatic slip pseudotumor

Imaging description

Prominent muscular slips of the diaphragm may be seen as soft-tissue nodules in contiguity with the diaphragm on CT or MRI (Figures 4.1 and 4.2) [1, 2].

Importance

Prominent diaphragmatic slips may mimic perihepatic metastatic implants, resulting in unnecessary follow-up investigations and patient anxiety.

Typical clinical scenario

Prominent diaphragmatic slips are described as being more frequent in deep inspiration [1]. Such diaphragmatic pseudotumors are also commoner in elderly or emphysematous patients [3].

Differential diagnosis

The distinction of prominent diaphragmatic slips from true peritoneal implants is based on their continuity peripherally with the diaphragm, curvilinear course when tracked over serial slices, and separation from adjacent viscera by subdiaphragmatic fat. Decubitus and expiratory CT sections are also said to help [1].

Teaching point

An apparent peritoneal implant abutting the diaphragm should be examined closely in order to make an accurate distinction from a prominent diaphragmatic slip.

REFERENCES

1 Rosen A, Auh YH, Rubenstein WA, et al. CT appearance of diaphragmatic pseudotumors. *J Comput Assist Tomogr* 1983; **7**: 995–999.

2 Schwartz EE, Wechsler RJ. Diaphragmatic and paradiaphragmatic tumors and pseudotumors. *J Thorac Imaging* 1989; **4**: 19–28.

3 Caskey CI, Zerhouni EA, Fishman EK, Rahmouni AD. Aging of the diaphragm: a CT study. *Radiology* 1989; **171**: 385–389.