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Pictorial Review

Ultrasound of the abdominal wall: What lies beneath?

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Clinically equivocal abdominal wall lesions often pose diagnostic dilemmas for clinicians. It can be equally challenging to appreciate the nature of abdominal wall lesions found incidentally on abdominal ultrasound examinations. Ultrasound is a non-ionizing, cheap, and easily accessible investigation for such lesions. It is widely used and has the added advantage of being a dynamic investigation. However, imaging with ultrasound is operator-dependent and relies on technical skills. It is important to understand the imaging of normal anatomy and to be familiar with the imaging appearance of lesions. We present a review of various lesions seen during ultrasound examinations of the abdominal wall or as incidental findings on abdominal ultrasound.

Introduction

Ultrasound is usually the first-line investigation for imaging abdominal wall disease entities. Incidental abdominal wall abnormalities may also be encountered while imaging the abdomen for other reasons. Ultrasound is readily available and has the advantage of being real-time, non-invasive, non-ionizing, and cheap. The spectrum of abdominal wall disease is very wide, and ultrasound can help differentiate various diseases.[1] It is important to recognize these sonographic findings so that patients may be appropriately and promptly managed. We discuss the normal anatomy of abdominal wall and imaging characteristics of various conditions on ultrasound that have been encountered in clinical practice.

Normal anatomy

On ultrasound imaging there are three identifiable layers in the abdominal wall (Fig 1). The superficial layer of skin and subcutaneous fat, the middle layer of abdominal wall muscles, and the deep layer formed by the properitoneal fat along with the parietal peritoneum. The skin is very echogenic and is a couple of millimetres in thickness. The thickness of subcutaneous fat is dependent on the patient's body habitus. The fatty lobules appear as round to oval hypoechoic nodules separated by echogenic septa and perforating vessels. The rectus muscle is situated in a paramedian location and is of medium echogenicity with multiple internal echogenic dots when viewed in transverse section. The two recti are joined in the midline by the midline raphe called "linea alba", a condensation of the deep fascia. Furthermore, the muscle is crossed by three fibrous bands, one usually at the level of the umbilicus and one each on either side of it giving it the "six-pack" or "eight-pack" appearance. Further laterally from inside out lies the transversus abdominis, internal oblique, and the external oblique muscles. The properitoneal fat layer is thin and a few millimetres in thickness. The epigastric vessels run in this layer and identifying these vessels prior to any intervention minimizes the risk of haemorrhage.

Rectus sheath haematoma

Rupture of the inferior epigastric artery or a tear of the rectus abdominis muscle usually results in a rectus sheath

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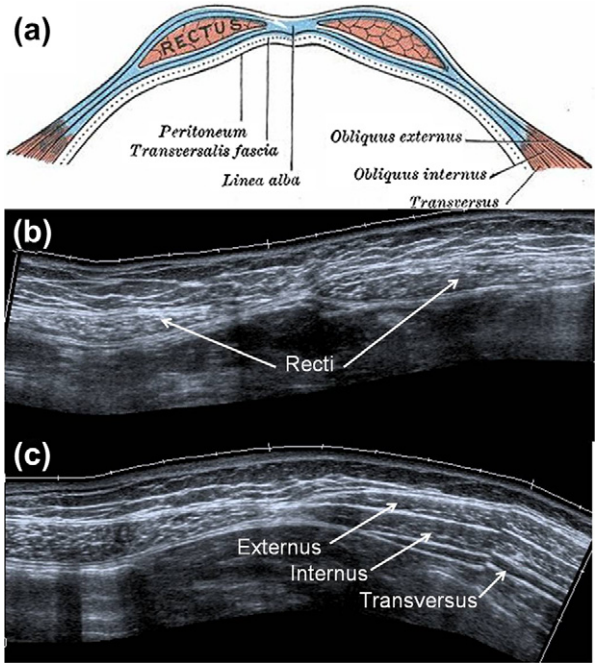

Figure 1 Anatomical diagram (a) and ultrasound images of panoramic views (b & c) of the transverse section of the anterior abdominal wall showing various layers and muscles. (b) The two recti and linea alba are seen in the midline, and (c) the transverse section of the left side of abdominal wall with rectus abdominis seen on the left and the external oblique, internal oblique, and transversus abdominis (from outside to inside) seen on the right. Gray, Henry. Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available from http://en.wikipedia.org/wiki/File:Gray399.svg (date accessed 12 March 2011).

haematoma. It is common in patients susceptible to bleeding, e.g., haemophilia, leukaemia, and those on anticoagulant therapy. It can result from trauma, direct violence, unaccustomed strenuous exercise, violent fit of cough, sneezing, or iatrogenic due to laceration of the epigastric vessels. Acute haematoma appears as a homogeneous echogenic mass. Appearances of subacute and chronic haematomas vary depending on the age and progression of the haematoma. With age the haematomas become gradually more hypoechoic and chronic haematomas can turn anechoic. The acute solid echogenic mass gradually liquefies with time and demonstrates septa (Fig 2). Chronic haematomas can appear as a well-defined anechoic fluid collection, although one or few septa tend to remain. Acute or subacute haematomas do not demonstrate any internal vascularity.

Foreign body

Ultrasound is especially useful in the imaging of radiolucent foreign bodies, which may not be seen on plain film. Foreign bodies appear hyperechoic with distal acoustic shadowing or reverberation (Fig 3). Foreign bodies may also cause inflammation of the adjacent tissues manifested as a surrounding ill-defined hypoechoic area with increased vascularity[2]. In later stages, a chronic granuloma can be seen as a well-defined hypoechoic and often hypervascular abnormality surrounding the foreign body. The demonstration of a foreign body should be correlated with the patient's clinical history as it may be an implanted device, e.g., a surgically placed mesh, catheter, ventriculoperitoneal shunt, etc. (Fig 4).

Inflammation and abscess

Inflammation and abscesses in the abdominal wall are often iatrogenic. At ultrasound, it is usually heterogeneously hypoechoic compared to neighbouring fat, tends to have irregular borders, and may show septa (Fig 5). There is usually peripheral hyperaemia on Doppler assessment. When gas bubbles are present in an abscess, they are highly echogenic with acoustic shadowing.[3] There is often a sinus track seen arising from it extending to the site of surgical scar or skin surface (Fig 6). Cellulitis shows subcutaneous oedema and dilation of superficial vessels (Fig 7). Comparison may be made with the normal side if there is doubt regarding the appearances.

Deep abdominal organs may be the source of inflammation in the abdominal wall, e.g., inflamed bowel wall or an inflamed appendix. Inflammatory bowel disease may sometimes be identified on ultrasound of the abdominal wall. Dilated loops of echogenic, thickened inflammatory bowel wall are seen under the abdominal wall on ultrasound (Fig 8). In such cases further evaluation using computed tomography (CT) or magnetic resonance imaging (MRI) may be required.

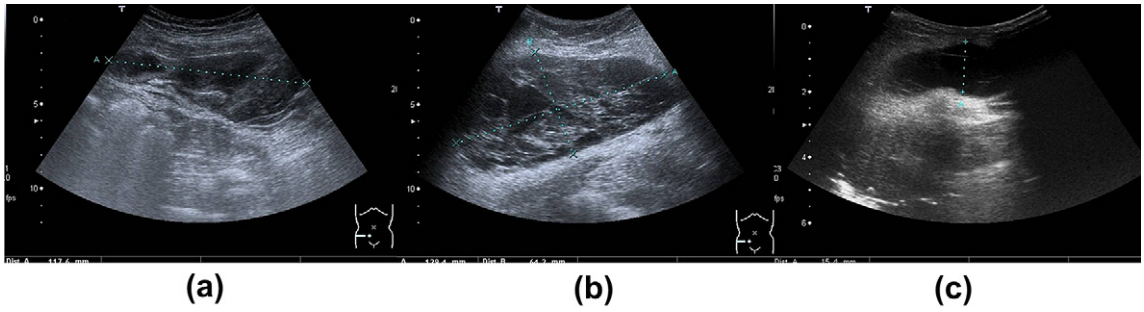

Figure 2 Ultrasound images showing large rectus sheath haematoma. There is mixed echogenicity in (a) in keeping with acute nature. Note the septae within the haematoma in (b) suggesting an organizing haematoma. The lesion in (c) is almost anechoic suggesting liquefaction.

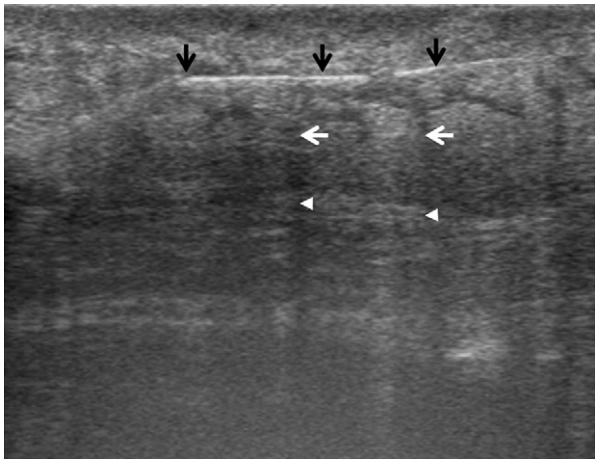

Figure 3 A linear hyperechoic foreign body (a wooden splinter) is seen in transverse section of the anterior abdominal wall (black arrows). Note the areas of posterior acoustic shadowing (white arrows) and reverberation (arrowheads).

Tumours

Tumours in the abdominal wall can be benign or malignant. The benign tumours include lipoma, neurofibroma, haemangioma, and lymphatic malformations. The malignant tumours include desmoid tumour, lymphoma, melanoma, and malignant fibrous histiocytoma in adults and sarcoma in children. Lipoma is the most common tumour of the abdominal wall. It is well-circumscribed, can be hypo-, iso-, or mildly hyperechoic in comparison with the surrounding fat (Fig 9). The appearance of a lipoma is similar to elsewhere in the body.

Haemangiomas are a few millimetres in diameter and appear as multiple hypo- or anechoic cystic areas in an echogenic hypervascular background. These hypoechoic vascular channels are completely compressible on applying pressure (Fig 10).

Desmoid tumours lack a capsule and are infiltrative. Therefore, although histologically benign, they are locally aggressive. On ultrasound, they are usually small and hypoechoic.[4,5]

Ultrasound features are not specific to a malignant lesion but ultrasound can facilitate biopsy of such lesions to allow histological diagnosis. Lymphoma in the abdominal wall may present with deposits, which can grow to large sizes (Fig 11). They are usually well defined, hypoechoic, and do not usually demonstrate increased vascularity on Doppler imaging. Sarcomas are hypoechoic solid masses and may have localized areas of necrosis or fluid.

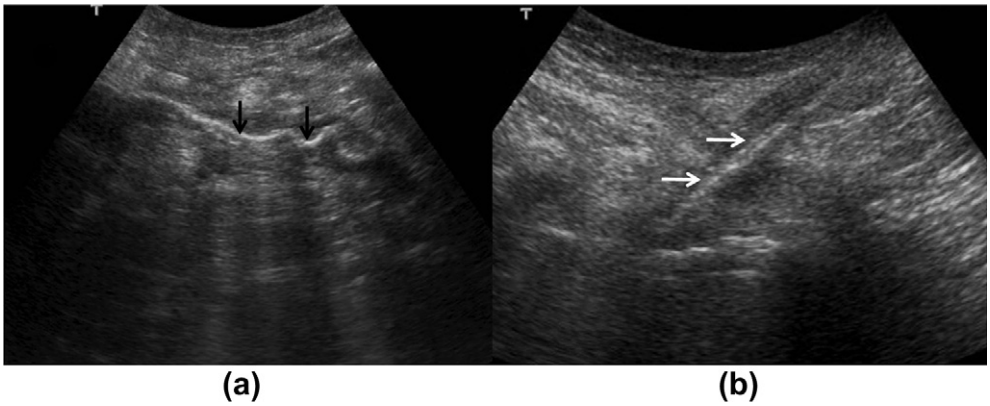

Figure 4 Some surgically placed devices may be mistaken for foreign bodies. Image (a) is a transverse section in midline showing a mesh (black arrows) and (b) is a suprapubic sagittal section showing a suprapubic catheter (white arrows).

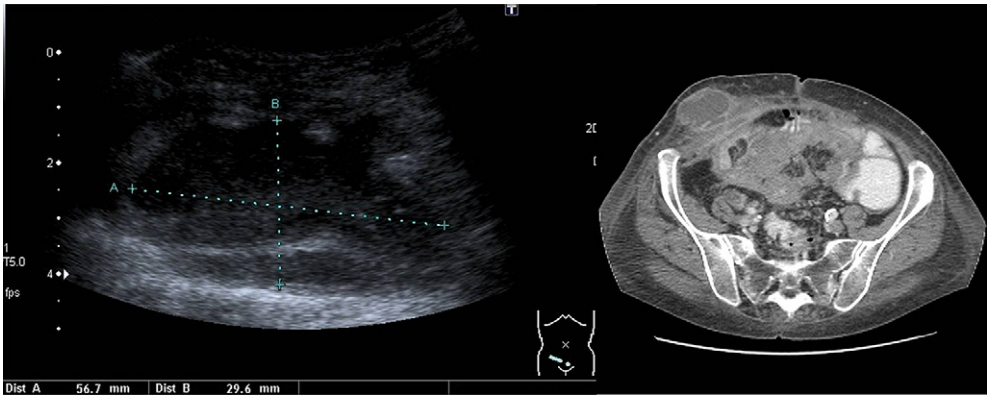

Figure 5 An abscess of the abdominal wall as seen on ultrasound and confirmed on the axial CT image.

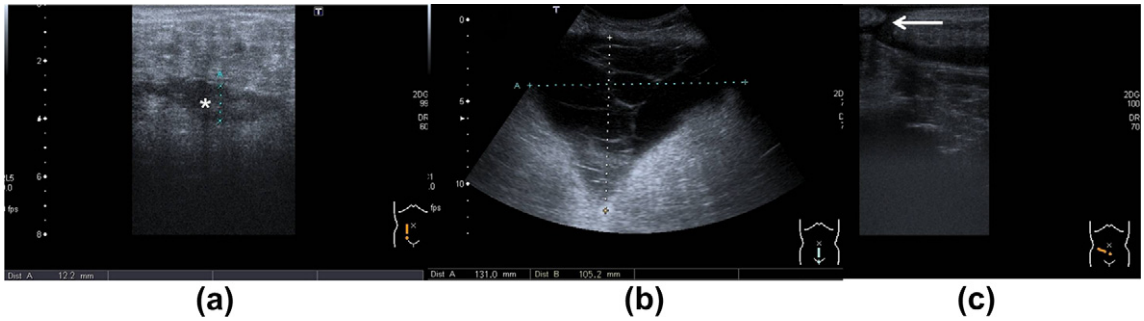

Figure 6 (a) High-frequency ultrasound image shows an abscess (asterisk) with surrounding inflammation. (b) Sagittal view in another patient shows a large, septated collection, and (c) a sinus track leading up to skin from an abdominal wall abscess (arrow).

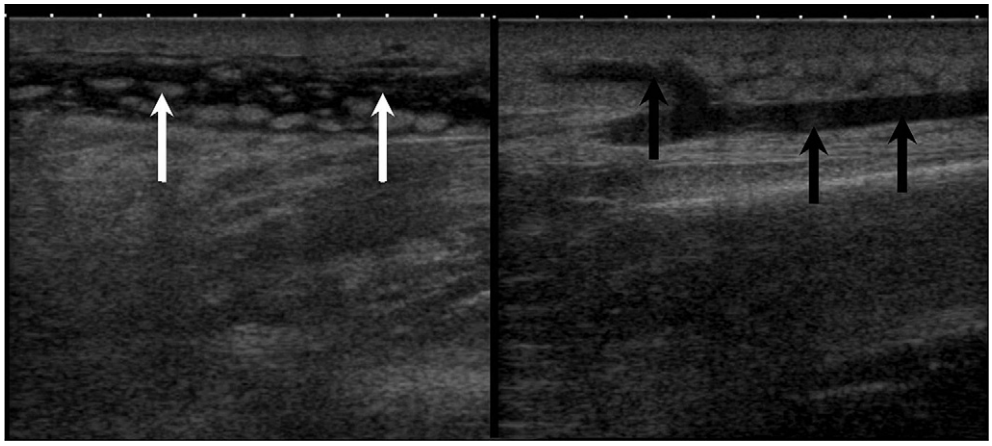

Figure 7 High-frequency ultrasound image using a linear probe shows cellulitis of the abdominal wall. Note the oedema (white arrows) and the dilated superficial vein (black arrows).

Metastasis to the abdominal wall can be due to haematogenous, lymphatic, contiguous spread or needle-tract seeding.[6–8] Metastatic nodules are round or oval hypoechoic masses. The source of metastasis tends to be a carcinoma or melanoma.[9]

A metastatic deposit in the umbilicus is called a Sister Mary Joseph's nodule. Approximately half of them are from gastrointestinal cancers[10] and a fourth from undetermined or undifferentiated primary cancers. Other origins include ovarian, pancreatic, and rarely small cell carcinoma of the

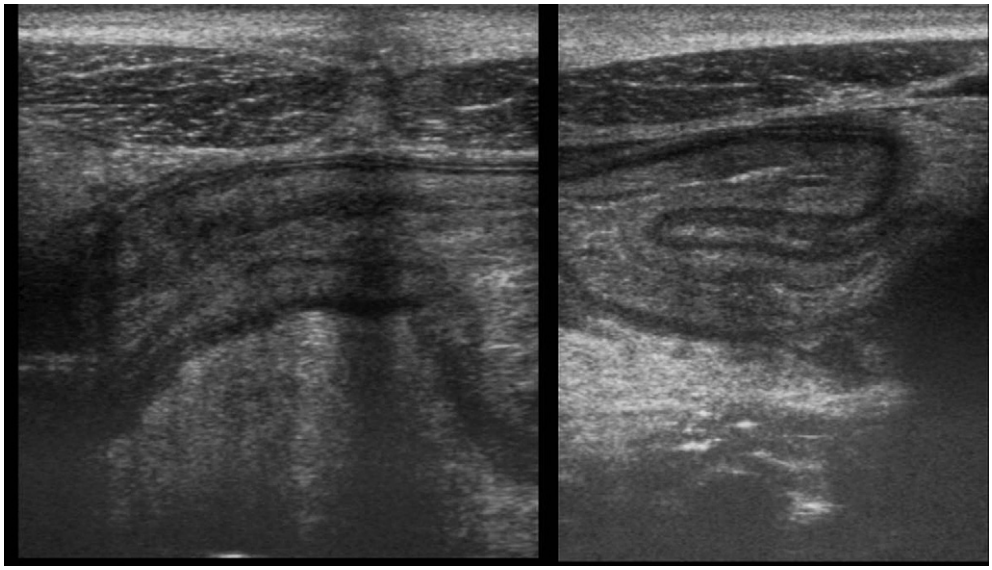

Figure 8 Transverse ultrasound of the abdominal wall in midline showing thickened loops of small bowel in a patient with active Crohn's disease.

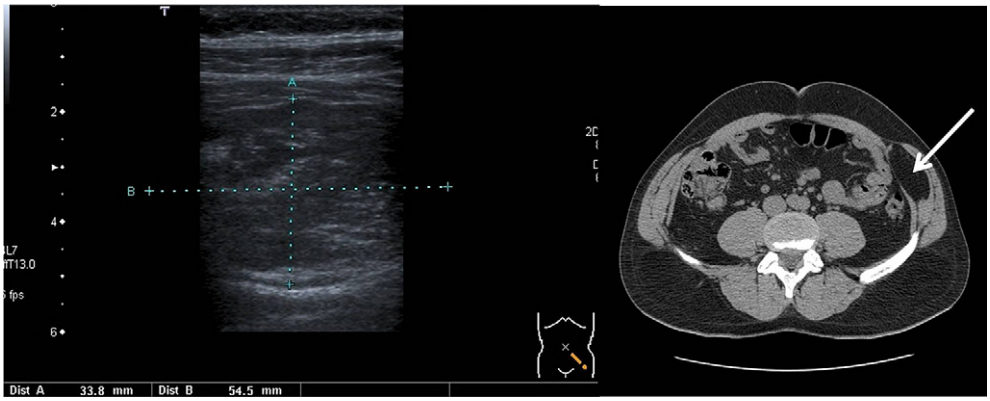

Figure 9 Transverse section ultrasound, using a high-frequency linear probe, of the abdominal wall showing a well-defined, slightly hypoechoic lesion with features suggestive of a lipoma. Low density at CT examination confirmed the diagnosis.

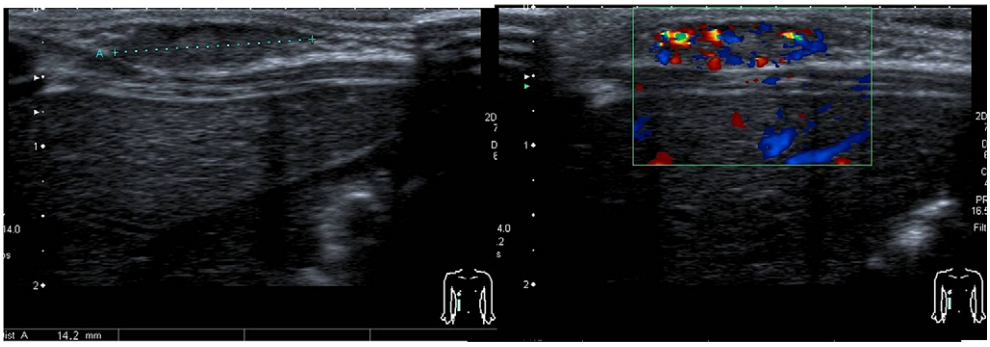

Figure 10 Grey-scale imaging showing a well-defined, hypoechoic lesion. This is hypervascular on Doppler and was later confirmed to be a haemangioma.

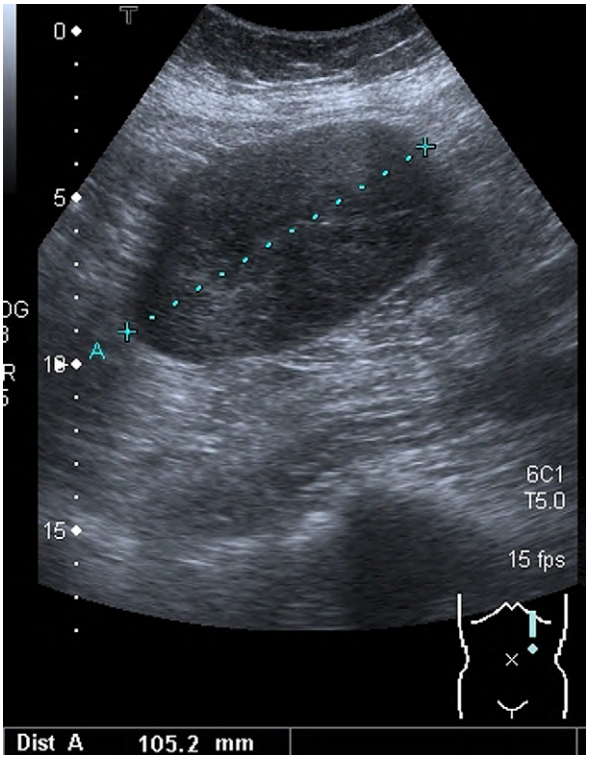

Figure 11 A large lymphomatous mass in the anterior abdominal wall.

lung. It is usually hypoechoic at US and lies adjacent to the umbilicus[11] (Fig 12).

In the presence of ascites, the inferior aspect of the omentum can be seen as a moderately hyperechoic structure of variable thickness, depending on the fat content.[12] Metastatic infiltration of the greater omentum (peritoneal carcinomatosis) is caused by tumours arising from the stomach, ovary, and colon and results in abnormally

Figure 12 Transverse section ultrasound adjacent to the umbilicus shows a hypoechoic lesion. This was confirmed to be a metastatic deposit from a stomach primary neoplasia.

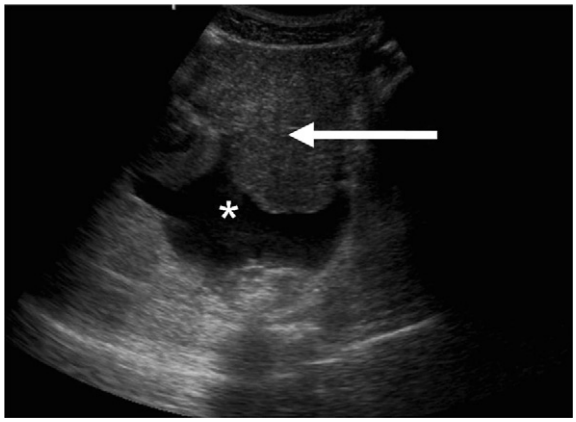

Figure 13 A large, homogeneous omental mass is seen adherent to the anterior abdominal wall (arrow). Also note that there is ascites in the peritoneal cavity (asterisk).

thickened appearance. This appearance is also associated with tuberculous peritonitis.[13] Ultrasound shows a large, homogeneous echogenic mass located anteriorly in the mid-abdomen between the abdominal wall and multiple loops of bowel. The echogenicity differs from that of adjacent bowel loops, and detection of bowel peristalsis helps differentiate the two structures. In the presence of large amount of ascites, the echogenic mass appears as a floating cake[14] (Fig 13).

Scar and complications

Surgical scars in the abdomen can be complicated by abscess formation, heterotopic calcification, incisional hernias, granuloma, seroma or lymphocoele formation, implantation endometrioma, needle-track tumour seedlings, and contiguous tumour spread. Heterotopic

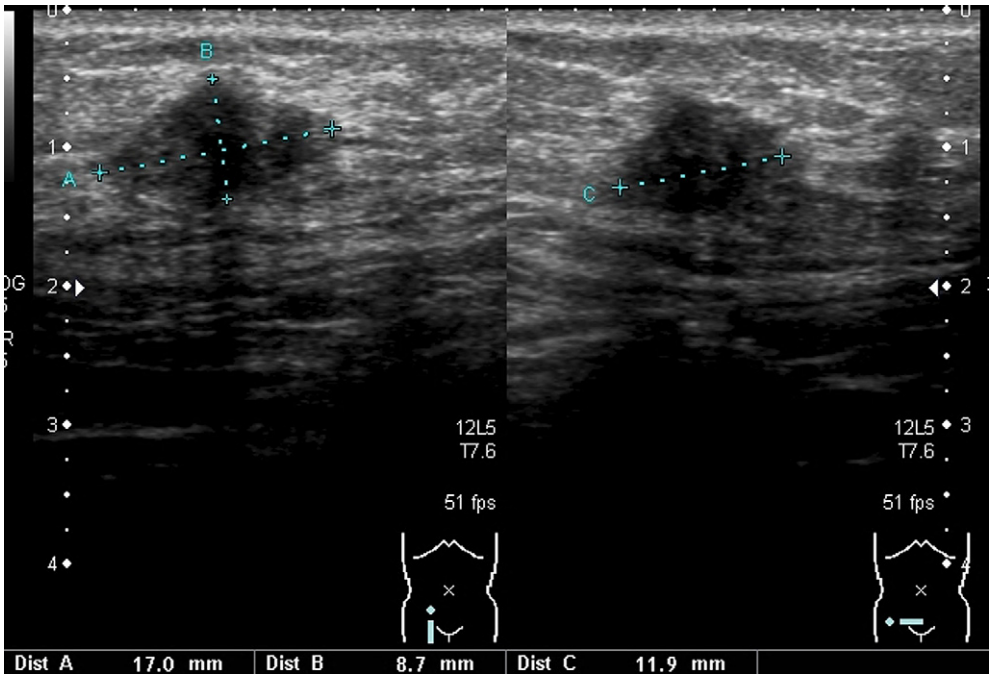

Figure 14 A hypoechoic lesion with irregular margins seen in the region of a scar is likely to represent a scar granuloma. Longitudinal and transverse images.

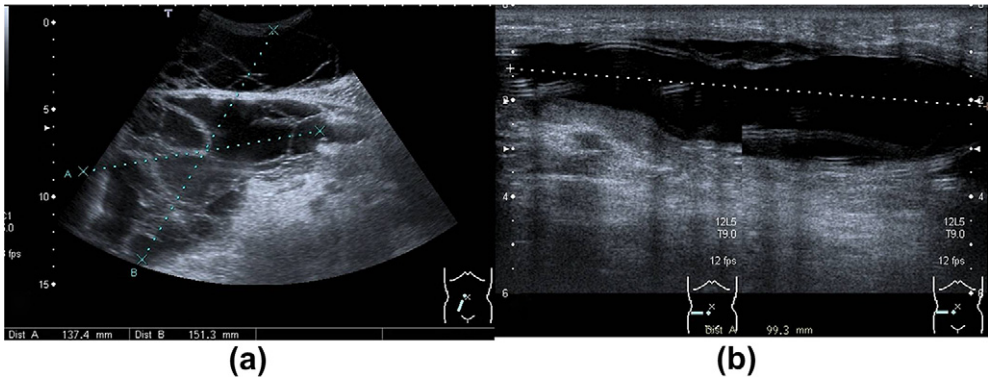

Figure 15 (a) Ultrasound appearances of a lymphocoele seen in a patient following renal transplant and (b) anechoic appearance of a seroma in a different patient following surgery for excision of sarcoma.

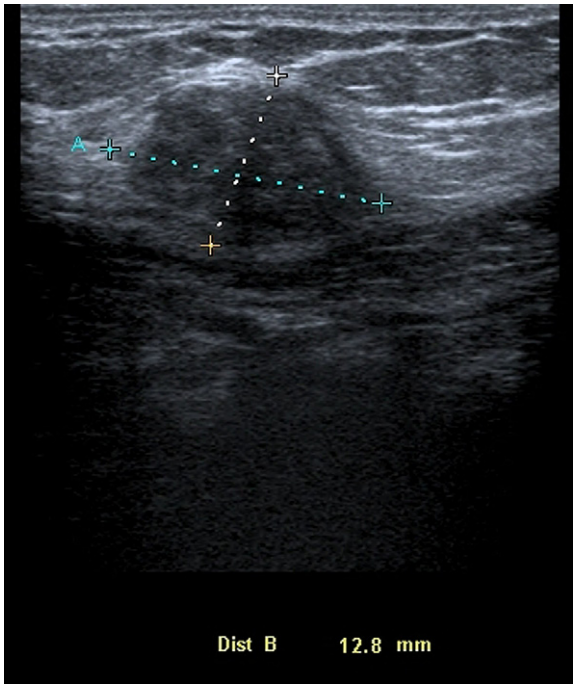

Figure 16 Implantation endometrioma seen in a caesarean section scar. The ultrasound appearances and clinical symptoms may differ during the different phases of menstrual cycle.

calcification is a benign lesion that is associated with posterior acoustic shadowing on ultrasound. A tumour recurrence containing calcification (such as from mucinous adenoma) can have similar appearance and hence cause diagnostic difficulty. A granuloma on ultrasound may appear as irregular and inhomogeneous, partly hyper- and partly hypoechoic (Fig 14). Acute haematomas are typically highly echogenic, whereas seromas and resolving haematomas are hypoechoic or anechoic. Lymphocoeles are usually anechoic and have septa (Fig 15). It is often not possible to differentiate between lymphocoele, seroma, and a chronic haematoma.

Endometriosis may also complicate scars, although it can also occur in the virgin abdominal wall. It appears as an ill-defined hypoechoic nodule usually located close to a laparotomy or laparoscopy scar[15–17] (Fig 16). Infrequently a typical endometrioma is seen as a well-defined cyst containing low-level echoes. The cyclical nature of symptoms provides a clue as to the diagnosis, and ultrasound features may vary with the phase of the menstrual cycle.

Tumour seeding may be seen in the operative scar (either laparoscopy or open surgery) or along the needle track after percutaneous needle biopsy of a malignant lesion.

Hernia

Hernia is a protrusion of abdominal contents through a point of weakness or defect in the abdominal wall, e.g., the umbilicus, the inguinal canal, the femoral canal, and incisional scars. The hernial contents may be omentum, fat (Fig 17a–b) or viscus. Ultrasound shows distinctive bright echoes from the intestinal gas and often peristalsis when bowel loops form the contents. The signs of strangulation may be seen and include irreducibility of the hernial sac,

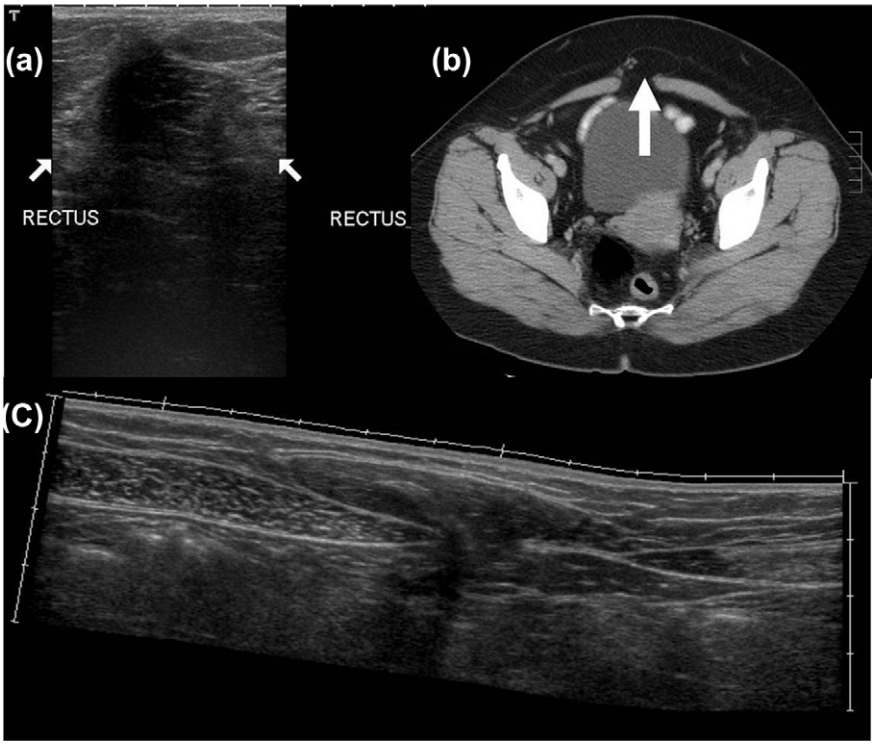

Figure 17 (a) High-frequency ultrasound showing a defect in the linea alba and abdominal fat herniating through the defect. (b) The findings are confirmed at CT. (c) The transverse panoramic view beautifully demonstrating the defect and abdominal contents herniating through it (compare this with the Fig 1).

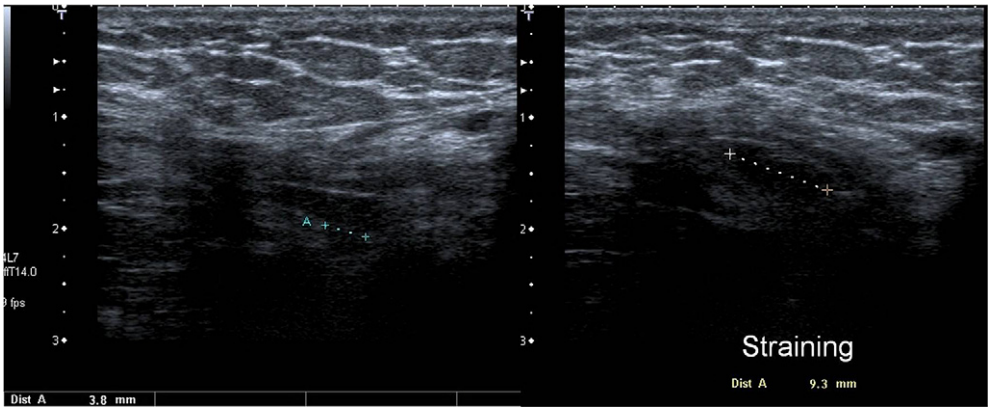

Figure 18 Real-time imaging is an advantage of ultrasound. Note how the defect in abdominal wall gets bigger on straining in this patient with a hernia.

free fluid in the sac, bowel wall thickening, and fluid in the herniated bowel loop. There may be dilated bowel loops in the abdomen due to obstruction. Newer ultrasound techniques, such as panoramic views, can demonstrate the anatomy and hernia defect very well (Fig 17c). Inguinal canals are best viewed commencing at either the deep inguinal ring (between the inferior epigastric vessels and common femoral vessels at mid-inguinal point) or the superficial inguinal ring just medial to the pubic tubercle. The inguinal canal is easier to identify in men due to the presence of spermatic cord and the testicular vessels. Indirect inguinal hernia is seen entering the inguinal canal through the deep inguinal ring whereas the direct inguinal hernia protrudes into the canal through the posterior wall. A femoral hernia is seen in the femoral canal medial to the common femoral vein at the level of inguinal ligament.

A reducible hernia may completely disappear on lying down and no abnormality may be visible. Ultrasound gives an opportunity to assess such a lesion dynamically while the patient performs a Valsalva manoeuvre or stands up (Fig 18). In fact, the hernia may only be visible on Valsalva, and the latter must be part of the routine scanning technique when evaluating for a possible hernia. The defect may be seen to get bigger and hernial contents are seen to move into the hernia. Hernia may recur following repair and imaging may be difficult due to presence of scar tissue and use of mesh. However, ultrasound is the first-line imaging technique, and CT and MR may be required for further evaluation.

Undescended testes

The normal testes have a smooth surface and fine granular and homogeneous echo texture. The normal testis is 35–50 mm in length, 25–35 mm in width, and 15–25 mm in height. An undescended testis may be located anywhere

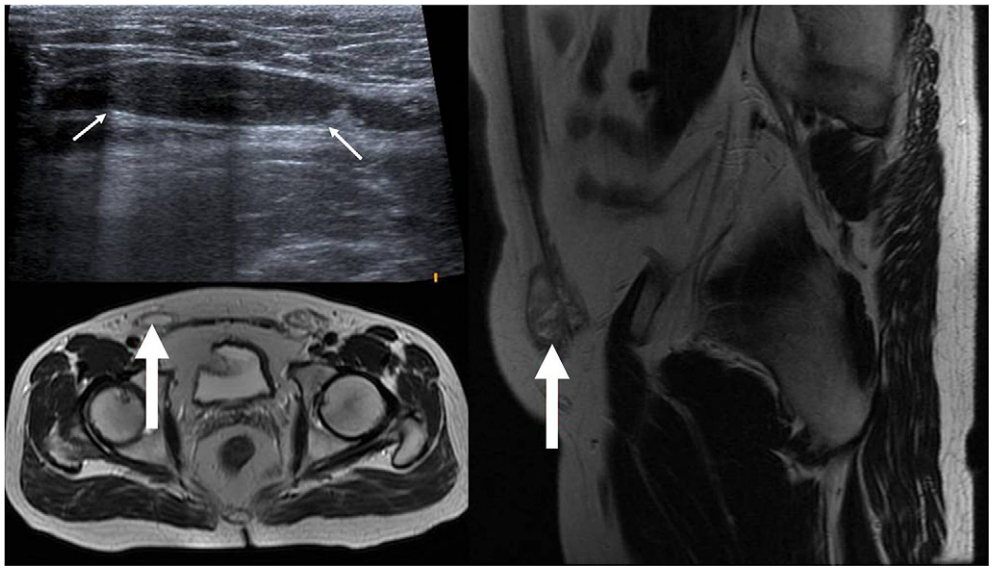

Figure 19 Ultrasound showing an undescended testis in the right inguinal canal (small arrows). The diagnosis was confirmed on axial and sagittal T2-weighted MRI (large arrows).

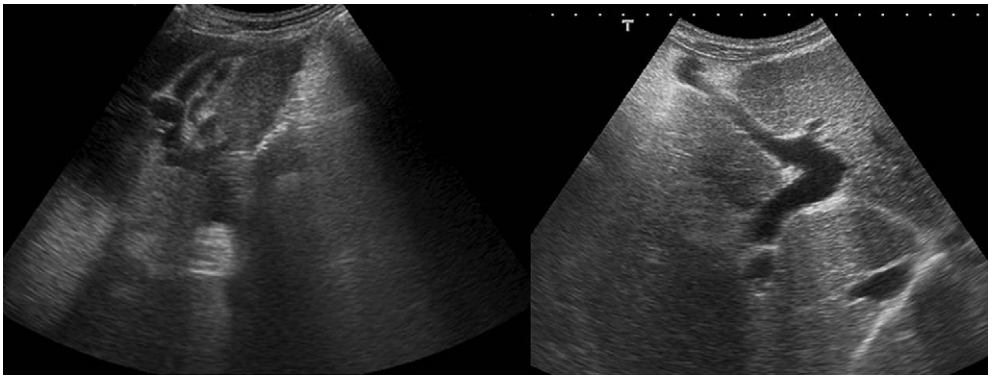

Figure 20 Ultrasound image of a patient with portal hypertension showing recanalized umbilical vein.

in the normal course of testicular descent between the lower pole of the kidney and the external inguinal ring. In 75–80% of cases the testis is located in the inguinal canal between the internal and external inguinal ring. Ultrasound is a very useful technique to locate the site, measure the size, and evaluate the testicular parenchyma, which is important in view of fertility and increased incidence of testicular malignancies (Fig 19).

Recanalization of umbilical vein in portal hypertension

The umbilical vein is present in foetal life and is obliterated after birth. However, it may recanalize in portal hypertension to form a portosystemic collateral called Cruveilhier–Von Baumgarten syndrome. On Ultrasound it appears anechoic and is seen inside the echogenic falciform ligament. It runs from the left portal vein to the umbilicus and is a supporting finding to diagnose cirrhosis and portal hypertension (Fig 20). There may be other signs of portal hypertension, such as liver nodularity, ascites, splenomegaly, and altered haemodynamics of the portal venous system on the scan.

Conclusion

Ultrasound is a widely available technique and several abdominal wall disease entities are likely to be either primarily investigated or incidentally detected by ultrasound. It is important for both the musculoskeletal and abdominal radiologists and sonographers to familiarize themselves with such entities so that patients may be appropriately managed.

References

1. Truong S, Pfingsten FP, Dreuw B, et al. Value of sonography in diagnosis of uncertain lesions of the abdominal wall and inguinal region. *Chirurg* 1993;**64**:468–75.
2. Graham Jr DD. Ultrasound in the emergency department: detection of wooden foreign bodies in the soft tissues. *J Emerg Med* 2002;**22**:75–9.
3. Yeh HC, Rabinowitz JG. Ultrasonography and computed tomography of inflammatory abdominal wall lesions. *Radiology* 1982;**144**:859–63.
4. Hanson RD, Hunter TB, Haber K. Ultrasonographic appearance of anterior abdominal wall desmoid tumors. *J Ultrasound Med* 1983;**2**:141–2.
5. Mantello MT, Haller JO, Marquis JR. Sonography of abdominal desmoid tumors in adolescents. *J Ultrasound Med* 1989;**8**:467–70.
6. Paolucci V, Schaeff B, Schneider M, et al. Tumor seeding following laparoscopy: international survey. *World J Surg* 1999;**23**:989–95. discussion 996–7.
7. Seyfer AE, Walsh DS, Graeber GM, et al. Chest wall implantation of lung cancer after thin-needle aspiration biopsy. *Ann Thorac Surg* 1989;**48**:284–6.
8. Kim SH, Lim HK, Lee WJ, et al. Needle-tract implantation in hepatocellular carcinoma: frequency and CT findings after biopsy with a 19.5-gauge automated biopsy gun. *Abdom Imaging* 2000;**25**:246–50.
9. Plaza JA, Perez-Montiel D, Mayerson J, et al. Metastases to soft tissue: a review of 118 cases over a 30-year period. *Cancer* 2008;**112**:193–203.
10. Al-Mashat F, Sibiany AM. Sister Mary Joseph's nodule of the umbilicus: is it always of gastric origin? A review of eight cases at different sites of origin. *Indian J Cancer* 2010;**47**:65–9.
11. Ching AS, Lai CW. Sonography of umbilical metastasis (Sister Mary Joseph's nodule): from embryology to imaging. *Abdom Imaging* 2002;**27**:746–9.
12. Hanbidge AE, Lynch D, Wilson RS. US of the peritoneum. *RadioGraphics* 2003;**23**:663–84. discussion 684–5.
13. Lee DH, Ko YT, Yoon Y, et al. Sonographic findings of intestinal tuberculosis. *J Ultrasound Med* 1993;**12**:537–40.
14. Morton MJ, Carlon JC, Charboneau JW. Ultrasound. Omental "cake" of metastatic adenocarcinoma. *RadioGraphics* 1990;**10**:117–8.
15. Dwivedi AJ, Agrawal SN, Silva YJ. Abdominal wall endometriomas. *Dig Dis Sci* 2002;**47**:456–61.
16. Alexiadis G, Lambropoulou M, Deftereos S, et al. Abdominal wall endometriosis—ultrasound research: a diagnostic problem. *Clin Exp Obstet Gynecol* 2001;**28**:121–2.
17. Tomás E, Martín A, Garfia C, et al. Abdominal wall endometriosis in absence of previous surgery. *J Ultrasound Med* 1999;**18**:373–4.