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High resolution ultrasonography of the anterior abdominal wall

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Introduction

With the introduction of high-frequency, high-resolution probes, detailed examination and recognition of different layers of the abdominal wall is now possible on USG examinations. A high-resolution examination is capable of deciding whether an abnormality is in the abdominal wall or inside the abdominal cavity. Physical findings in abdominal wall pathologies have low specificity and often a clinically suspected intra-abdominal lump proves to be in the abdominal wall. Typically when Carnett's sign is positive, a USG examination of the abdominal wall is advised.[1,2]

Technique

High-frequency linear array transducers, exquisitely show the anatomy of the abdominal wall layers. Examination of the skin, however requires very high-frequency probes or the use of some sort of stand-off device. All patients were scanned with a Voluson 730 Expert scanner (GE Medical Systems, Bangalore, India) or an HDI 5000 scanner (Philips Medical Systems, Mumbai, India), using high-frequency (6-12 mHz) linear transducers. Extended or panoramic views were often recorded to demonstrate the lesion in relation to the adjacent structures in the abdominal wall.

There is no need for abdominal preparation. Abdominal wounds, if any should be cleaned and if possible covered with a thin, sterile, plastic adhesive membrane; more simply, the probe may be covered with sterile plastic or a glove.

Understanding the Layered Structure of the Anterior Abdominal Wall

The abdominal wall is a layered structure, consisting of skin, superficial fascia, subcutaneous fat, the muscle layer, the transversalis fascia and a layer of extra-peritoneal fat [Figure 1]. The most important layer to be appreciated is the muscle layer and is composed of paired midline rectus muscles and anterolaterally situated internal and external oblique and the transverse abdominis muscles. The aponeurosis of the external and internal oblique and transverse abdominis muscles continues medially as the rectus sheath. Two layers of the rectus sheath enclose the rectus muscles. The posterior rectus sheath is absent below the arcuate line. In the midline, the two recti are separated by fusion of the anterior and posterior layers of the rectus sheath to form the linea alba.

The skin is echogenic. The subcutaneous fat is usually hypoechoic.[3] The muscles reveal medium-level echoes with a lamellar pattern of the muscle fibers.

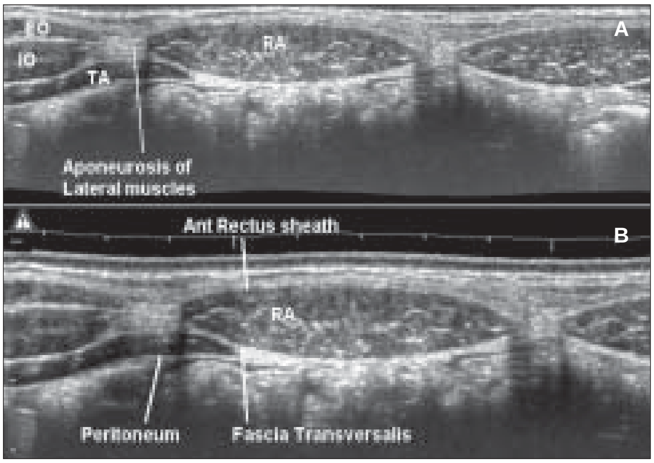

Figure 1 (A, B): Transverse panoramic scans of the anterior abdominal wall show detailed anatomy. RA – rectus abdominis, EO – external oblique, IO – internal oblique, TA – transverse abdominis

Abdominal Wall Muscles and Low Back Pain

Previous research has shown that the transverse abdominis muscle is part of the support and protection mechanism of the spine. The twin transverse abdominis muscles support the lumbar girdle. One of the most important actions of the transverse abdominis, is to draw-in the abdominal wall and this action has been shown to stiffen the sacroiliac joints. Each muscle belly thickens as well as shortens in length during this action, to form a deep musculo-fascial corset supporting the lumbopelvic region. People with deficient contraction of the transverse abdominis muscle, respond poorly to low back pain treatment measures[4,5] [Figure 2].

Real-time USG can reliably assess the changes in the thickness of the abdominal muscles, when they contract.[6-8] Hides et al, have found good correlation between USG and MRI measurements of the thickness of the transversus abdominis and the internal oblique muscles, as well as the fascial slide.[9]

Hernias

Hernias are common abdominal wall lumps. They are classified into different categories, depending on their location and cause. With high-resolution scanning, the fascial defect underlying the hernia, can be visualized. The appearance of the herniated bowel loops varies depending on their air/fluid content and the presence/absence of obstruction. Real-time examination can demonstrate induction and reduction of hernias. When the patient is asked to cough or perform a Valsalva maneuver, the increase in the intra-abdominal pressure causes herniation of peritoneal contents.

Inguinal Hernia

Inguinal hernias are the commonest of all hernias. An indirect internal hernia occurs when there is protrusion of the peritoneal sac contents through the internal inguinal ring into the inguinal canal.[10] The internal inguinal ring is a defect in the transversalis fascia. It is located anterior to the femoral vessels, lateral to the inferior epigastric artery and above the inguinal ligament. The superficial inguinal ring is a defect in the external oblique aponeurosis. A direct inguinal hernia occurs when the peritoneal sac contents protrude directly through the weakened inguinal canal floor, medial to the inferior epigastric artery. Identification of the inferior epigastric artery helps differentiate a direct from an indirect inguinal hernia[11,12]. [Figure 3].

The USG appearance of an inguinal hernia depends upon its contents [Figure 4], which commonly include fat or air or fluid-containing bowel loops. When there is bowel obstruction within a hernia, the bowel loop becomes distended, edematous and aperistaltic [Figure 4c]. In old people, especially with a coexisting bladder outflow obstruction, the urinary bladder may sometimes extend into the hernia [Figure 5]. In female neonates and infants, the ovaries may prolapse into the hernia [Figure 6].

Femoral Hernia

A femoral hernia occurs when there is herniation of peritoneal sac contents through the femoral canal [Figure 7a]. On transverse scanning, the herniation is seen to lie medial to the femoral vein[13] [Figure 7b]. Typically, the patients are elderly and obese and complain of abdominal or groin pain, with or without a palpable mass.

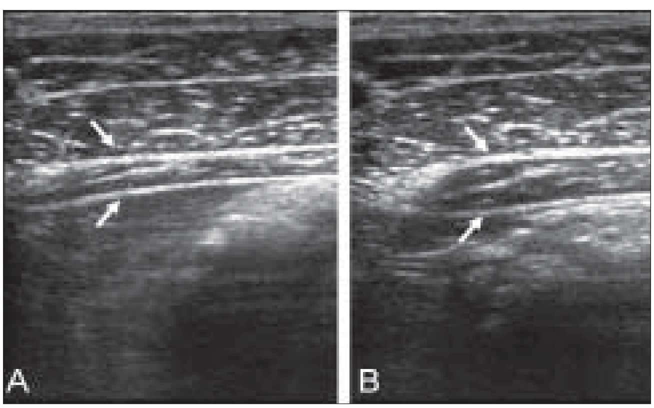

Figure 2 (A, B): Transverse scans showing the transverse abdominis muscle (arrows) at rest (A) and after the patient draws in the abdominal wall (B), which leads to increased thickness of the muscle

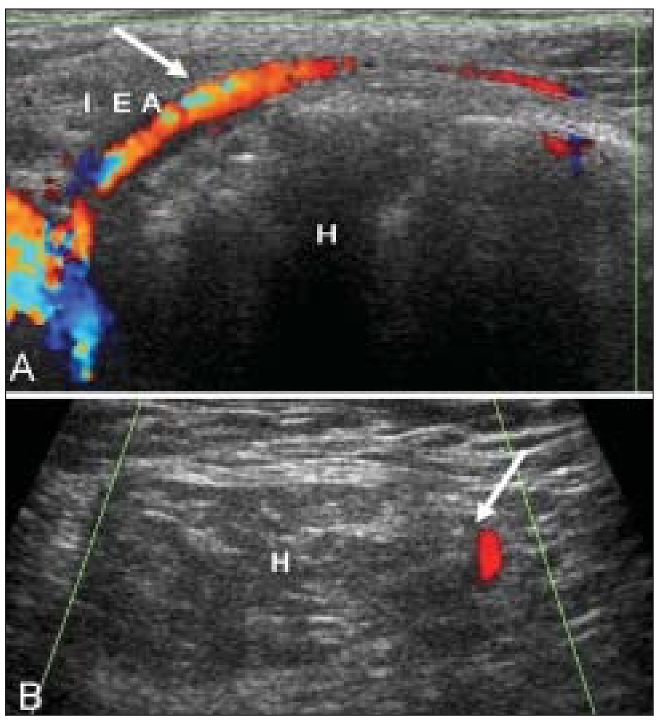

Figure 3 (A, B): The position of the inferior epigastric artery (arrow), shown in these color Doppler images differentiates a direct inguinal hernia (A), which lies medial to it from an indirect inguinal hernia (B), which lies lateral to it

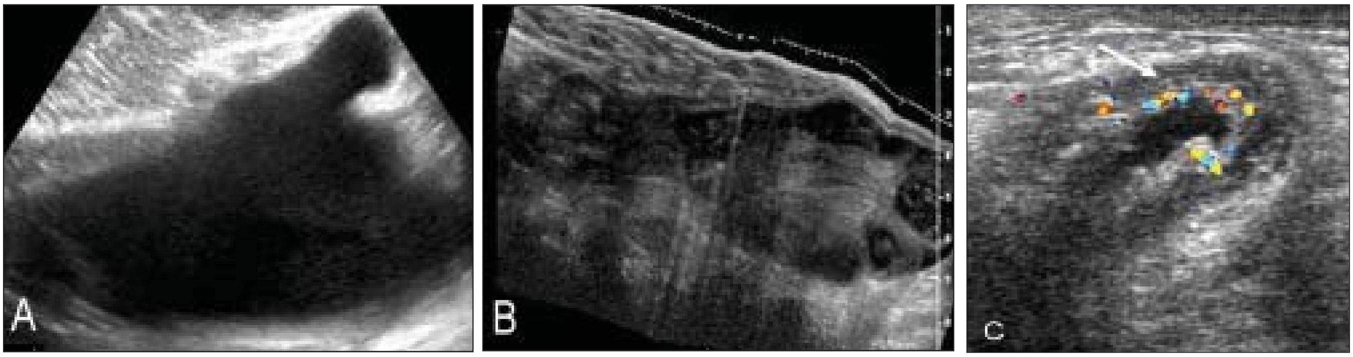

Figure 4 (A-C): Inguinal herniae in different patients, containing fluid (A) and non-obstructed (B) and obstructed (C) bowel loops. Note the thickening of the bowel wall (arrow) and increased vascularity in the obstructed loop

Figure 5: Panoramic image shows the urinary bladder extending into the inguinal hernia. BL – bladder, H - hernia

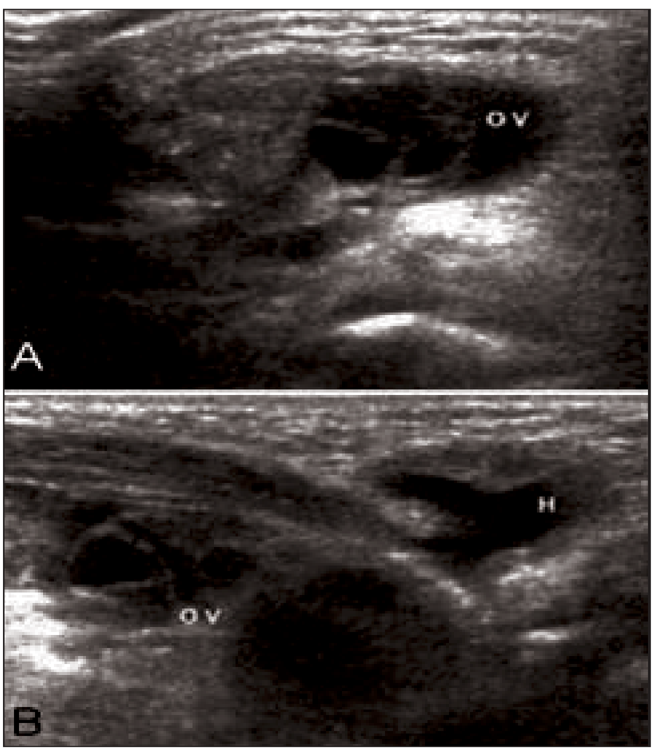

Figure 6 (A, B): Inguinal hernia in an infant girl, containing a prolapsed ovary (A), which subsequently reduces into the peritoneal cavity (B). OV – ovary, H – hernial Sac

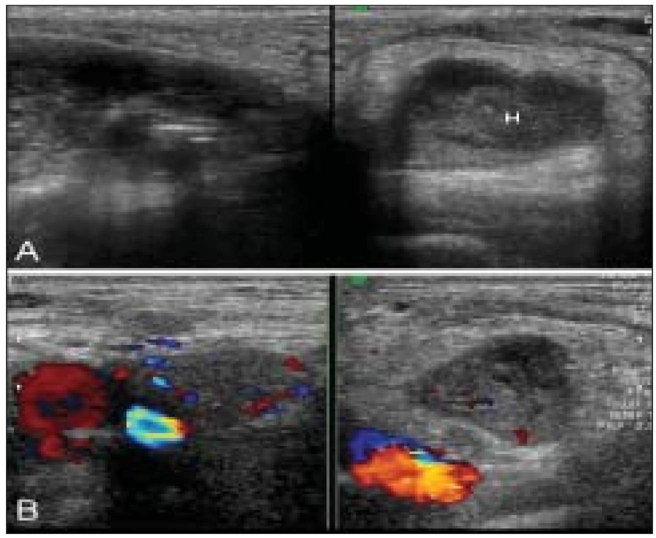

Figure 7 (A, B): Femoral hernia. The grayscale images (A) show a femoral hernial sac at two different levels. The color Doppler (B) images show the sac lying medial to the femoral vessels (showing color flow)

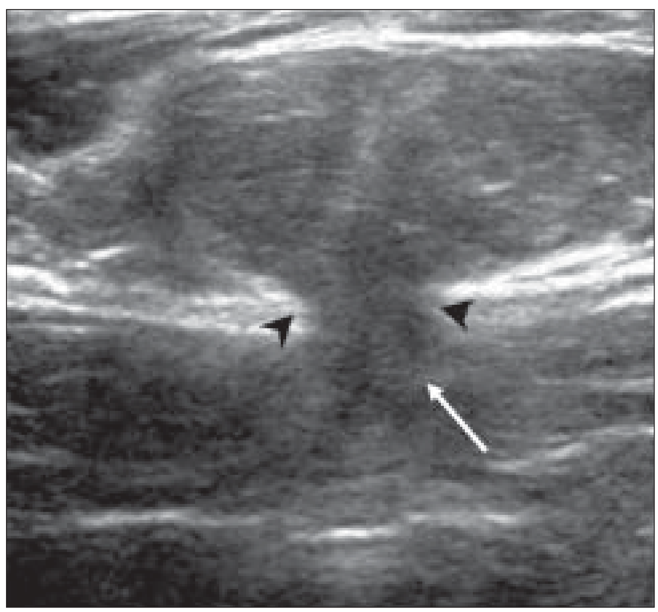

Figure 8: Ventral hernia. The omental fat (arrow) is seen protruding through a defect (arrowheads) in the rectus sheath

Ventral Hernia

They occur typically where there is no muscle support along the linea alba in the midline in the epigastrium [Figure 8] or periumbilical region [Figure 9]. The hernia typically has a button mushroom-like appearance. The defect in the rectus sheath can be very well seen on a 3D coronal projection [Figure 9b]. The hernia very often contains only fatty tissue, but at times may be large and contain bowel loops also.[14,15]

Spigelian Hernia

A Spigelian hernia occurs through a defect in the aponeurosis of the transverse abdominis muscle and the rectus sheath. The commonest site is the point where the linea semilunaris crosses the arcuate line.[16,17] The hernia may sometimes extend laterally and present as a flank lump [Figure 10].

Incisional Hernia

A focal defect in an incisional scar may lead to an incisional hernia. It usually develops 4-8 months after surgery, but may go unnoticed by the patient, till it attains a significant size. It can even develop after laparoscopic procedures[Figure 11].[1018,19] USG is very useful in screening for hernias at surgical sites and in the follow-up of the integrity of wire-mesh implants [Figure 12a, 12b].

Fluid Collections

Localized fluid collections in the abdominal wall may be due to seromas, abscesses or liquefying hematomas.

Non-infected *seromas* following surgery are usually anechoic collections. Fluid collections complicated by infection or hemorrhage appear more complex with variable internal echoes, layering and/or septae [Figure 13].[3]

A *cold abscess* secondary to tuberculosis of the ribs may present as a lump. USG reveals pockets of fluid, along the costal margin [Figure 14A], with internal echoes. Destruction of the corresponding rib may be seen[20,21] [Figure 14b].

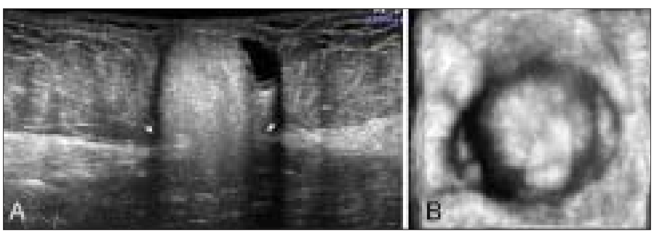

Figure 9 (A, B): Peri-umbilical hernia. The 2D image (A) shows fat (long arrow) herniating through a defect in the rectus sheath (arrows). The coronal 3D image (B) shows the rectus defect (arrows)

Figure 10: Spigelian hernia. The panoramic image shows the hernia (arrow), containing bowel loops (arrowheads)

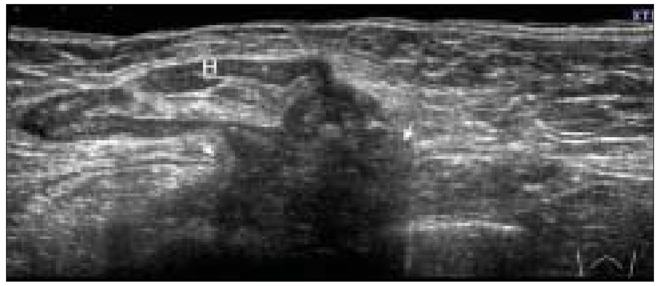

Figure 11: Incisional hernia. The panoramic image shows the hernial sac, protruding through a laparoscopy scar defect (arrows). H – hernial sac

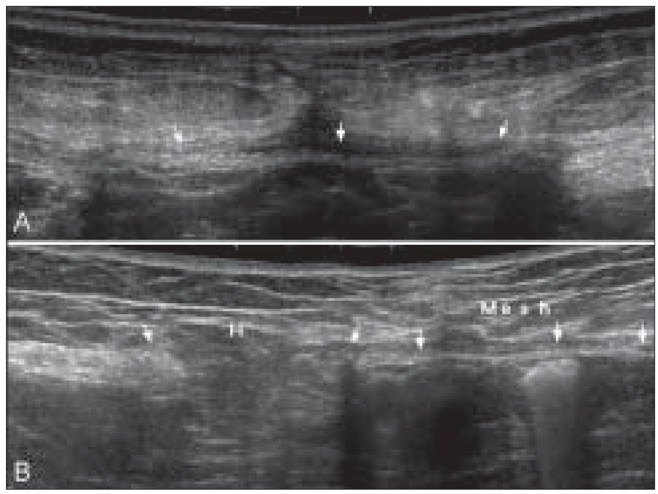

Figure 12 (A, B): Panoramic images show a mesh implant in place after herniorrhaphy (arrows in A) and a hernial recurrence besides the edge of the mesh implant (arrows in B). H – hernial sac

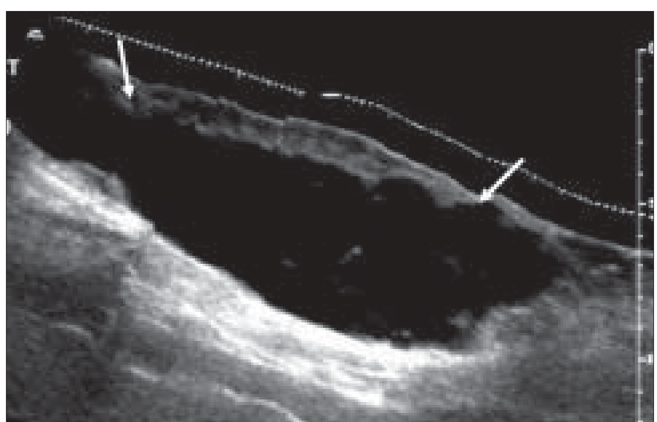

Figure 13: Seroma. Panoramic view shows an abdominal wall seroma (arrows), after splenectomy

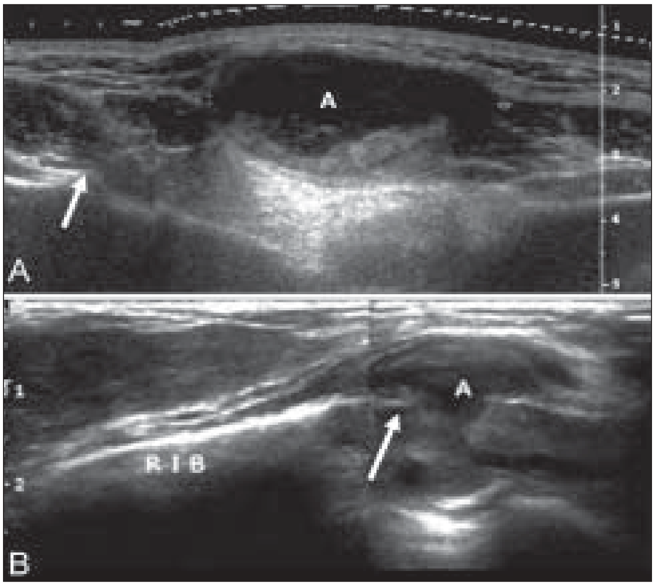

Figure 14 (A, B): Tuberculous abscess. Panoramic view (A) shows a complex abscess, inferior to the costal margin (arrow). In another patient, a panoramic view shows the abscess overlying an area of rib destruction (arrow). A – Abscess

Suture abscesses are seen as irregular collections within the layers of the abdominal wall, around infected sutures; fragments of suture material may sometimes be seen within these collections [Figure 15].

Hematomas commonly occur in the rectus sheath, in patients who are on anticoagulant therapy or in those who suffer from some coagulation disorder, especially following violent muscle contraction e.g. after a bout of coughing or seizures. The shape of the hematomas depends on their location and follows the limits of the rectus sheath. Above the arcuate line, hematomas are usually ovoid in shape, with a supero-inferior long axis, typically seen on one side. Below the arcuate line, they can extend across the midline, as there is no midline aponeurosis [Figure 16].[27-29] In neonates, an abdominal wall hematoma may be limited to the subcutaneous layer and may be spread transversely in the supra-umbilical region. In post-operative patients, large hematomas may often be seen, in the vicinity of the surgical scar [Figure 17].

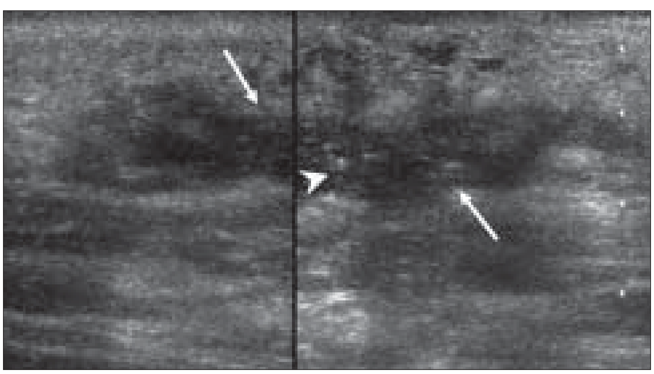

Figure 15: Suture abscess. An irregular collection (arrows) is seen with echogenic material within, which may represent suture fragments (arrowhead)

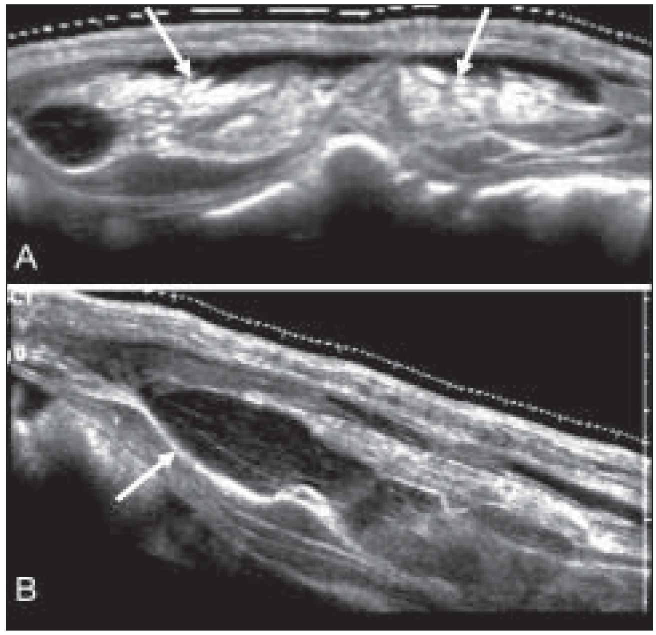

Figure 16 (A, B): Rectus sheath hematoma. Transverse (A) and longitudinal (B) panoramic images show a hematoma (arrows), in an old woman, following severe cough

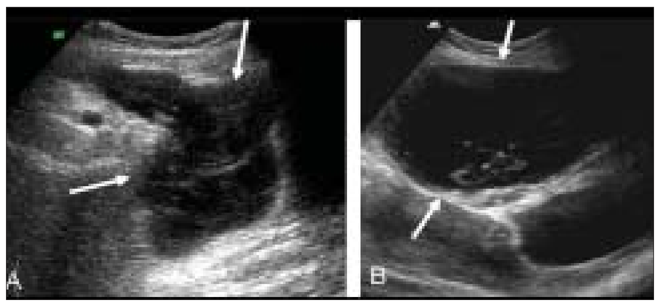

Figure 17 (A, B): Abdominal wall hematomas (arrows), in a patient (A) with disseminated intravascular coagulation (DIC) with a resolving abdominal wall hematoma in another patient (B) with DIC after a Cesarian section.

Miscellaneous Lesions

Everted Xiphisternum

Rarely, an everted xiphisternum may present as a hard, painless mass in the epigastrium [Figure 18].

Divarication of Recti

The weak and stretched aponeurosis at the linea alba may bulge out when the patient strains, simulating a large hernia [Figure 19].

Urachal Cyst

A urachal cyst develops from urachal remnants. It is usually situated between the umbilicus and the urinary bladder. USG reveals a clear cyst or with faint internal echoes[22,23] [Figure 20].

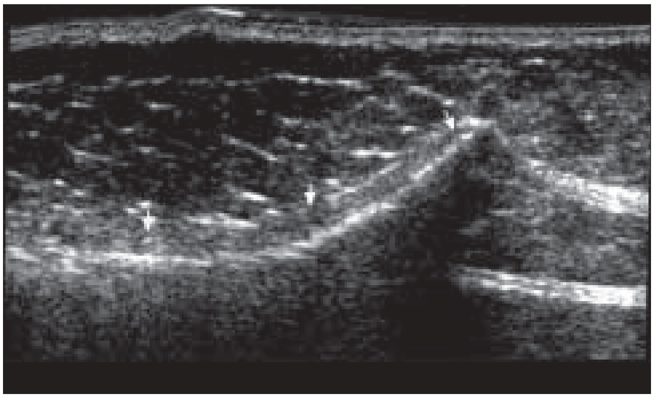

Figure. 18: Longitudinal image showing a prominently everted xiphisternum (arrow)

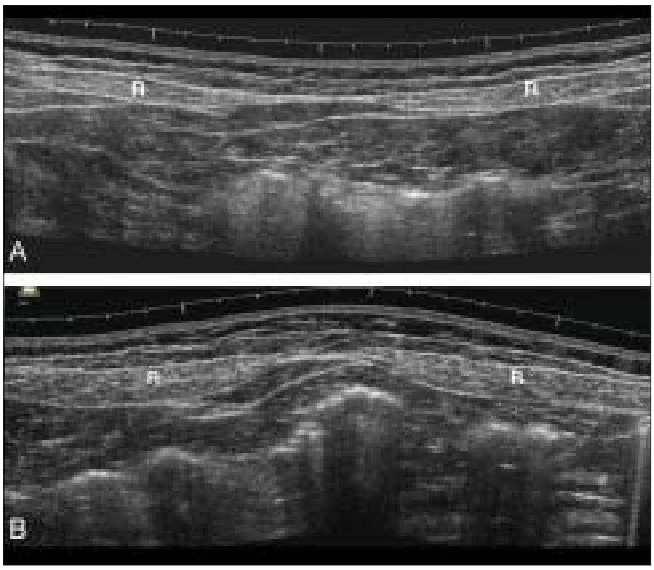

Figure 19 (A, B): Divarication of recti. Panoramic images with the patient relaxing (A) and straining (B) showing Divarication of the rectus muscles. R – rectus muscles

Endometriosis

Endometriosis of the abdominal wall usually develops as complication of uterine surgery, due to seeding of endometrial tissue. Typically it is seen as a focal mass at the scar of previous surgery. The size and the associated pain may vary cyclically [Figure 21].[24-26]

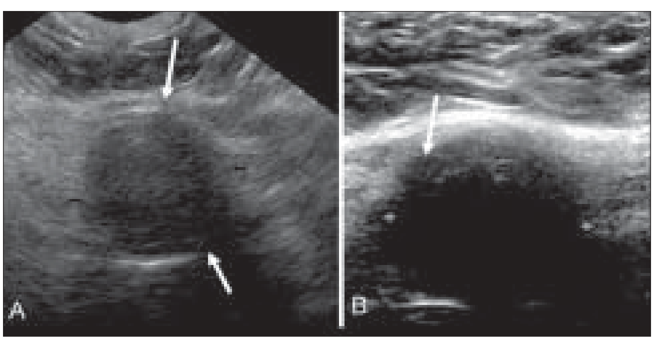

Figure 20 (A,B): Urachal cyst. Transverse image (A) shows an infected urachal cyst (arrows), containing faintly echogenic fluid, the anterior wall of which produces reverberation artifacts (B)

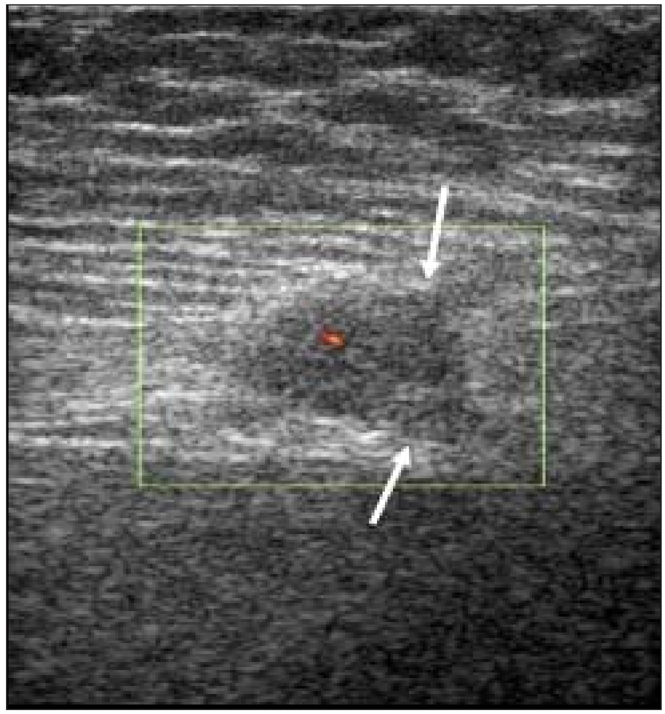

Figure 21: Endometriosis. Transverse image shows a focal nodule (arrows) at the site of the cesarian section scar

Neoplasms

Lipomas are the commonest abdominal wall neoplasm. They are well–defined, ovoid or pad-like masses [Figure 22]. Most of them reveal an iso to slightly hyperechoic texture as compared to the muscles, along with a thin echogenic capsule.[3,30]

A *desmoid* tumor arises from the fascia or the muscle aponeurosis . It often develops at the site of a previous surgical scar and is more common in women than men[31,32] [Figure 23].

Metastatic melanoma is probably the commonest malignant tumor to occur in the abdominal wall. Less commonly, metastases from lymphoma, lung, breast, ovary and colon may be seen [Figure 24]

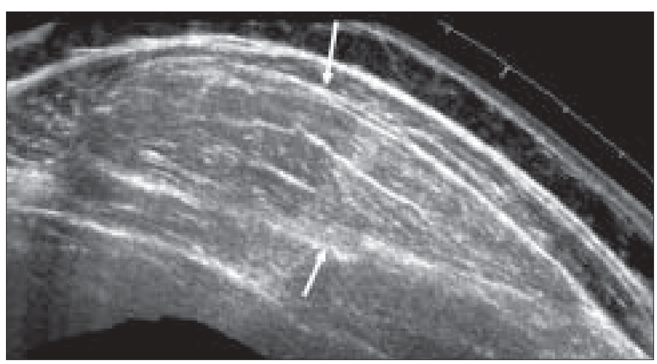

Figure 22: Lipoma. Panoramic view shows a well-defined mass (arrows) with a capsule in the abdominal wall

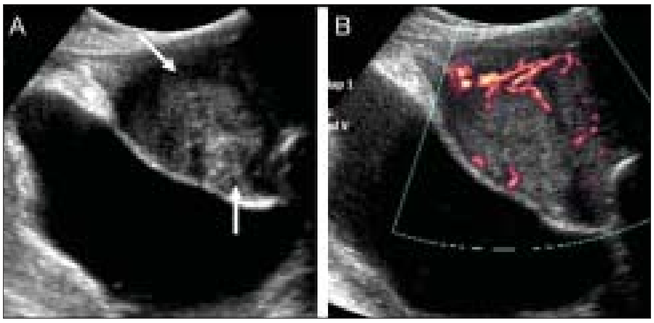

Figure 23 (A, B): Desmoid. Grayscale (A) and color Doppler (B) images reveal a mass (arrows) at the site of a previous surgical scar, showing some vascularity within

Figure 24: Metastasis. A recurrent ovarian neoplasm (arrows) is seen, with a metastatic nodule (arrowheads) in the abdominal wall

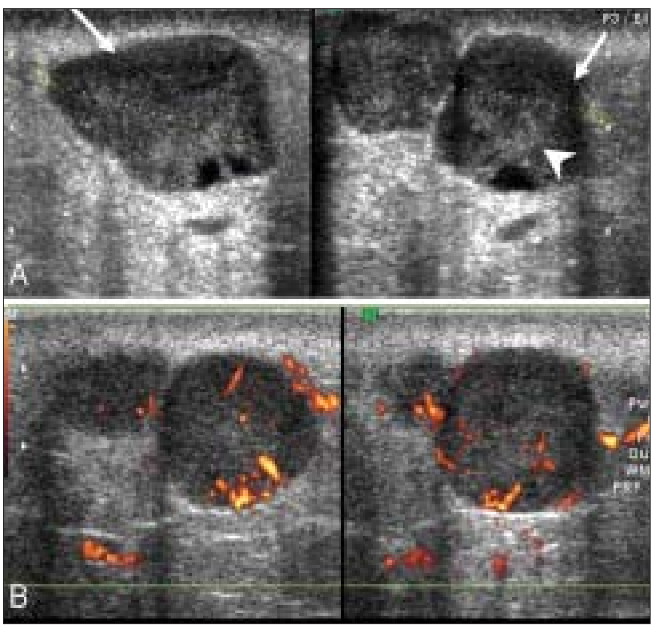

Figure 25 (A, B): Inguinal lymphadenopathy. Grayscale (A) and color Doppler (B) images show enlarged inguinal nodes (arrows) with increased vascularity. Note the echogenic hilum (arrowhead)

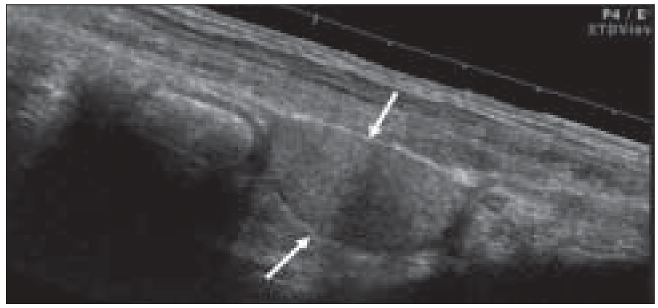

Figure 26: Undescended testis. Extended view shows an echogenic nodule (arrows) in the inguinal canal, representing an undescended testis. Note the absence of a hilum

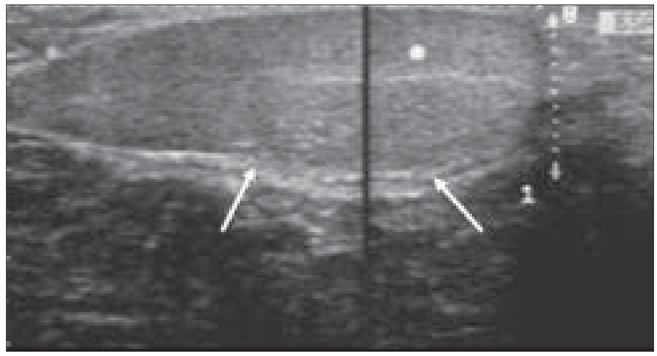

Figure 27: Lipoma of the inguinal canal. An echogenic, ovoid mass (arrows) is seen in the inguinal canal

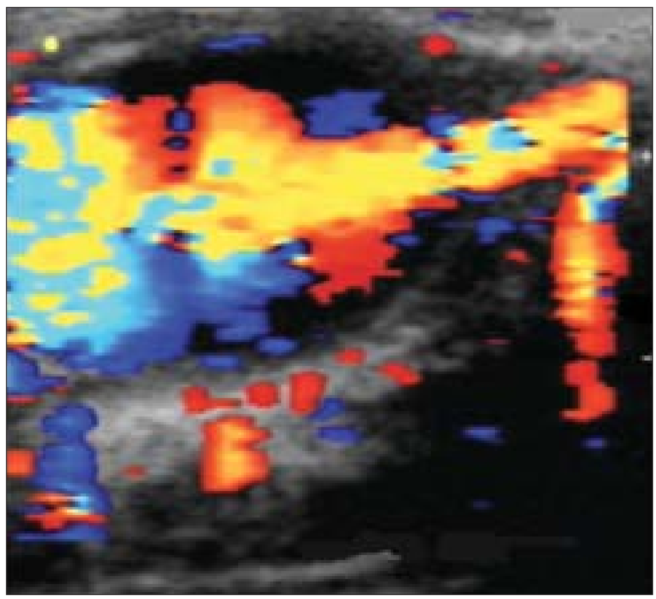

Figure 28: Pseudoaneurysm. Color Doppler image shows "to and fro" flow in this pseudoaneurysm of the common femoral artery

Inguinal Masses

Lymph Nodes

Lymph nodes have a characteristic USG appearance with an echogenic central area and a hypoechoic peripheral zone[30] [Figure 25].

Undescended Testis

An undescended testis may get arrested anywhere between the scrotum and the renal hilum. By far the commonest site, is the inguinal canal. A low, undescended testis is usually smaller, ovoid and reveals a homogenous hypoechoic structure. The absence of an echogenic hilum distinguishes a testis from a lymph node[33-35] [Figure 26].

Lipoma of the Spermatic Cord and Inguinal Canal

The commonest tumor of the spermatic cord is a lipoma, which occurs commonly in the inguinal canal. Though it is a poorly recognized entity, it is commonly seen as a spindle–shaped, echogenic mass along the inguinal canal or in the upper part of scrotum [Figure 27]. Clinically it is indistinguishable from an inguinal hernia.[36,37] .

Pseudoaneurysm

Pseudoaneurysms develop due to local trauma to the vessel wall, especially after catheterization procedures. They are extra-axial cystic structures, which may reveal pulsations and swirling of echogenic blood within the cystic fluid-filled cavity on USG. Color Doppler reveals "to and fro" flow, with a typical "yin-yang" sign[38,39] [Figure 28].

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