Chapter 6
Adult Hip

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INTRODUCTION

Advances in sonographic technology and increasing awareness of its capabilities have led to a rapidly expanding role for ultrasound in assessing the adult hip. Ultrasound provides a valuable addition or alternative to other imaging modalities due to its dynamic capabilities, rapid scan times, exquisite soft tissue detail (even in the presence of metal implants), and ability to guide interventional procedures. This chapter describes the anatomy, scanning technique, and pathologies of the adult hip and pelvis. Advantages and limitations of ultrasound when compared with magnetic resonance imaging (MRI) are also discussed.

ANATOMY AND TECHNIQUE

The optimal probe for scanning the hip depends on the depth of the structure being imaged and the size of the patient. High-frequency linear transducers of the order of 17 MHz provide excellent superficial soft tissue detail in smaller patients, but 12 MHz, 9 MHz linear, or even 2 to 5 MHz curvilinear probe may be required for deeper structures in larger patients. Start with the highest frequency and then reduce as required.

Anatomy and scanning techniques are best considered as four quadrants: anterior, posterior, medial, and lateral.

Anterior

The anterior quadrant contains the anterior joint recess, iliopsoas tendon, rectus femoris, sartorius, and tensor fascia lata (TFL). (Examination of groin hernias is covered in the hernia section.) The examination is performed with the patient supine and transverse (TS) and longitudinal (LS) images are obtained (Fig. 6.1). The anterior joint recess is evaluated with the probe aligned obliquely along the femoral neck to look for the presence of an effusion or large anterior labral injury in the normally hyperechoic labrum. The hyperechoic iliofemoral ligament can sometimes be seen overlying the anterior capsule (Fig. 6.2A).

The iliopsoas muscle is scanned in true longitudinal and transverse views (Figs. 6.2 and 6.3). It lies superficial to the capsule and lateral to the femoral neurovascular bundle. The hyperechoic iliopsoas tendon lies on the deep and medial aspect of the muscle and inserts distally on the lesser trochanter. The iliopsoas bursa lies between the anterior joint capsule and tendon, but is not seen unless bursitis or fluid are present. Superficial to iliopsoas is sartorius, which can be traced distally from the anterior superior iliac spine (ASIS). Tensor fascia lata is superficial and lateral and also originates from the ASIS and iliac crest (Fig. 6.3). The TFL courses laterally to blend into the anterior aspect of the fascia lata. Superficial and medial to iliopsoas is rectus femoris, which originates from the anterior inferior iliac spine (AIIS). Longitudinal views of these muscles and tendons should be performed when evaluating for tendinopathy and muscle tears.

Posterior and Lateral

For anatomical purposes these two quadrants are considered together. They incorporate the gluteal muscles and tendons. The hamstring origins and sciatic nerve will also be considered here.

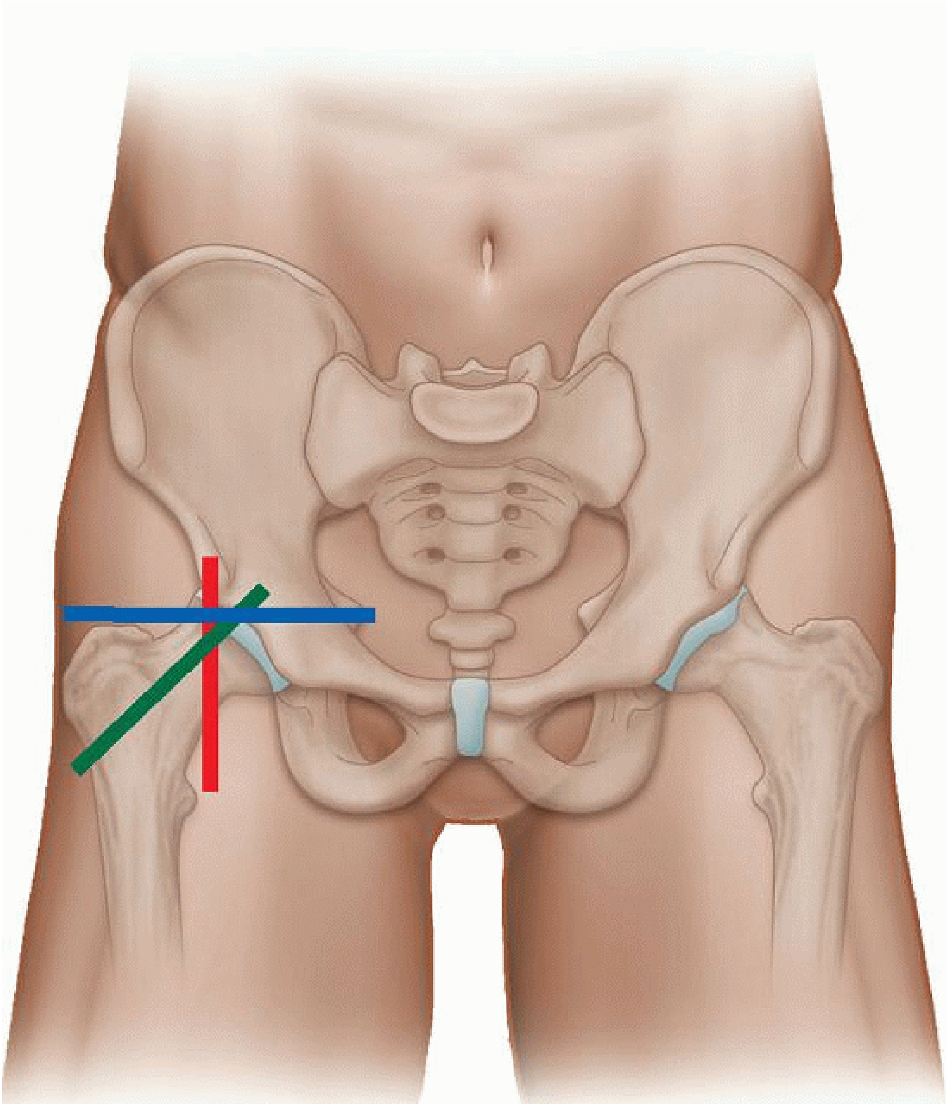

Figure 6.1. Anterior hip probe positions. The three probe positions for imaging the anterior hip are demonstrated by the three colored lines: True LS (red), longitudinal femoral neck (green), and TS (blue).
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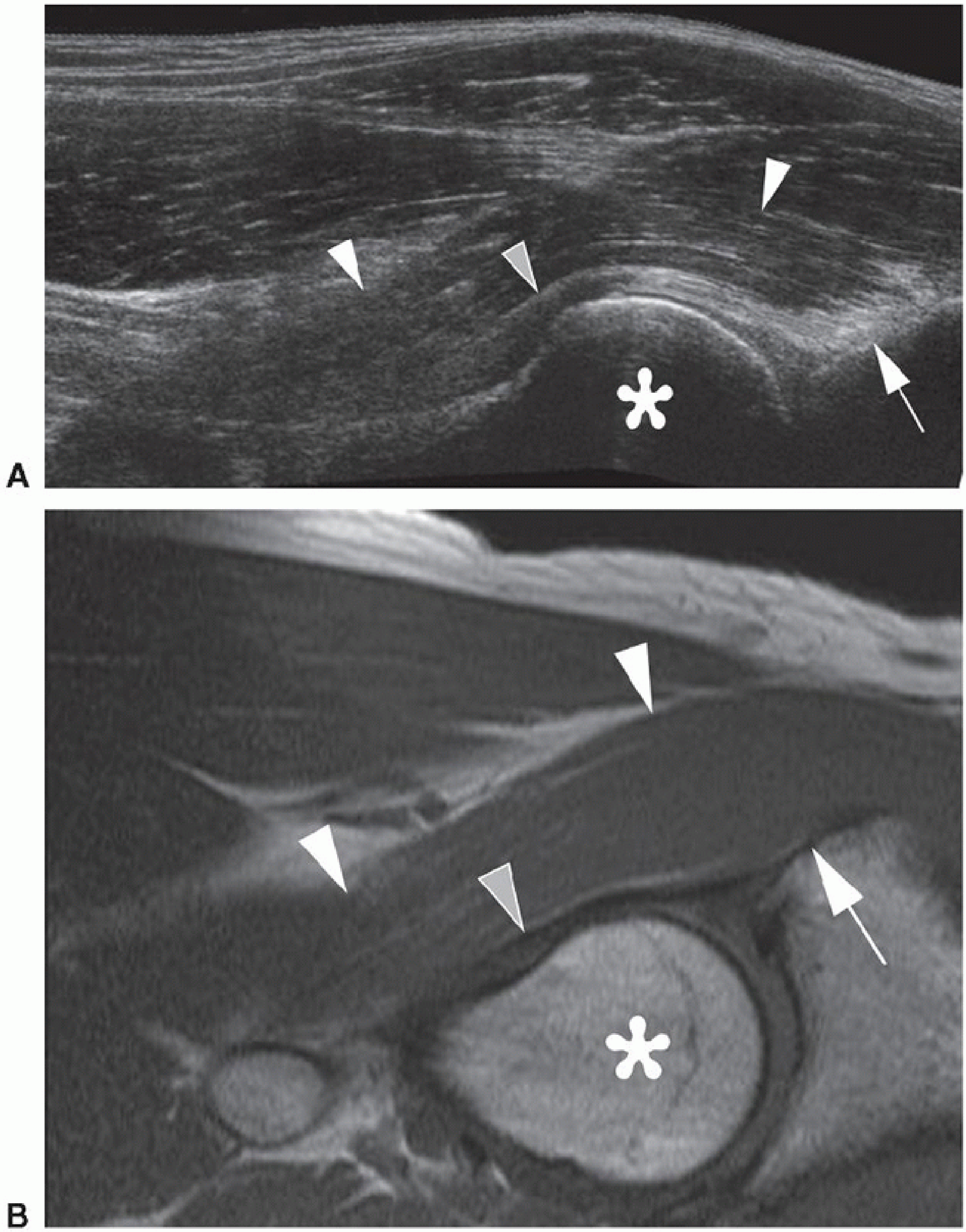

Figure 6.2. Normal LS views of the hip. A: Longitudinal sonogram and B: Sagittal T1-weighted (T1W) MRI show femoral head (asterisk), iliopsoas (white arrowheads), normal capsule (gray arrowhead) and acetabular rim (white arrow).

For gluteal assessment, the patient is initially scanned in the lateral decubitus position with a high-frequency probe. Gluteus medius (deep) and gluteus minimus (superficial) can be traced cranially down to the greater trochanter in both long-axis and short-axis scans (Fig. 6.4). The TFL is adjacent to the anterior margins of these two muscles, and gluteus maximus overlies the posterior portion of gluteus medius. The echogenic tendons of gluteus minimus and medius insert into the anterior and lateral aspects of the greater trochanter, respectively. Long-axis and short-axis scans should be performed to detect tendinopathy and evidence of bursitis between the tendons and trochanter.

Evaluation of the hamstring origins is performed with the patient prone with the feet hanging over the end of the couch. Lower frequency probes may be required for larger patients. The ischial tuberosity is first identified, located medially at the junction of buttock and thigh (Fig. 6.5). The origin of the ischiocrural tendons (semimembranosus, long head of biceps femoris, and semitendinosus) attaches laterally (Fig. 6.6). They cannot always be appreciated separately at this level on

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ultrasound, but individual tendons can be identified by tracing them caudally. They initially separate into the semimembranosus tendon (medial) and the conjoined tendon of semitendinosus and the long head of biceps femoris (superficial and lateral). The conjoined tendon then further divides into the muscle bellies of semitendinosus (medial) and biceps femoris (lateral). Evaluate them in longitudinal and transverse planes to assess for tendinopathy (Fig. 6.7). Lateral to the ischiocrural tendon origin, the sciatic nerve has the characteristic neural fascicular pattern (Fig. 6.6).

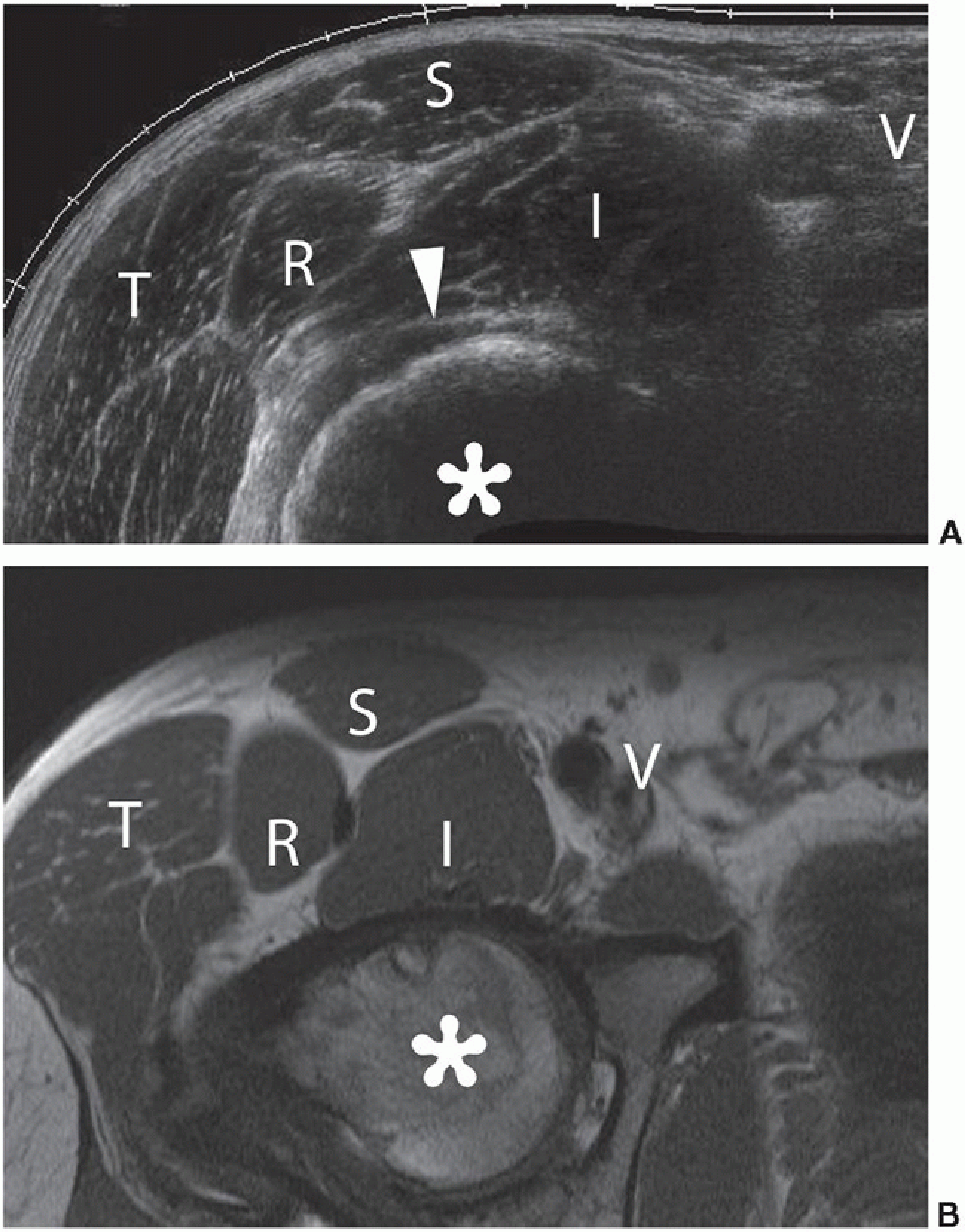

Figure 6.3. Normal TS views of the hip. A: Transverse sonogram and B: Axial T1W MRI show femoral head (asterisk), iliopsoas (I), TFL (T), rectus femoris (R), sartorius (S), femoral vessels (V), and capsule (arrowhead).

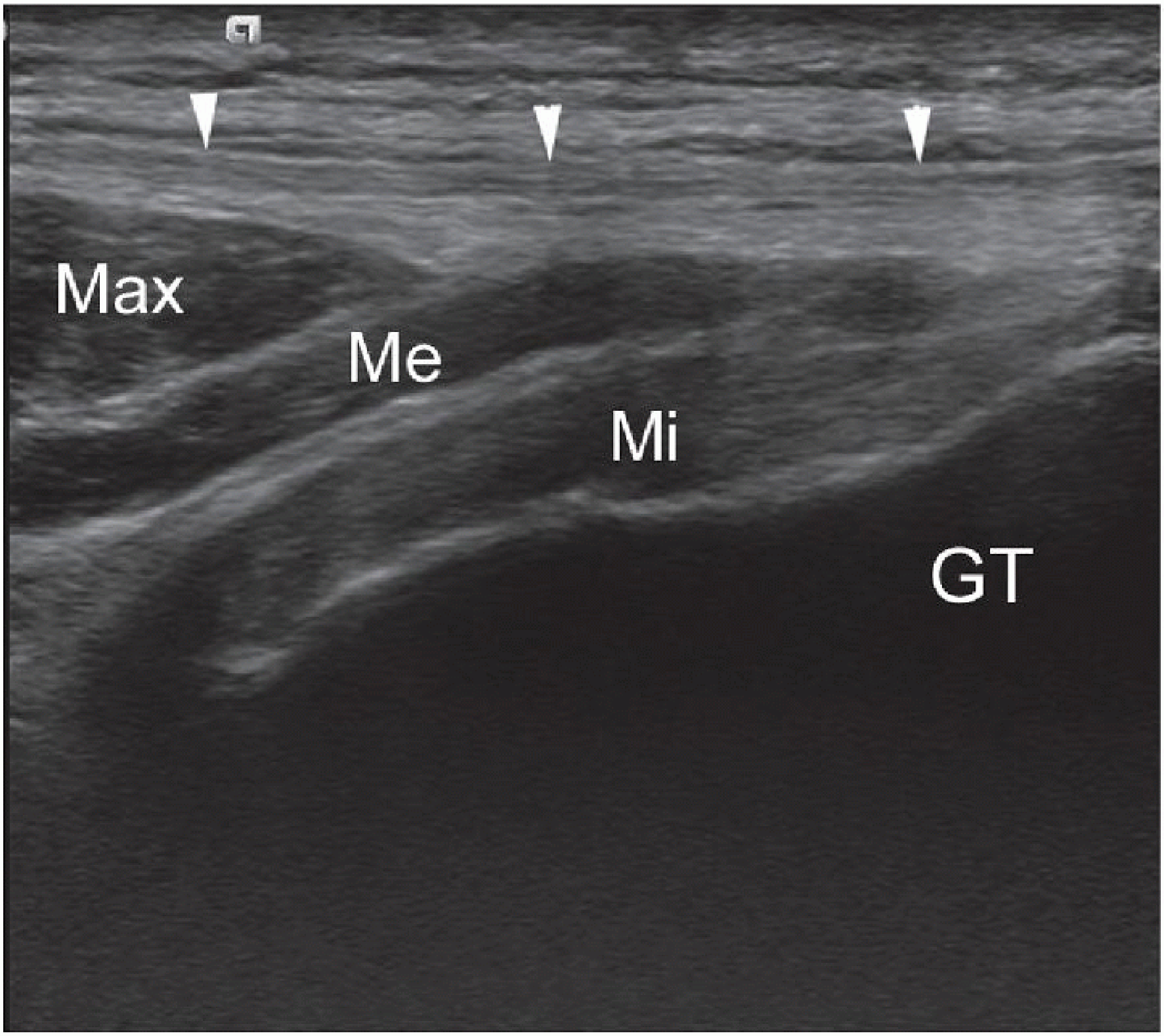

Figure 6.4. Longitudinal view of the greater trochanter. Longitudinal sonogram shows normal greater trochanter (GT), gluteus medius (Me), and minimus (Mi) muscles and tendons. The gluteus maximus (Max) is more superficial with overlying fibrillar fascia lata (arrowheads).

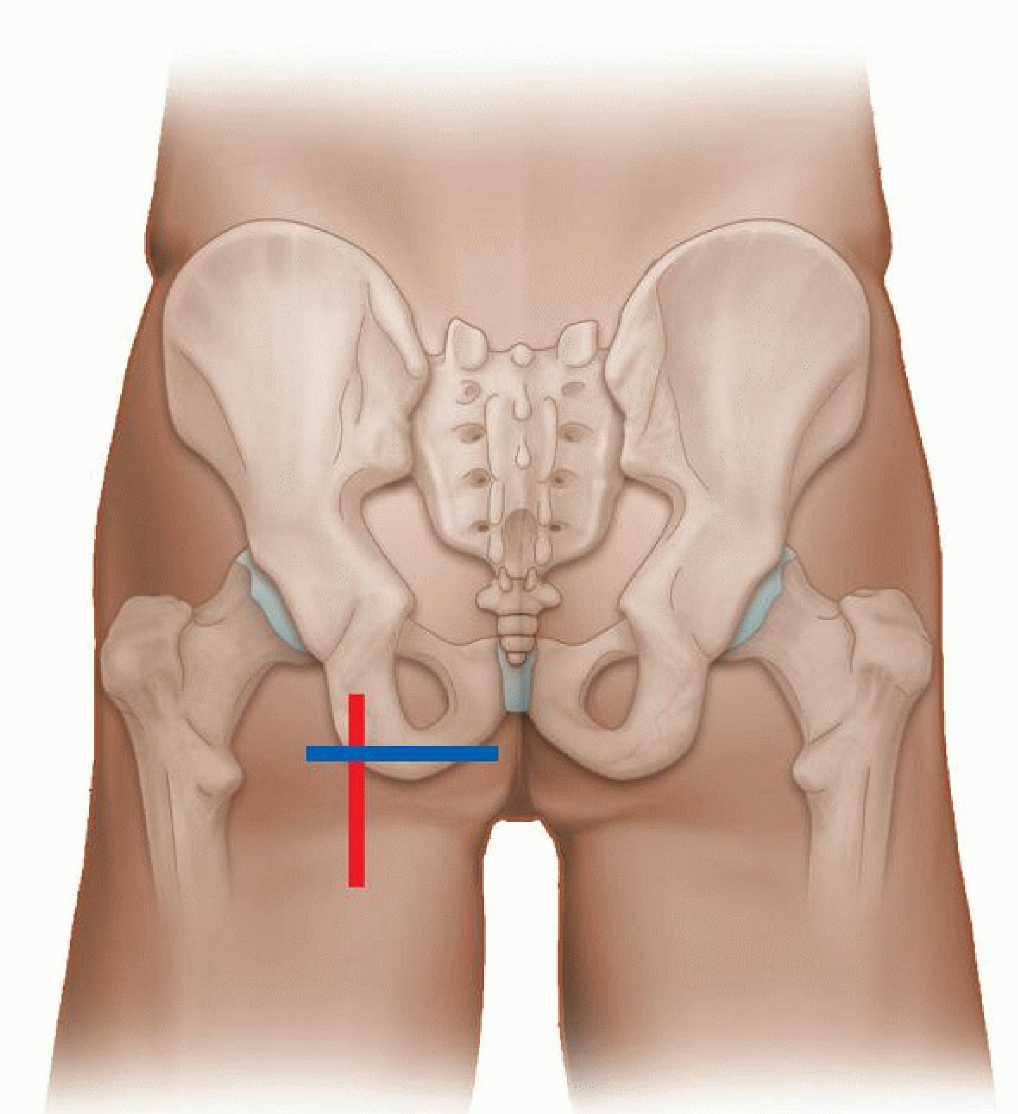

Figure 6.5. Posterior hip probe positions. The two probe positions for imaging the posterior hip are demonstrated by the two colored lines: LS (red) and TS (blue).

Medial

This quadrant contains the origins of the adductor muscles: longus, brevis, and magnus along with gracilis and the insertion of iliopsoas. The patient is scanned in the supine position with the thigh abducted and externally rotated and the knee flexed (Fig. 6.8). The insertion of iliopsoas can be best assessed in this position using LS views, as anisotropy is a common problem, with the leg in the adducted position.

Place the probe over the anterior aspect of the medial muscle compartment, medial to the neurovascular bundle to reveal the three adductor muscles separated by hyperechoic fascial planes (Fig. 6.9). Adductor longus is anterior, adductor brevis is intermediate, and adductor magnus lies posterior. Gracilis is found medial to adductor longus and superficial to adductor brevis. The muscles can be traced to their origin at the pubis to evaluate for tendinopathy and muscle tears using LS and TS views. Next, assess the

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symphysis pubis joint space, found medial to the adductor insertion, for arthropathic changes (Fig. 6.10).

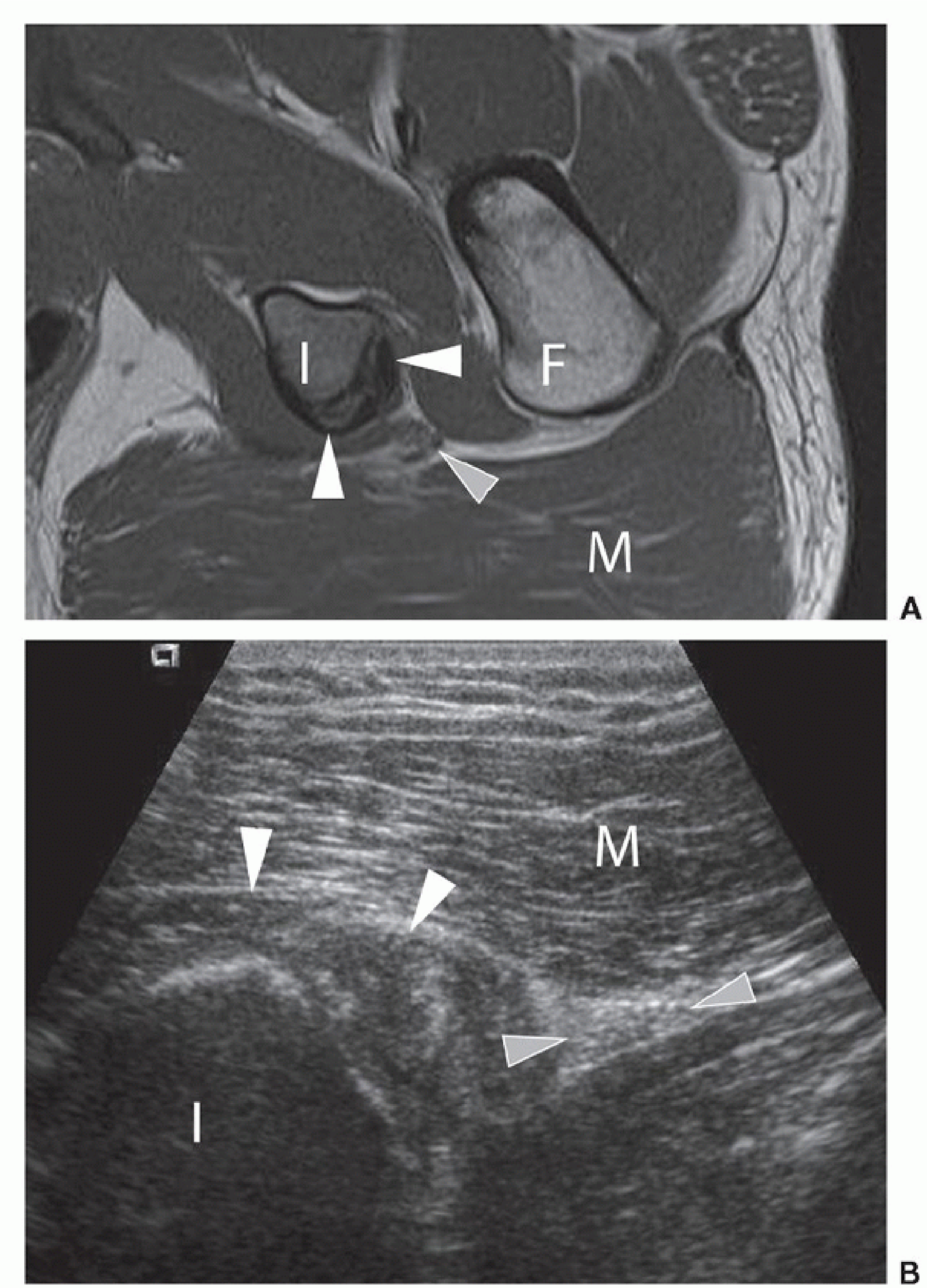

Figure 6.6. Normal axial/TS views of the ischial tuberosity. A: Axial TW1 MRI and B: Transverse sonogram shows ischial tuberosity (I), femur (F), gluteus maximus (M), hamstring origins (white arrowheads) and sciatic nerve (gray arrowheads).

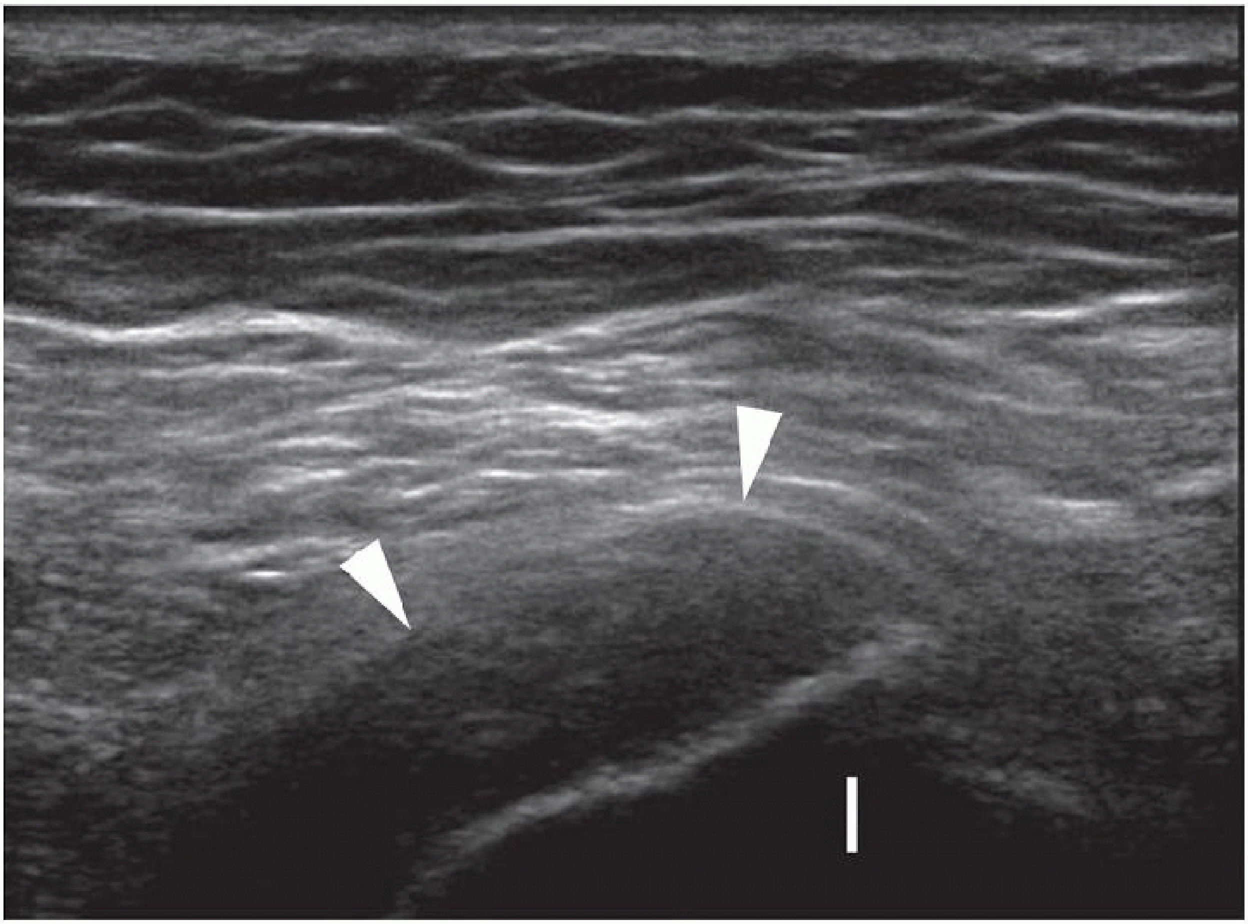

Figure 6.7. Overuse hamstring tendinopathy. Longitudinal sonogram shows hypoechoic thickened hamstring origin tendons (arrowheads) and adjacent ischial tuberosity (I).

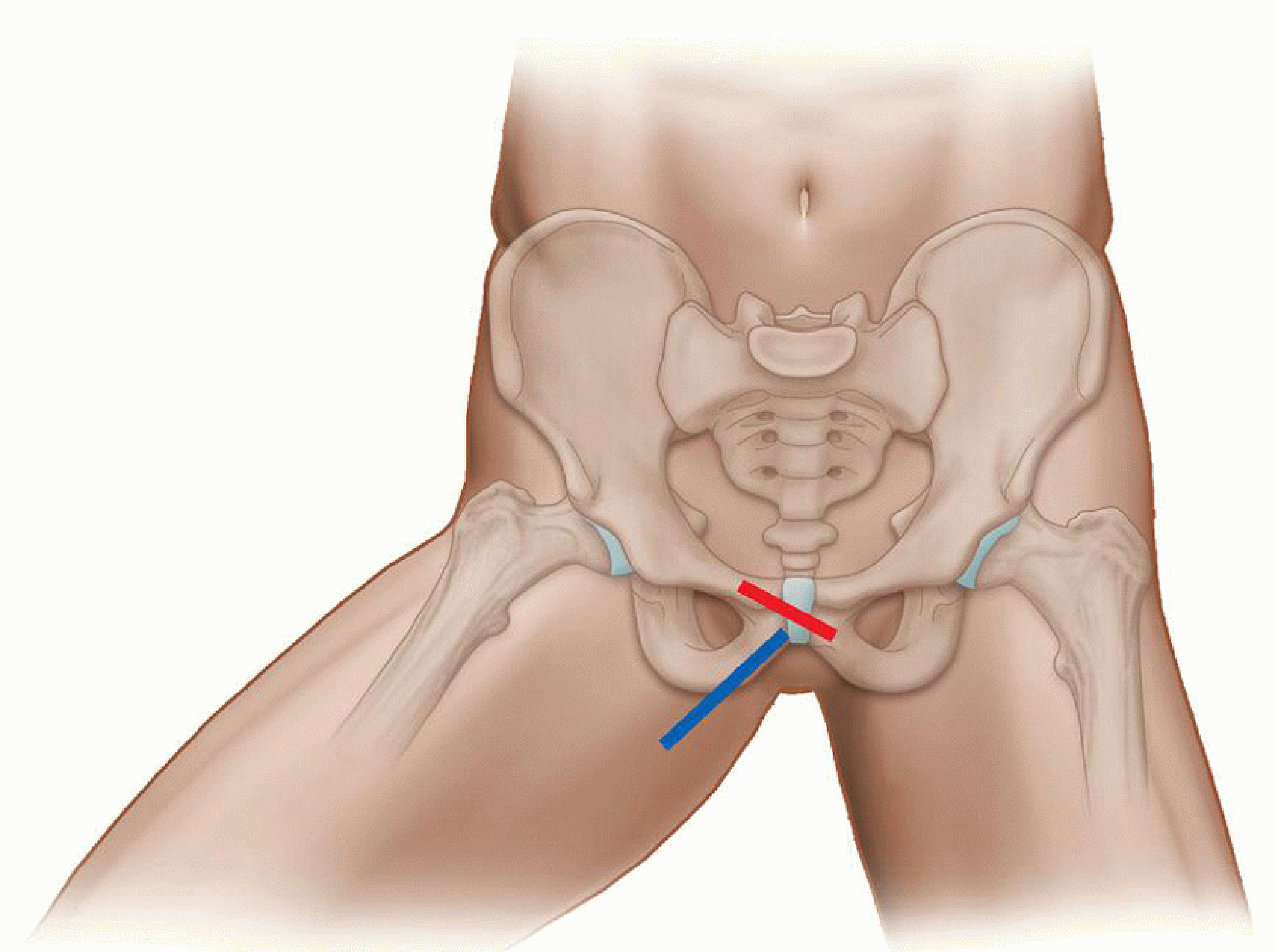

Figure 6.8. Medial hip probe positions. The two probe positions for imaging the adductor area are demonstrated by the two colored lines: LS (blue) and TS (red).

HIP JOINT EFFUSION

Effusions of the hip joint are almost always pathological, but are rarely detectable clinically owing to the depth of the hip joint. Ultrasound is rapid, portable, and effective[1],[2],[3], avoids unnecessary "dry" aspirations and joint contamination, and shows extra-articular collections. Power Doppler identifies coexisting inflammation. Ultrasound can be employed to guide diagnostic aspiration, biopsy, and therapeutic injections.[4]

Causes

Hematological seeding during bacteremia is the most common cause of septic arthritis, most often due to Staphylococcus aureus.[3] Risk factors include IV drug abuse, endocarditis, indwelling catheters, advanced age, immunosuppression, and preexisting joint injuries.[5] Other causes include adjacent surgery or direct extension of infection from the abdomen via iliopsoas. Rapid diagnosis is vital as delay worsens the prognosis.[3] Bacterial arthritis results in irreversible loss of joint function in 25% to 50% of patients and 5% to 15% fatality rates.[6] The appearances of the effusion in terms of complexity and echogenicity do not predict infectious or inflammatory nature.[7] Ultrasound cannot prove sepsis and if suspected, analysis of aspirated fluid is usually required. However, large joint effusions with extra-articular extension in painful prosthetic hips are strongly associated with infection.[8]

Inflammatory arthritides, both seropositive and seronegative, cause hip effusions. Immunosuppressive treatment increases the risk of avascular necrosis and infection, which themselves cause effusions. Increased synovial power Doppler flow suggests an inflammatory rather than noninflammatory cause, but does not differentiate between types of inflammation, for example, infective or noninfective.[9] Marginal erosions may rarely be seen at the bone-cartilage interface at the femoral head and neck in inflammatory arthropathy.

Benign tumors of bone and soft tissue, including synovial osteochondromatosis, pigmented villonodular synovitis, osteoid osteoma, and giant cell tumors of bone can be associated with hip effusions.[10] Effusions in association with malignant tumors of bone may indicate joint involvement or be a consequence of underlying pathological fracture, but MRI and plain radiographs provide the optimum method of assessment.

Effusions can occur in osteoarthritis. Synovitis and debris in the joint and underlying osteonecrosis may occur.[10] Osteophytes at the femoral head/neck junction can also be demonstrated, but are better shown on plain radiographs, computed tomography (CT), and MRI.[1]

For clinically suspected fracture not confirmed by radiographs, MRI is the investigation of choice. Ultrasound is not very sensitive or specific in these cases, but may occasionally show a femoral neck fracture. In addition to the resulting hip effusion/hemarthrosis, the fracture may be seen as a step or breach of the hyperechoic cortex.[1] An osteochondral injury could also result in effusion, but would not itself be visible on ultrasound.

Postsurgical complications such as infection, aseptic loosening, or wear debris can all result in effusion. Ultrasound appearances of hip replacement will be discussed later in the chapter.

Identifying Pathology on Ultrasound

An effusion appears as a hypoechoic layer between the hyperechoic bone cortex of the femoral neck and the

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overlying psoas muscle, extending along the anterior recess on the femoral neck (Fig. 6.11). The optimal probe position is an oblique longitudinal scan along the femoral neck. Hip joint effusions as small as 1 to 2 mL may be identified,[11] although small effusions may “disappear” into the posterior recess and become undetectable on ultrasound.

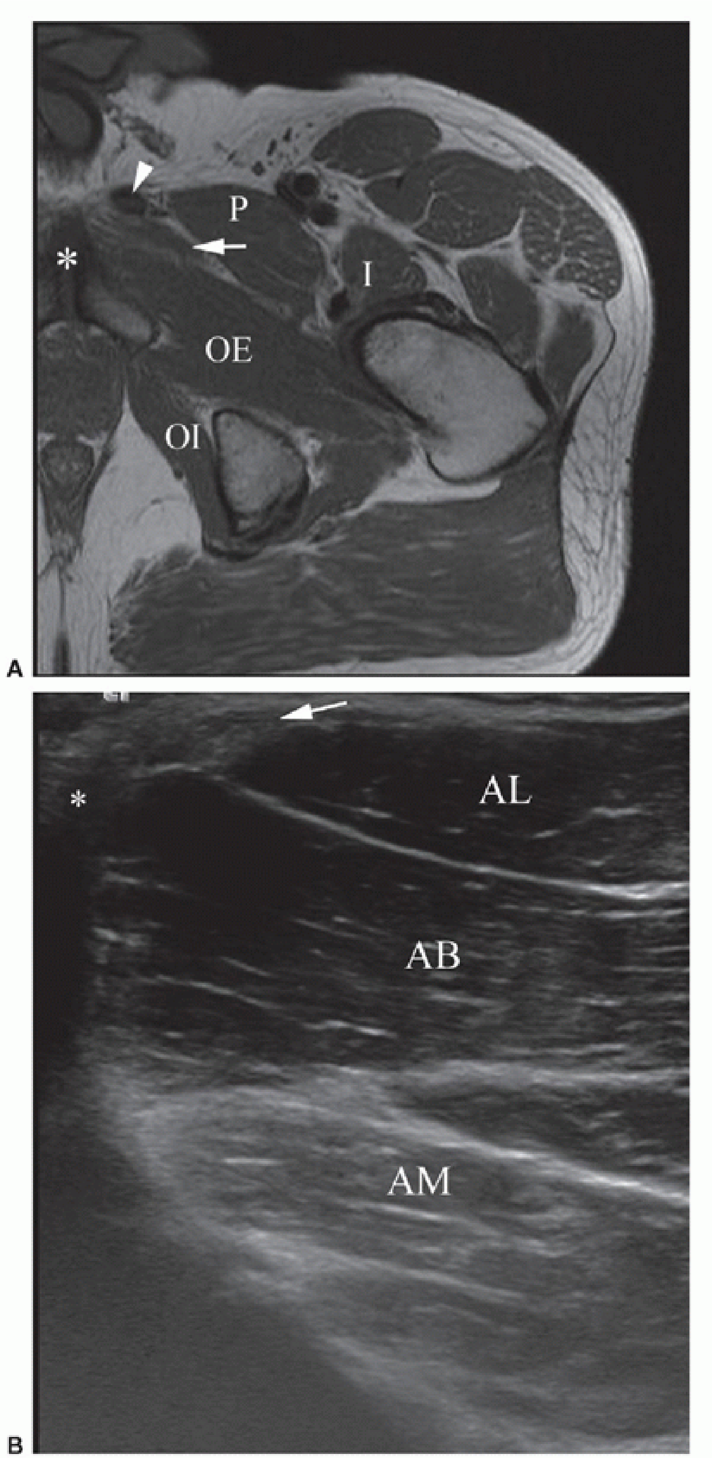

Figure 6.9. Normal views of the adductor origins. A: Axial T1W MRI shows the adductor origin, including adductor longus (arrowhead), brevis (arrow), and obturator externus (OE) with adjacent Iliopsoas (I), obturator internus (OI), pectineus (P), and pubic symphysis (asterisk). B: Short-axis sonogram of the thigh inferior to (A) shows the adductor longus tendon (arrow) and muscle (AL) with adductors brevis (AB) and magnus (AM) lying deep and pubic symphysis (asterisk) lying superficial.

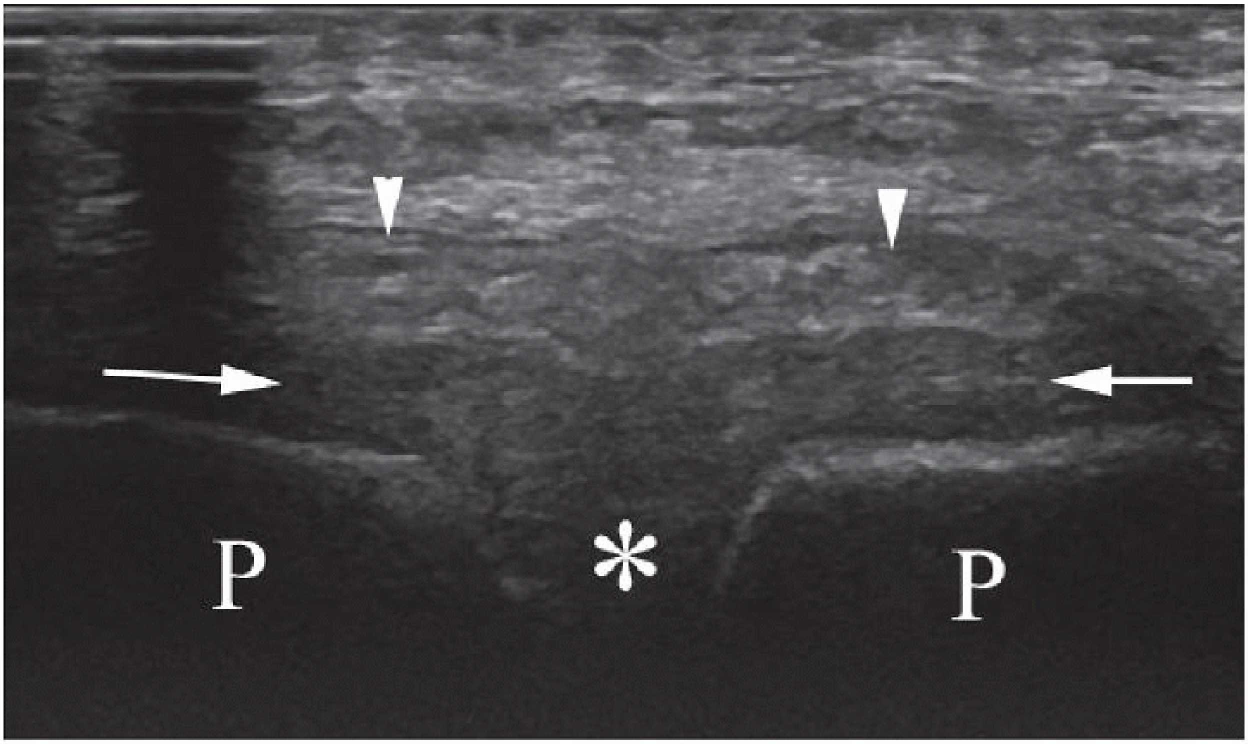

Figure 6.10. Normal pubic symphysis. Transverse sonogram shows pubic symphysis joint space and disc (asterisk), pubic bones (P), anterior capsule (arrows) and attachment of rectus abdominis muscles (arrowheads).

Effusion can be difficult to distinguish from the synovial thickening. Under normal circumstances, synovium is not visible on ultrasound, and the fibrous layer is a thin hyperechoic band (Fig. 6.11). Aging, degenerative disease, synovitis, and surgery can result in thickening of the synovial layer or joint capsule, and this may be mistaken for an effusion (Fig. 6.12).

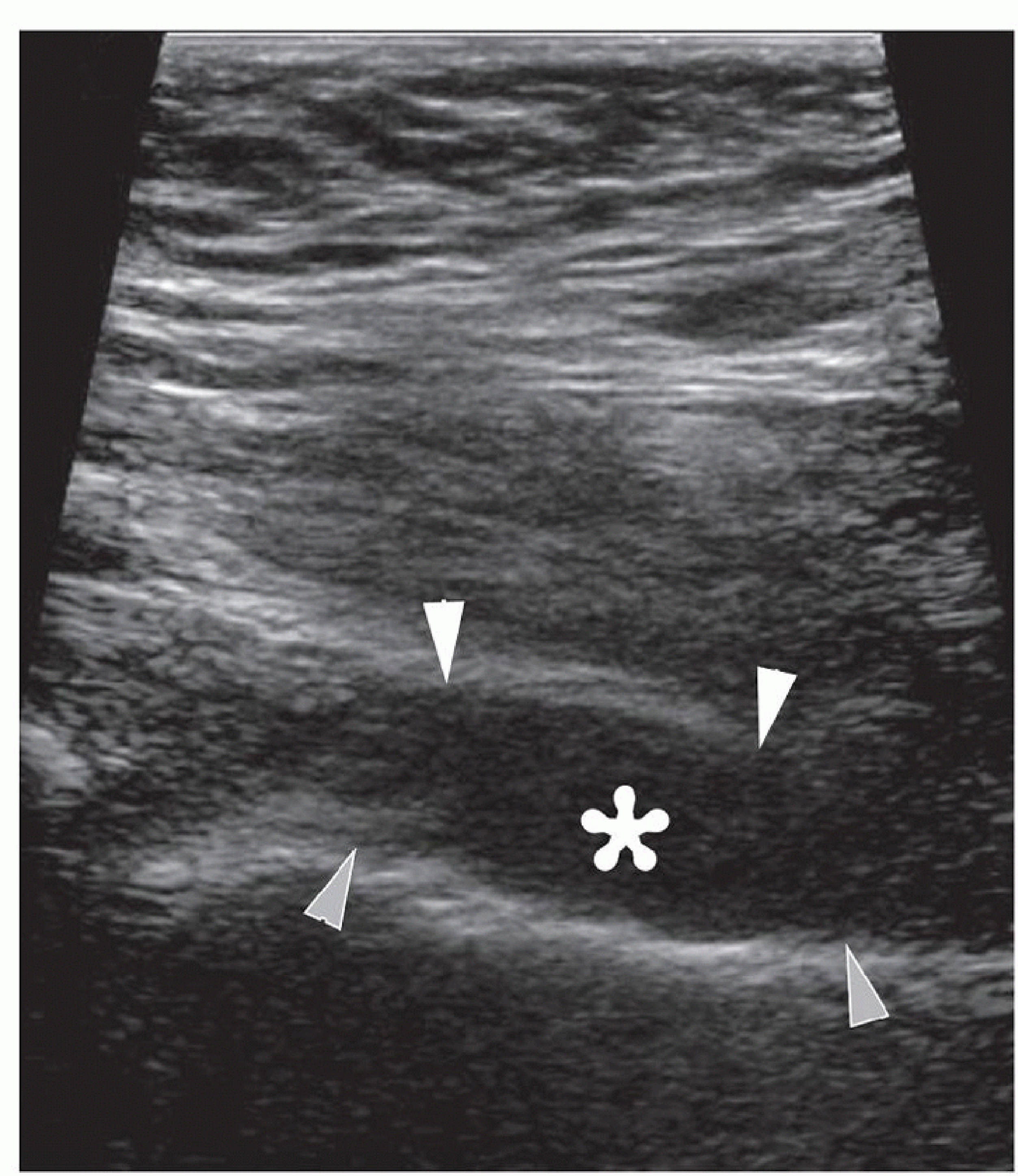

Figure 6.11. Hip effusion. Longitudinal sonogram shows anechoic hip effusion (asterisk) between the hyperechoic capsule (white arrowheads) and femoral neck (gray arrowheads).
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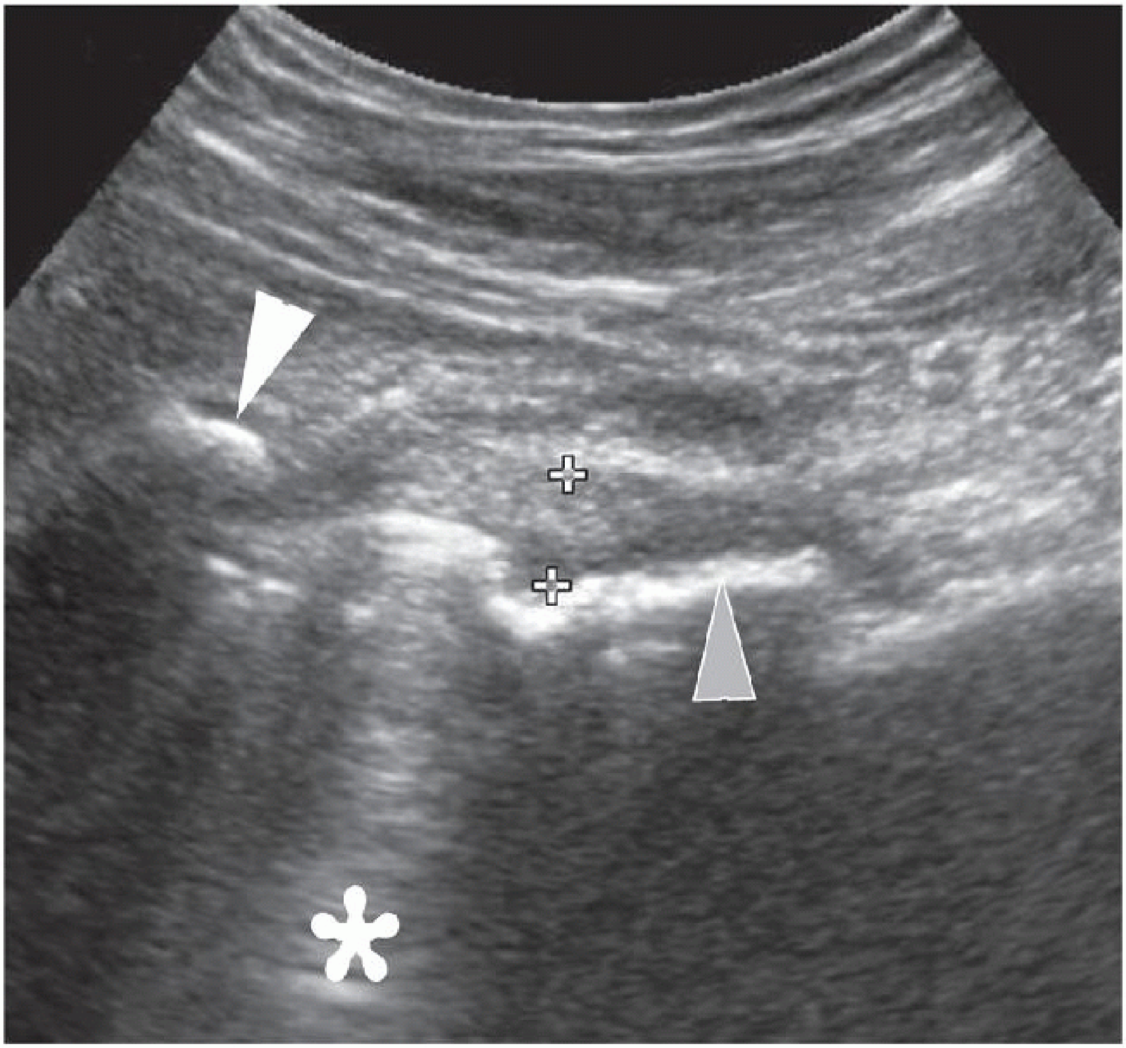

Figure 6.12. Normal sonographic appearances of a metallic hip. Longitudinal sonogram shows metal-on-metal resurfaced hip with the typical hyperechoic margin at the acetabulum (white arrowhead), femoral neck (gray arrowhead), and significant reverberation artifact. Calipers measure the capsule that shows typical thickening postsurgery.

Tips For Identifying an Effusion:

- Ensure the probe is perpendicular to avoid anisotropy artifact.
- Check the joint contour—a convex, bulging contour suggests effusion.
- Do not press too firmly with the probe or small effusions may be effaced.
- Measure the depth: capsular thickening or displacement of 5 to 10 mm are more significant.[10,12]
- Compare with the other hip. A discrepancy of 1 to 2mm or more has been described as significant,[12,13] but this needs to be interpreted with caution as surgery, aging, and previous synovitis may leave residual capsular thickening.[10]
- Use power Doppler: the presence of internal flow indicates thickened synovium rather than fluid.
- If still in doubt, a diagnostic tap can be performed to confirm the presence of fluid, with the advantage that a sample is then available for biochemical and microbiological analysis.

It is important to be aware that other pathologies may mimic effusions on USS.

- The iliopsoas bursa lies between the hip joint capsule and the iliopsoas muscle/tendon. The bursa is usually empty and not normally visible, but appears as an anechoic/hypoechoic area anterior to the capsule if bursitis is present (Fig 6.13A).
- Paralabral cysts can form near the anterior recess (Fig 6.13B).
- Femoral artery aneurysms are identifiable by their pulsatile nature: check with Doppler for internal flow (Fig 6.13C).
- Extra-articular abscesses/collections do not communicate with the joint and may demonstrate surrounding increased Doppler flow (Fig 6.13D).

ASPIRATION AND INJECTION

Aspiration can show if bacteria or crystals are present and can relieve pain by decompressing large effusions. Ultrasound-guided aspirations reduce the risks of a "dry tap" or contamination of a sterile hip with the infected contents of an extra-articular collection compared with blind aspirations that rely on bony landmarks. The absence of ionizing radiation makes it preferable in pregnant women and children when compared to fluoroscopy or CT. A major concern when performing hip aspiration is to avoid iatrogenic septic arthritis. The risk is low (<1/1,000) provided that proper aseptic technique is observed,[14] but this should be discussed when obtaining consent from the patient. Ultrasound-guided joint injections can be diagnostic (contrast for arthrography, including MR arthrography) and diagnostic/therapeutic (local anesthetic and steroid for arthritis). Recent evidence has suggested that local anesthetic may be chondrotoxic and should be used with caution.[15] This is also discussed in Chapter 14 Interventional.

There are two methods for aspirating an effusion/suspected effusion from the hip. The first is to use ultrasound to mark the position of the target point on the skin, and then proceed “blind.” The second method is to place the needle and aspirate under direct ultrasound vision. For both techniques, strict aseptic technique is essential. A sterile probe cover should be used for the direct vision method. A spinal needle of at least 18G caliber should be chosen, as pus may be thick and viscous, and a narrow needle may result in a “dry tap.” The needle length should be at least 5 cm, but may need to be longer, depending on patient size. Pre-measurement of the skin-to-effusion distance with ultrasound is useful if in doubt. Infiltration with 1% lidocaine is advised for local anesthesia. Care should be taken to avoid the neurovascular structures medially.

Tip:

If the first aspiration attempt is unsuccessful, rotate the bevel clockwise or counterclockwise. If the needle becomes blocked with debris, reinsert the stylet, and this may resolve the problem. Gradual needle withdrawal while applying gentle suction may succeed where the bevel has become embedded in the periosteum. Viscous or small effusions can be difficult to aspirate, and in these cases injection of a small volume of sterile saline into the effusion may aid aspiration.[7] This is particularly useful in cases with a high clinical suspicion of infection but minimal effusion.

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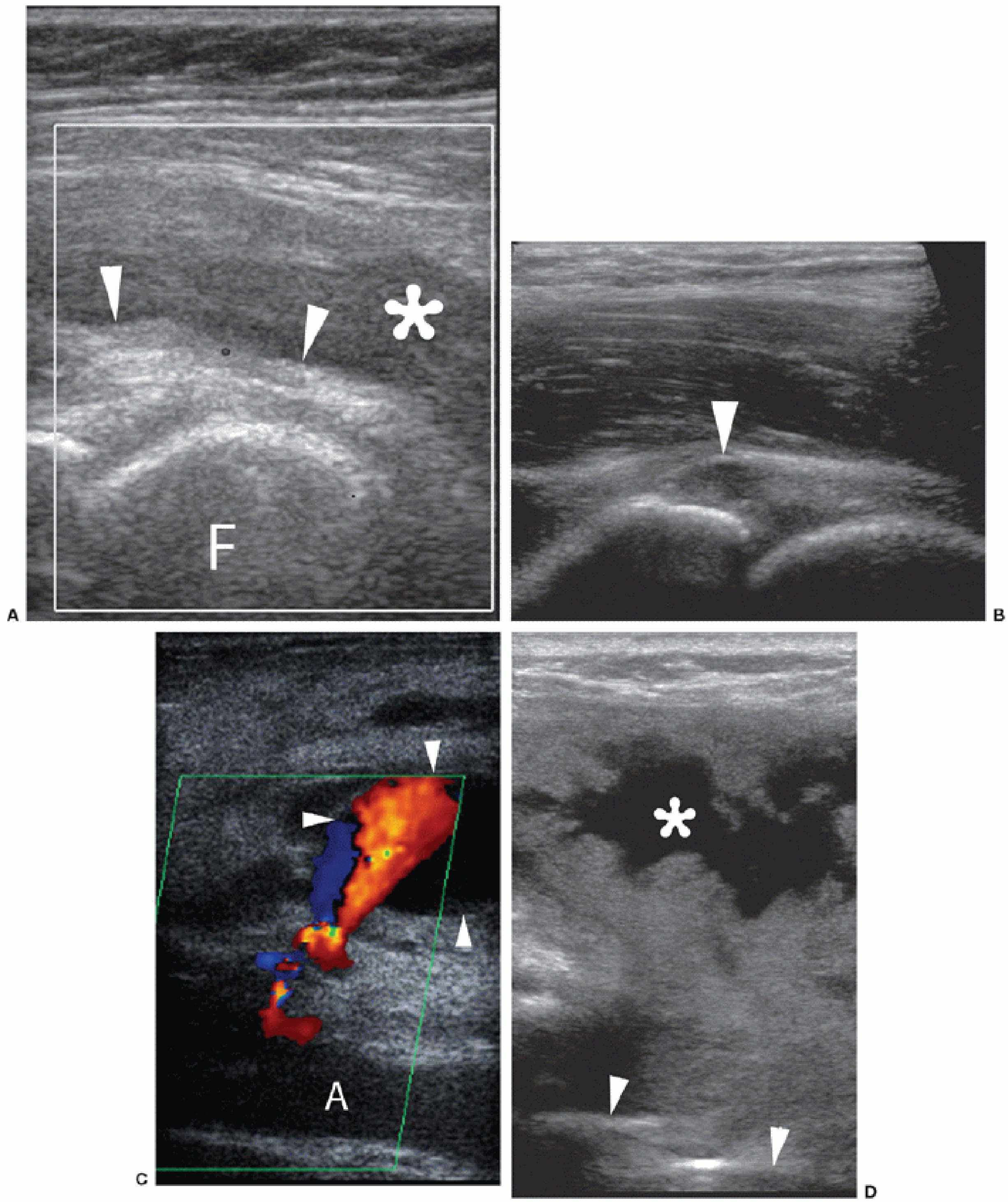

Figure 6.13. Mimics of hips effusion. A: Longitudinal sonogram shows femoral head (F) and psoas bursa (asterisk). Arrowheads mark the hyperechoic capsule deep to the fluid. B: Longitudinal sonogram shows anechoic paralabral cyst (arrowhead) at the acetabular rim. C: Longitudinal sonogram shows femoral artery false aneurysm (arrowheads). Color Doppler shows communication with the underlying artery (A) and turbulent internal flow. D: Longitudinal sonogram shows extra-articular collection (asterisk) separate from the deeper femoral neck (arrowheads) and effusion.

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Blind aspiration offers the advantage of a quick procedure for anxious/agitated patients and a simpler needle approach for deep joints in large patients. The probe is orientated along the femoral neck in longitudinal and/or transverse section, with the center of the footprint at the desired point of aspiration. The ends of the footprint are marked, followed by the center point, once the probe has been removed. Alternatively, the skin should be marked with the transducer oriented along both short and long axes of the femoral neck and the needle inserted at the point of intersection of the two lines. Following aseptic preparation and injection of local anesthetic, the needle is advanced through the skin vertically down to the femoral cortex, and aspiration is then performed. It is essential that the needle is vertically oriented.

The direct vision technique is useful for small effusions that can be difficult to target and for injections so that the position of the injectate can be confirmed. Transverse or longitudinal probe orientation is used with the transducer centered over the effusion. The end of the transducer is marked on the skin. After cleaning the skin and injecting local anesthetic, the needle is advanced obliquely under direct ultrasound guidance (Fig. 6.14). The needle should be inserted parallel or as close to parallel as possible to ensure maximum visualization of the needle tip. This may be difficult in larger patients, and altering transducer angulation or employing beam steering may help.

Tip:

If difficulty in needle visualization occurs, first check the alignment of the probe and needle, and reposition as necessary. Short, gentle needle motions can help reveal the location of the tip.

Magnetic resonance imaging provides additional information regarding the surrounding bone, cartilage, and peri-articular soft tissues compared with ultrasound. This is particularly useful in suspected infection, tumor, arthritides, and occult fracture. Small effusions that recede into the posterior recess in the supine position may also be more readily detected by MRI. The advantages of ultrasound as an initial test, particularly in suspected infections when speed is of the essence, are that it is quick, readily available, and offers diagnostic and therapeutic intervention.

TOTAL HIP REPLACEMENT

Sonographic imaging in the early postoperative period is a challenge due to difficulties recognizing “normal” postoperative changes from evolving pathologies such as major hematoma and associated infection. Clinical detection of these pathologies is often difficult, and ultrasound has been advocated[16], [17] as having superior sensitivity to clinical examination[18] and avoiding the difficulties posed by susceptibility artifact on MRI. Ultrasound demonstrates extra-articular collections not shown on arthrography. Where mobility is poor, ultrasound offers portable ward-based assessment. In the late postoperative period, ultrasound provides dynamic assessment of associated pathology such as gluteus minimus or medius tendon tears. Ultrasound can also guide aspiration of joint or fluid collections, capsular biopsy, and therapeutic injection.

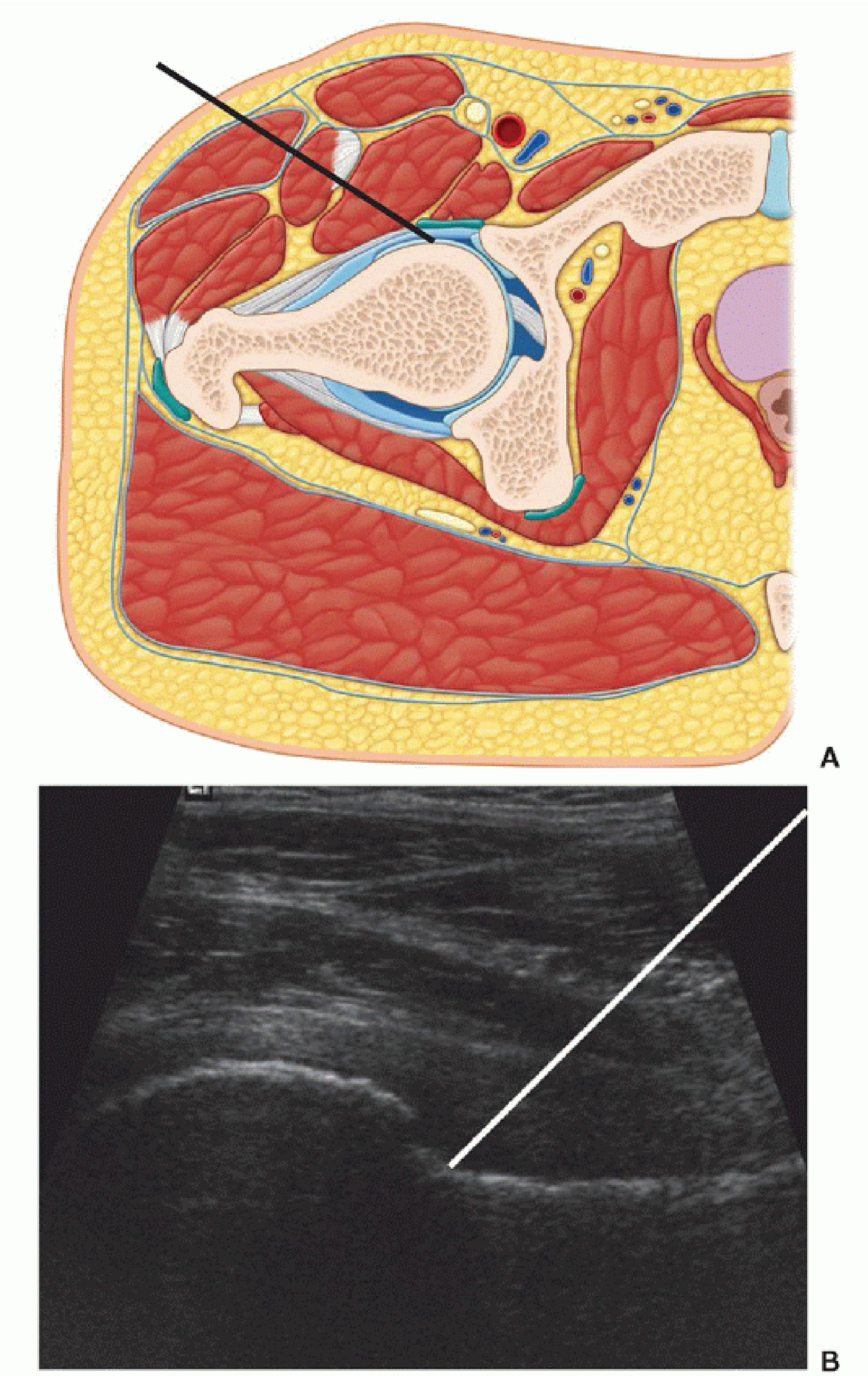

Figure 6.14. Approaches to hip aspiration. The two approaches to aspirating a hip effusion are demonstrated. A: The transverse approach (black line). B: The longitudinal approach (white line).

Normal Postoperative Appearances

In the early postoperative period, a hypoechoic track extending from the skin incision to the hip represents

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the path of surgical access. Collections may routinely be identified along this path or around the prosthetic joint or the femur. The surface of the prosthesis is highly echogenic, more so than normal bone cortex, and may generate reverberation artifact (Fig. 6.12). A study of 47 postoperative hips at the second and fifth postoperative day concluded that a bone-to-capsule thickness of up to 6 mm, deep soft tissue fluid collections up to 21 mm, and superficial collections up to 28 mm were all considered to be normal.[16] Communication with the joint is an important distinction that is usually demonstrable by ultrasound, though it may be more readily demonstrated by arthrography.[19]

Subsequently, thickening of the joint capsule may be seen due to fibrosis and previous hemorrhage[10] (Fig. 6.12). Effusions and extra-articular collections are not normal after the first few weeks (Fig. 6.13D).

Complications

Mechanical loosening of the prosthesis is a common cause of pain after total hip arthroplasty. Infection is less frequent, but more serious. Preoperative diagnosis is important because prosthetic loosening is treated by revision arthroplasty, while infection often requires removal of the prosthesis followed by multistage revision procedures[8] and prolonged courses of antibiotics. Infection may occur years after arthroplasty, but typically occurs within 2 years of the initial operation, and may be due to hematological seeding from a remote site,[20],[21] for example, urinary tract infection.

Distinguishing between loosening and infection using clinical assessment and radiographs alone is often not possible. Magnetic resonance imaging is limited by the artifact even when metal artifact reduction sequences are used, although large collections can be demonstrated. Ultrasound can identify and characterize fluid collections and effusions (Fig. 6.15). A study of 48 patients with total hip replacement (THR) found that infected hips have intra-articular fluid and fluid collections outside the pseudocapsule in most cases.[8] Guided aspiration can be performed in these cases to confirm or exclude infection. Prosthetic wear can also cause effusions in patients with replacement joints.[8]

Tip:

If uncertainty exists regarding the communication between collection and joint, do not use the same needle to aspirate or penetrate both in the same pass, as infection may be disseminated between the two.

Communications between the bursae of the greater trochanter, iliopsoas bursa, and supra-acetabular region are common in patients with pain following hip arthroplasty[22] (Fig. 6.16). Bursitis can occur as a result of impingement of the prosthesis on the surrounding soft tissues, especially the acetabular cup; for example, bony spurs or cement may impinge on the rectus femoris tendon. Guided injection can offer diagnostic/therapeutic benefit in these cases. Care should be taken because of the increased susceptibility of prosthetic hips to iatrogenic infection.

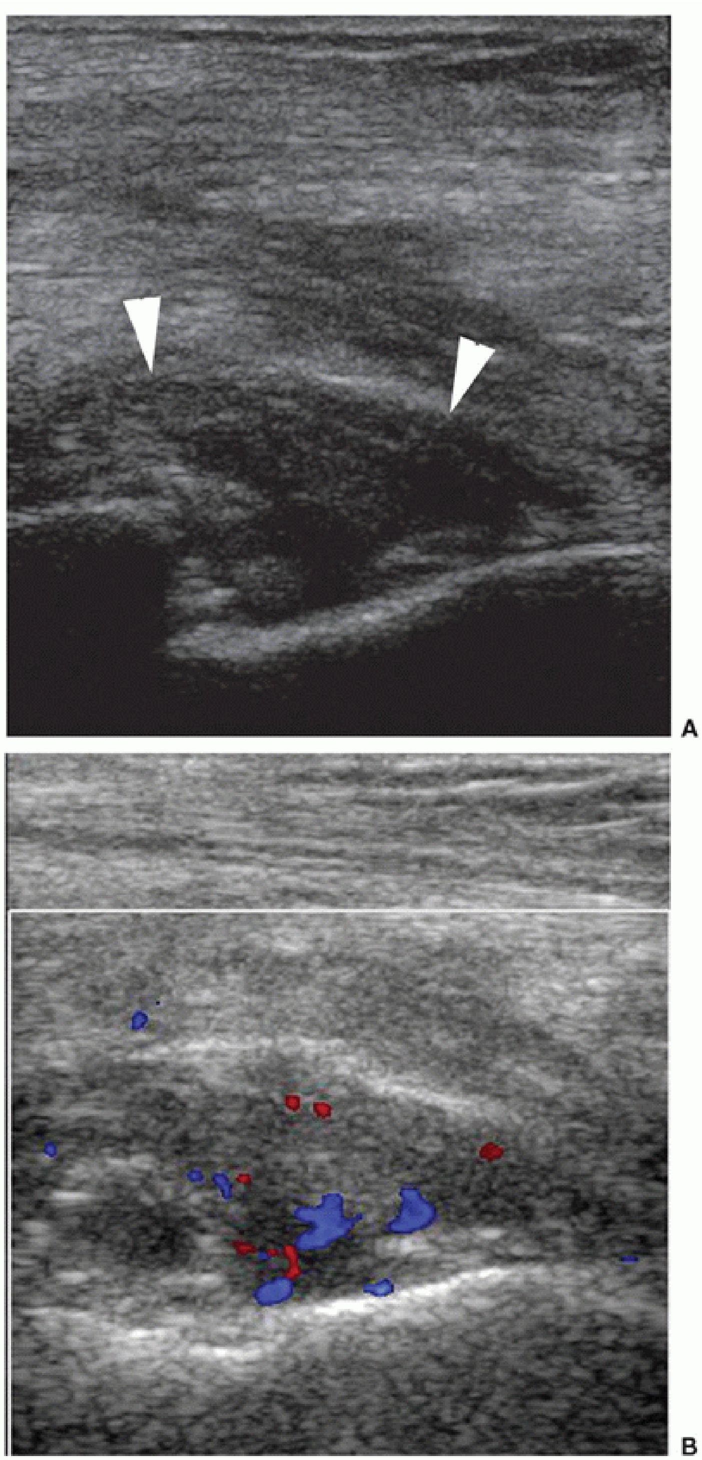

Figure 6.15. Infected Hip. Longitudinal sonogram shows (A) heterogeneous hypoechoic collection in a distended joint (arrowheads) and (B) Color Doppler demonstrates increased vascularity due to inflammation.
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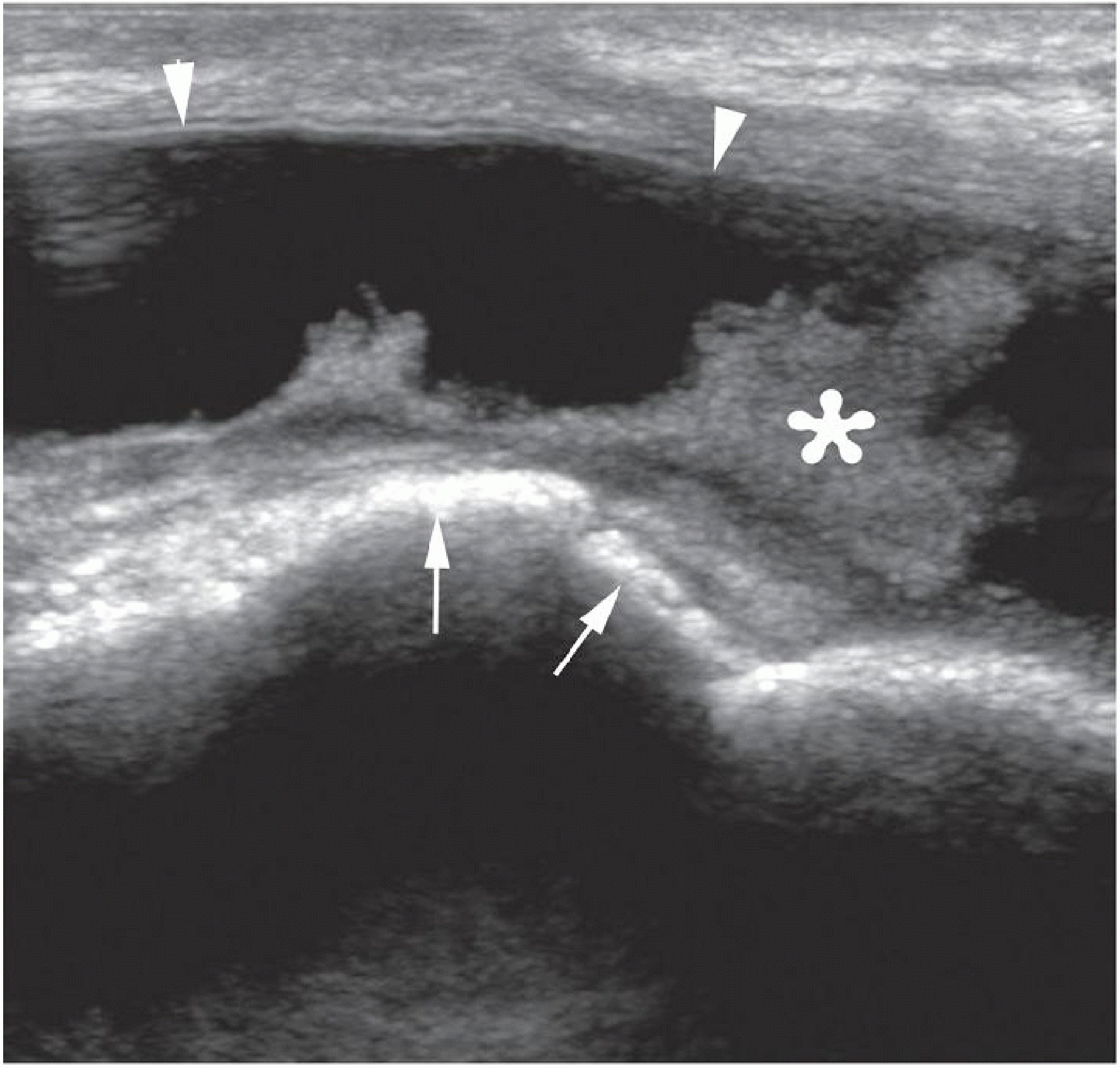

Figure 6.16. Bursa following THR. Longitudinal sonogram shows large anechoic bursa (arrowheads) with fronds of synovial thickening (asterisk) against hyperechoic prosthetic hip (arrows).

Hematoma is a common postoperative finding. Major hematomas can cause shock and increase the risk of infection. Appearances vary with the age of the hematoma, but are typically mixed echogenicity with a characteristic web-like appearance (Fig. 6.17). Slow swirling may be seen within a hematoma. Significant color flow indicates active bleeding, and arterial trace indicates a false aneurysm (Fig. 6.13C). In cases of non-active hematoma, ultrasound may further assist by therapeutic aspiration or marking for surgical drain placement.

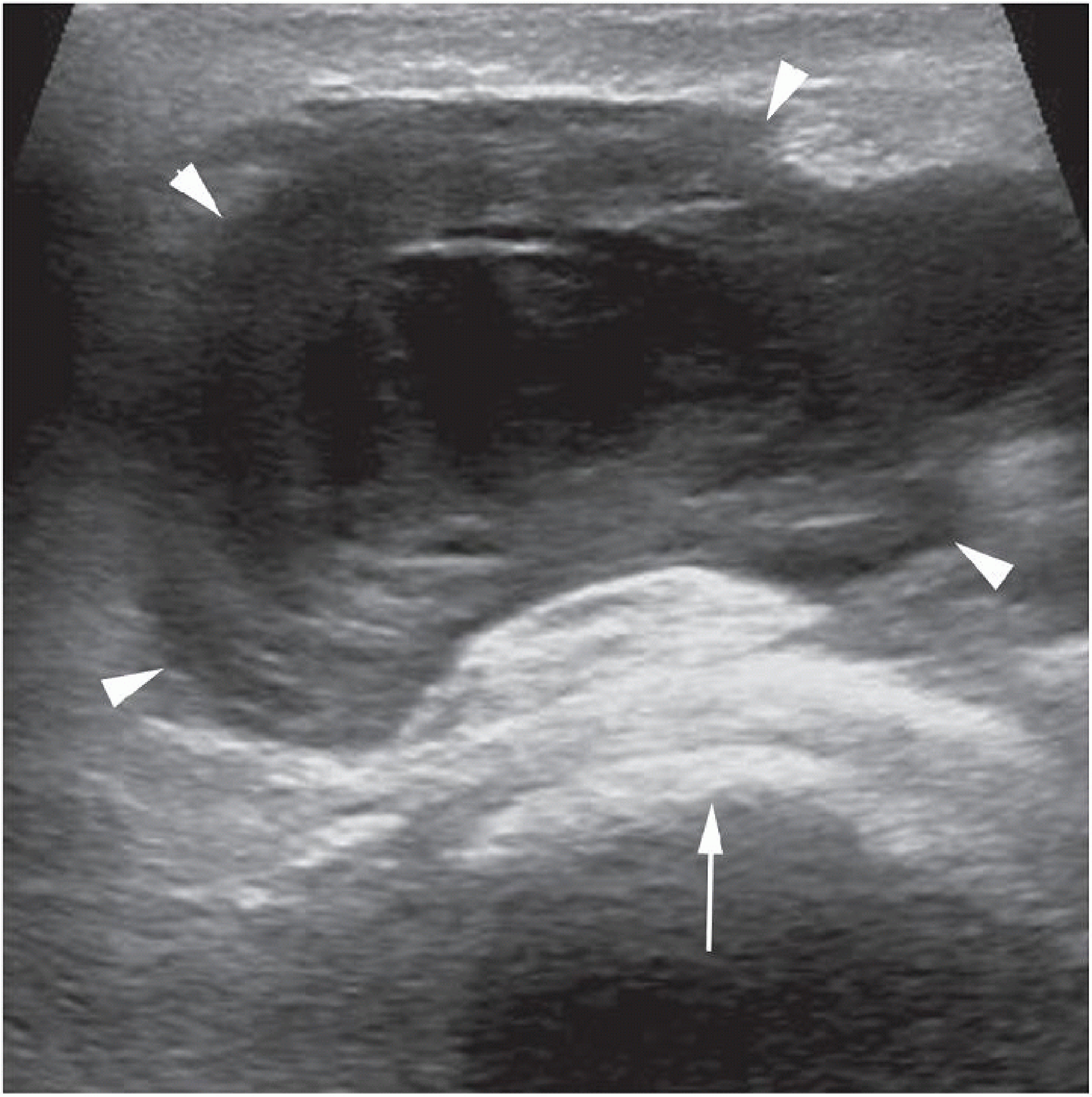

Figure 6.17. Organizing hematoma following THR surgery. Transverse sonogram shows organizing hematoma (arrowheads) with complex internal structure and underlying hyperechoic prosthesis (arrow).

Although relatively uncommon, the para-articular tendons can be injured postoperatively following THR. Acetabular remodeling, insufficiency, or forward protrusion of the acetabular cup, cement, bone graft, or cup fixation screws can cause impingement on the posterior aspect of the iliopsoas tendon, resulting in muscle/tendon wear and bursitis.[23] This iliopsoas impingement syndrome clinically manifests as anterior groin pain worsened by flexion/extension with medial groin tenderness. Presentation is typically in the early postoperative period, but may occur years after the initial operation.[24,25] Dynamic ultrasound with the probe placed transversely over iliopsoas can demonstrate bursitis, tendonitis, and snapping of the tendon over the anterior acetabular margin (Fig. 6.3B). Protrusion of the hyperechoic screws, cup, or cement may also be seen. Steroid/local anesthetic injection deep to iliopsoas (Fig. 6.18) has been advocated for diagnostic/therapeutic purposes.[25] Plain film and CT are useful to further evaluate the cup, cement, and screw positions.

Assessment of the gluteal tendons at the greater trochanter is also important to assess for tendinopathy or rupture. This will be discussed further in the next section on tendinopathy.

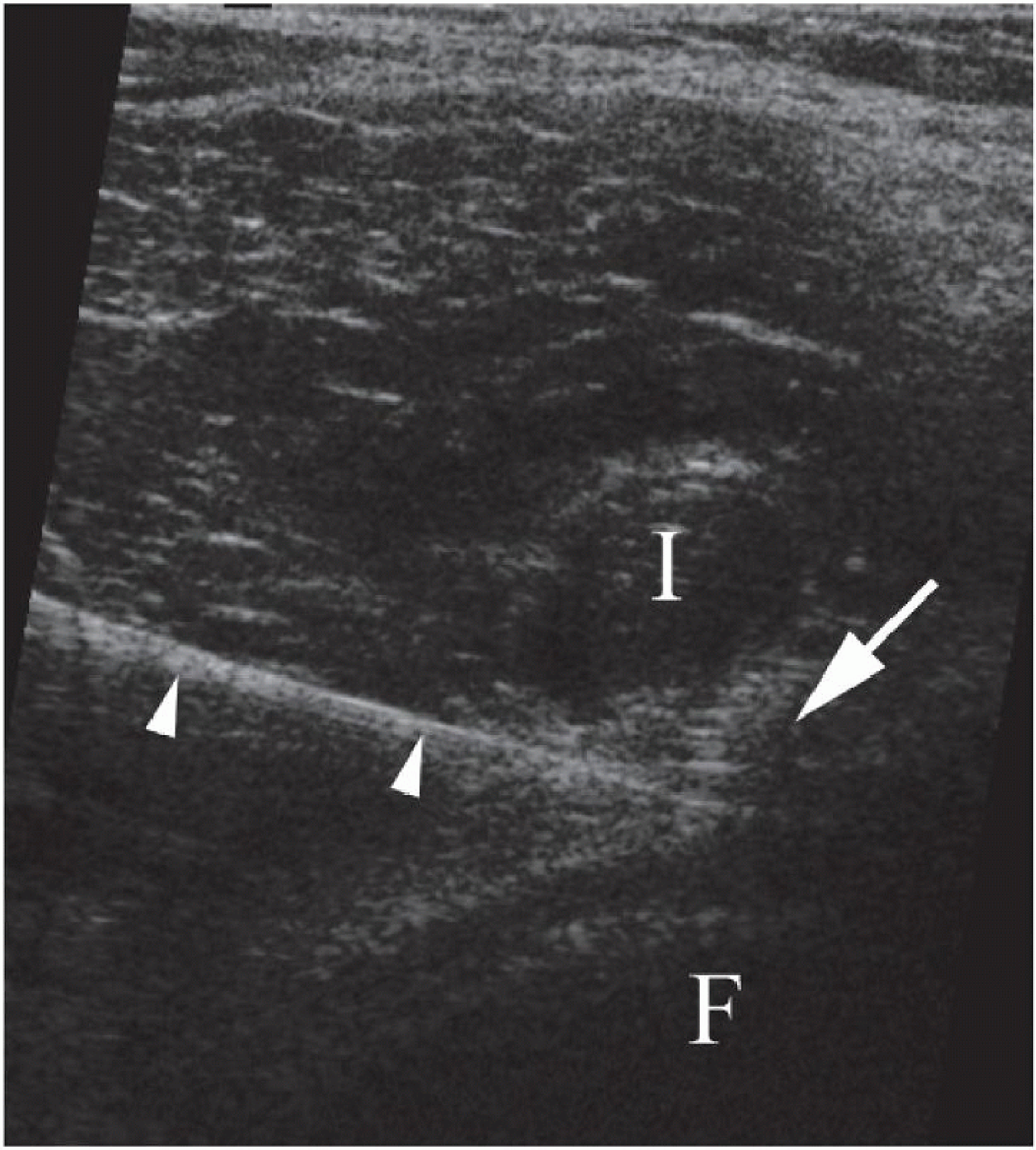

Figure 6.18. Iliopsoas tendon undergoing guided injection. Transverse sonogram demonstrates lateral approach injection of the iliopsoas muscle (I) and hyperechoic iliopsoas tendon (white arrow), which is being targeted with steroid and local anesthetic via the needle (white arrowheads) at the level of the femoral head (F).
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Granulomatous disease may occur secondary to debris from wear and impingement. Features are nonspecific, but large sterile effusions and psuedobursae are characteristic. Heterotopic bone formation is also associated with THR, especially in those with hypertrophic arthritis, Paget's disease, ankylosing spondylitis, and diffuse skeletal hyperostosis.[26] Although not optimally imaged by ultrasound, ossification may be seen as echogenic foci causing acoustic shadows. Minor ossification may be asymptomatic. More florid disease can result in pain and reduced range of movement.[20]

Role of MRI

Soft tissue detail assessment by MRI and CT has previously suffered from artifact from the prosthesis, although suppression techniques are constantly improving. Deep soft tissue detail may be superior in patients of large bodily habitus where collections can be missed on ultrasound. The extent of collections and edema are better shown on MRI, as is bone pathology beyond the artifact. Normal bone scintigraphy suggests that loosening or infection is unlikely. Increased activity on bone scintigraphy occurs in loosening, infection, and around normal prostheses for at least a year after insertion, and for longer in uncemented prostheses.[20]

METAL-ON-METAL RESURFACED HIP

Hip resurfacing arthroplasty offers advantages over traditional THR by preserving bone stock, increasing stability, and optimizing the movement range and stress transfer to the proximal femur,[19] resulting in increased use of these prostheses, especially in younger patients in whom conventional implants have a shorter survival rate.[27] Prostheses are composed of cobalt chromium alloys and have metal-on-metal (MOM) articulation. Component wear leading to local and systemic release of metals ions may cause an immunological response with perivascular and plasma cell infiltrates around some metal on metal prostheses,[28] so-called aseptic lymphocytic vasculitis-associated lesions (ALVALs). They manifest on MRI, CT, and ultrasound as cystic and solid masses (Fig. 6.19) or "pseudotumors" and are not associated with infection or neoplasia.[19] Presentation is often with early nonspecific hip pain and normal serum inflammatory markers and X-rays.[29] Superficial masses may be palpable.

As masses may be anterior, medial, lateral, or posterior, all sectors of the hip should be scanned. Anterior masses may involve the psoas bursa and muscle and may extend above the inguinal ligament. Cysts up to 21 cm have been documented, and these appear to arise from the joint.[19] Ultrasound or MRI may be used to evaluate suspected ALVAL lesions. Ultrasound is preferred by many due to the absence of susceptibility artifact. Large periprosthetic inflammatory masses are also identified on MRI. Bone marrow and muscle edema, muscle atrophy, and avulsion have been reported on MRI in symptomatic MOM arthroplasty patients, but these may form part of the normal spectrum of postoperative changes for any hip prosthesis.[29,30] Ultrasound classically demonstrates mixed cystic and solid lesions that appear as low echogenicity/anechoic fluid, with or without internal debris, and heterogeneous more echogenic solid components (Fig. 6.19).

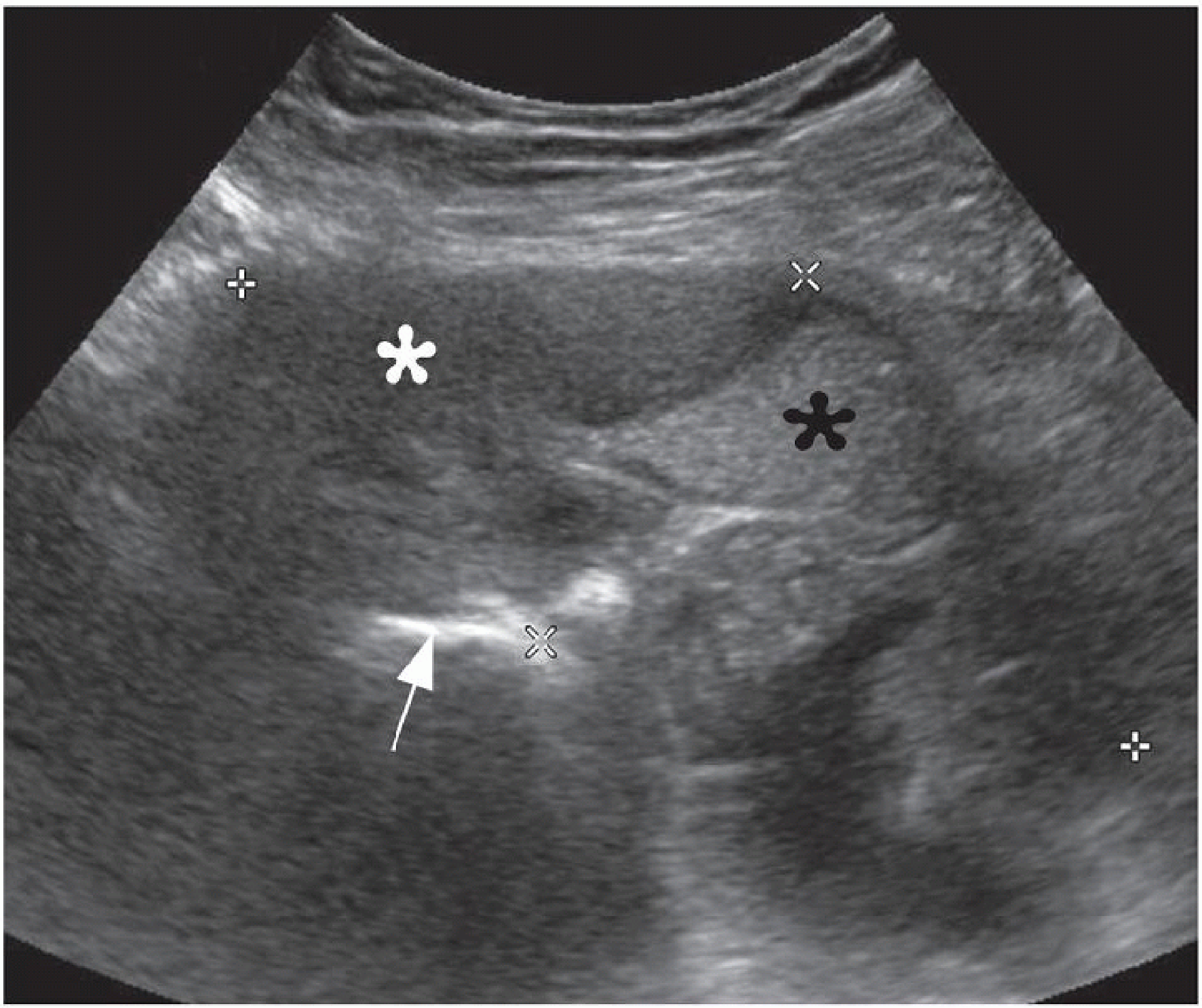

Figure 6.19. ALVAL. Longitudinal sonogram along the anteromedial femoral neck shows typical mixed solid (black asterisk) and cystic (white asterisk) lesion (calipers) adjacent to the hyperechoic edge of the resurfaced hip (arrow).

There have been concerns over possible health risks including malignancy but so far long-term follow-up suggests that both MOM and metal on polyethylene (MP) prostheses are safe.[31]

MUSCLE AND TENDON INJURIES

Injuries of the muscles and tendons around the hip may occur acutely from sudden force during athletic injury or trauma, or chronically from overuse injuries, involving microtrauma and friction. The myotendinous junction is the most vulnerable point in the kinetic chain from muscle to bone in healthy skeletally mature individuals, whereas the apophysis is the most vulnerable point in children and adolescents, prior to fusion. Older patients with degenerative musculoskeletal disease may suffer rupture of chronically weakened tendons.[10]

Many injuries are managed conservatively and do not require imaging. The role of imaging in suspected trauma is to evaluate cases where pain is persistent or the original diagnosis is in doubt. Characterization of injuries and measurement of severity can contribute to surgical consideration/planning or deciding the rehabilitation strategy for a professional athlete. Correlation of ultrasound findings with the clinical history is vital, since

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traumatic soft tissue injury may have an aggressive appearance on imaging, which can be mistaken for neoplasia. If necessary, follow-up imaging is useful in these cases to ensure resolution and confirm the benign nature.

Evaluation of the pelvic soft tissues can be challenging due to the overall bulk, and a compartmental approach is advised as previously described.

Anterior

Iliopsoas is a compound muscle comprising psoas major, iliacus, and in some individuals, psoas minor. Psoas major originates from the lateral vertebral bodies and transverse processes of T12 to L5. When present, psoas minor originates from L1-5 and lies anterior to psoas major. Iliacus arises from the anterior surface of the iliac blade. The psoas major and iliacus muscles unite at the level of the inguinal ligament, run deep to the inguinal ligament and anterior to the hip joint, and insert via a short tendon into the lesser trochanter of the femur.

Iliopsoas tendinopathy may arise from overuse in younger/athletic patients or due to impingement by osteophytes or prostheses in older patients.[10] Ultrasound is best performed in the transverse plane (Fig. 6.18). The last few centimeters of the tendon can be difficult to visualize and are best seen with the thigh abducted and externally rotated, as previously discussed. Tendinopathy results in hypoechogenicity and thickening of the tendon and loss of the normal fibrillar pattern. Peritendinous fluid may be present, but should not in isolation be considered to represent tenosynovitis as fluid can also be seen normally due to the communication between the iliopsoas bursa and the hip joint. The underlying cause of the tendinopathy may also be seen where a prominent osteophyte or prosthesis impinges on the tendon.

Tip:

When uncertainty exists over the possibly tendinopathic appearances of the iliopsoas tendon, comparison with the normal, asymptomatic side is useful.

Iliopsoas snapping may be caused by intrinsic tendinopathy or paratenon edema at the level of the iliopectineal eminence.[10] Patients experience a sudden shifting sensation during flexion and extension of the hip, often associated with pain. This shift may be palpable to the clinician via the hand or probe, or audible as a “click” in some cases. The dynamic capability of ultrasound is ideal for demonstration of this condition and has the advantages of being noninvasive when compared with the alternative methods of bursography. Place the probe transversely about the level of the femoral head and medial to the AIIS. Flexion with external rotation and extension with internal rotation of the hip should demonstrate smooth medial-lateral translation of the tendon in normal hips. In iliopsoas snapping, this becomes a sudden jumping/snapping movement. As with tendinopathy, comparing the two hips can be useful in equivocal cases. The snapping tendon itself may appear normal. Injection of steroid and local anesthetic around the tendon may relieve symptoms[32] and aid diagnosis. A lateral approach under direct vision to avoid the femoral vessels allows safe and accurate injection (Fig. 6.18). It has been suggested that patients may benefit from iliopsoas bursal injection, where the clinical picture is suggestive, even when the snapping hip is not visualized.[33] Cases unresponsive to injection may undergo surgical lengthening of the tendon.[34]

If iliopsoas snapping is not demonstrated, consider other external causes of hip snapping (see Table 6.1) such as TFL snapping, which may be clinically apparent, and intra-articular causes such as labral tears, which are better assessed by MRI/MR arthrography or CT.[35,33]

The iliopsoas bursa is the largest bursa in the body and is located between the hip joint and the iliopsoas muscle/tendon. The bursa is not normally seen on ultrasound because it is collapsed in its natural state (Fig. 6.2A). However, it may communicate with the hip joint, and bursal distension can be a consequence of hip joint pathology, including inflammatory arthropathy, osteoarthritis, trauma, and infection. The enlarged bursa is hypoechoic (Fig. 6.13A) and may contain internal septa, synovial thickening, and echogenic foci, but typically no solid component. Solid masses in this region include lymph nodes, tumors, and undescended testes. Use color or power Doppler to distinguish bursitis from vascular pathology such as aneurysm (Fig. 6.13C) and to detect increased vascularity in adjacent soft tissues, which indicates an inflammatory process such as infection. Some internal drift of debris may be seen, but look for peristalsis, which is indicative of hernia rather than bursitis. Paralabral cysts may also occur here in conjunction with hip degeneration (Fig. 6.13B).

Rectus femoris and sartorius tears are rare, and there is often a previous history of tendinopathy. Patients commonly present with pain in the groin and inability to flex the hip. Rectus femoris is vulnerable as it spans both the hip and knee joints. It arises from two heads, the straight head at the AIIS and the deeper reflected head at the

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margin of the hip capsule. Proximal tendon injuries are less common than those to the muscle belly or distal myotendinous junction at the quadriceps tendon, which are discussed further in Chapter 11.

TABLE 6.1. Causes of Hip “Snapping”

Extra-articular	*Intra-articular*

Gluteal tendon	Articular surface defects
Iliopsoas	Fracture fragments
TFL/Iliotibial band	Femoral head subluxation/instability
	Labral tears
	Loose bodies
	Synovial folds

TFL, tensor fascia lata.

Avulsion fractures at the AIIS apophysis in skeletally immature individuals typically occur during kicking, when the hip is extended and the knee flexed. Large bony avulsions are visible on radiographs. Smaller fractures or fibrocartilage injuries are not seen on radiographs, but are readily demonstrated on ultrasound, which shows the avulsed fragment and increased vascularity on power Doppler. Measurement of the degree of fragment retraction is important when surgical reattachment is contemplated.

Proximal myotendinous junction partial tears (grade 2) are the most common proximal rectus femoris injuries. Ultrasound shows a gap and hematoma in the muscle. Complete tears can retract distally, and in these cases the course of the rectus femoris should be followed down the thigh, to identify the retracted end. A similar pattern of injury can be seen in the sartorius, where it arises from the ASIS.

Lateral

Tensor fascia lata originates from the outer lip of the iliac crest between sartorius and gluteus medius (Fig. 6.3) and inserts into the iliotibial band around the junction of the upper- and middle-thirds of the thigh. Its function is to contract the iliotibial band and stabilize the knee during flexion and extension. Tendinopathy and tears at the iliac crest usually present with anterior groin pain, below the iliac crest during or after exercise, and have a typical swollen, hypoechoic appearance[36] (Fig. 6.20).

The iliotibial band may impinge on the greater trochanter, causing snapping and tendinopathy similar to iliopsoas. This is often clinically apparent and can be demonstrated during hip flexion. The underlying trochanteric surface may appear irregular.

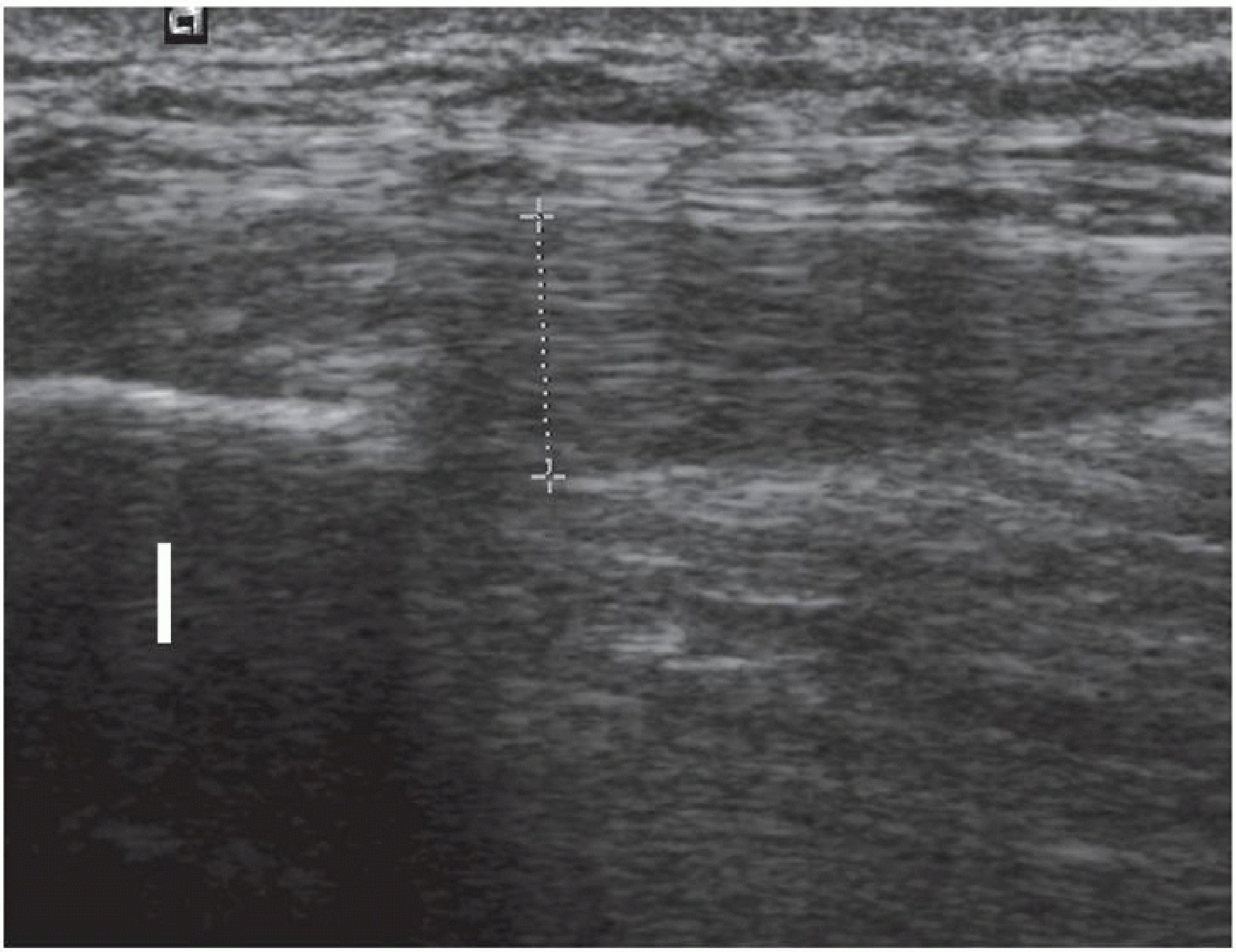

Figure 6.20. Tendinopathic TFL. Longitudinal sonogram shows thickened hypoechoic TFL (calipers) with maintained fibrillar pattern at the iliac crest origin (I).

Tensor fascia lata may shear from the overlying subcutaneous fat due to direct trauma, rather than, for example, falls on the hip or direct impact during sports. During the acute phase, ultrasound shows hematoma and edema between TFL and the fat. Tensor fascia lata itself often appears normal. Individual fat lobules can be dissected by blood products and fluid, and over time a pseudocapsule may form (Fig. 6.21). The resulting mass has been named a Morel-Lavallee lesion. Appearances are variable, but are generally hypoechoic with hyper- and hypoechoic fat lobules separated by septa and hypoechoic fluid, surrounded by the hyperechoic pseudocapsule[37] (Fig. 6.21). Sedimentation of blood components can also

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result in a fluid-fluid level.[38] Slow growth can occur over time due to re-accumulation of fluid and the appearance, along with the associated pain, can be misdiagnosed as soft tissue tumor, particularly if the trauma has been omitted from the history.[1] Chronic lesions can fibrose and calcify with re-accumulation of fluid causing growth (Fig. 6.21). MRI may be useful to further evaluate uncertain cases, as is follow-up interval scanning. Care should be taken during scanning not to apply excessive probe pressure, as this can efface the lesion, especially if it is unencapsulated. Morel-Lavallee effusions should not be aspirated or drained, because of the risk of infection and re-accumulation.

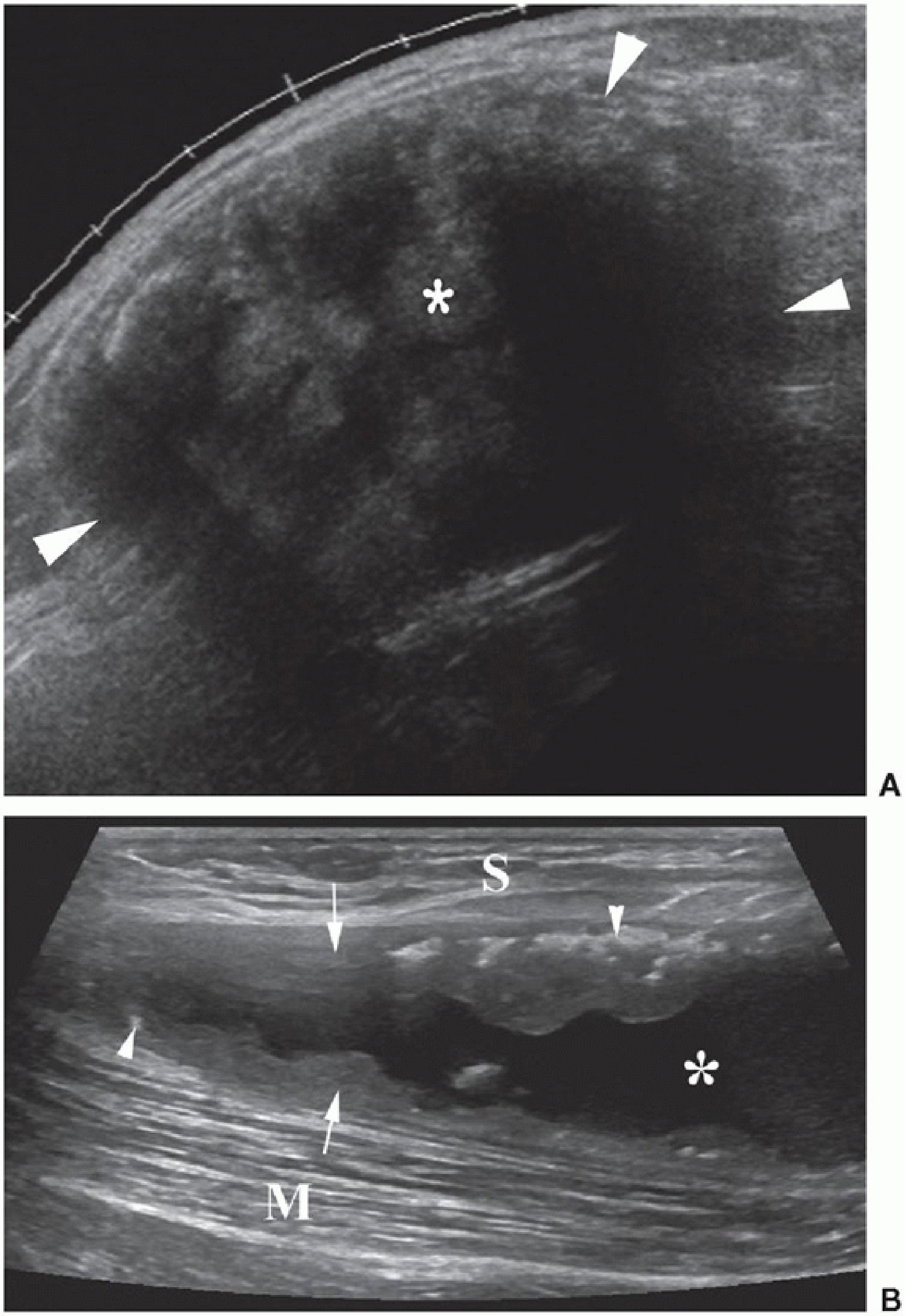

Figure 6.21. Morel-Lavallee lesions. A: Longitudinal sonogram shows large predominantly hypoechoic lesion (arrowheads) with lobules of echogenic fat (asterisk). B: Longitudinal sonogram shows chronic lesion forming after documented trauma 4 years previously with thick-walled pseudocapsule (arrows) containing echogenic particles (arrowheads) between the muscle (M) and subcutaneous fat (S) layers. The fluid (asterisk) had accumulated, causing apparent growth.

Posterior

The hamstrings are the most commonly injured muscle group during sports and athletics. Injuries may be acute or chronic and commonly present as buttock pain and difficulty in walking.

Tendinopathy with associated paratenon inflammation can arise from repetitive microtrauma caused by overuse. Low-grade change can be difficult to detect on ultrasound, and the tendons may appear normal. Magnetic resonance imaging may be necessary to confirm subtle paratenon edema. Frank fluid collections are rare. In chronic injuries, the tendons may appear hypoechoic and thickened (Fig. 6.7), with calcification or hyperostosis at the insertion. Ultrasound guidance can be used to inject local anesthetic and steroid into the paratenon where conservative measures have been unsuccessful. A transverse approach under direct vision is advised. First, the ischial tuberosity should be identified, and then the probe moved inferiorly to identify the tendon origins and adjacent sciatic nerve. A high-frequency linear probe will offer the best detail, but a lower frequency curvilinear probe may be required depending on habitus. The needle entry point is lateral to the transducer, and care should be taken to avoid the sciatic nerve (Fig. 6.6B). The injectate should be used to bathe the tendon origin, but not injected into the tendons.

Acute injuries are caused by forceful leg extension resulting in tendon rupture or avulsion of the ischial tuberosity, particularly in adolescents. As with the anterior thigh, displacement of the avulsed fragment should be measured and reported. More frequently, tears occur at the myotendinous junction (Fig. 6.22). If the tear is complete, it may be necessary to scan distally, to find the retracted muscle end. Echogenic, thick scars may be seen in chronic tears. The proximity of hematoma and scar tissue to the sciatic nerve should be noted, as they can cause neuropathic pain (Fig. 6.22) and even distal motor and sensory deficit. Ultrasound may be difficult in large patients, and MRI may be required.

Gluteal tendinopathy typically presents with pain localized over the greater trochanter, particularly during weight-bearing or lying on the affected side, without restriction of movement. The pain has been attributed to trochanteric bursitis, but greater trochanteric pain syndrome may be a more appropriate term for this condition. Although bursae are found between the individual tendons and the greater trochanter, bursal thickening and collections are rarely identified.

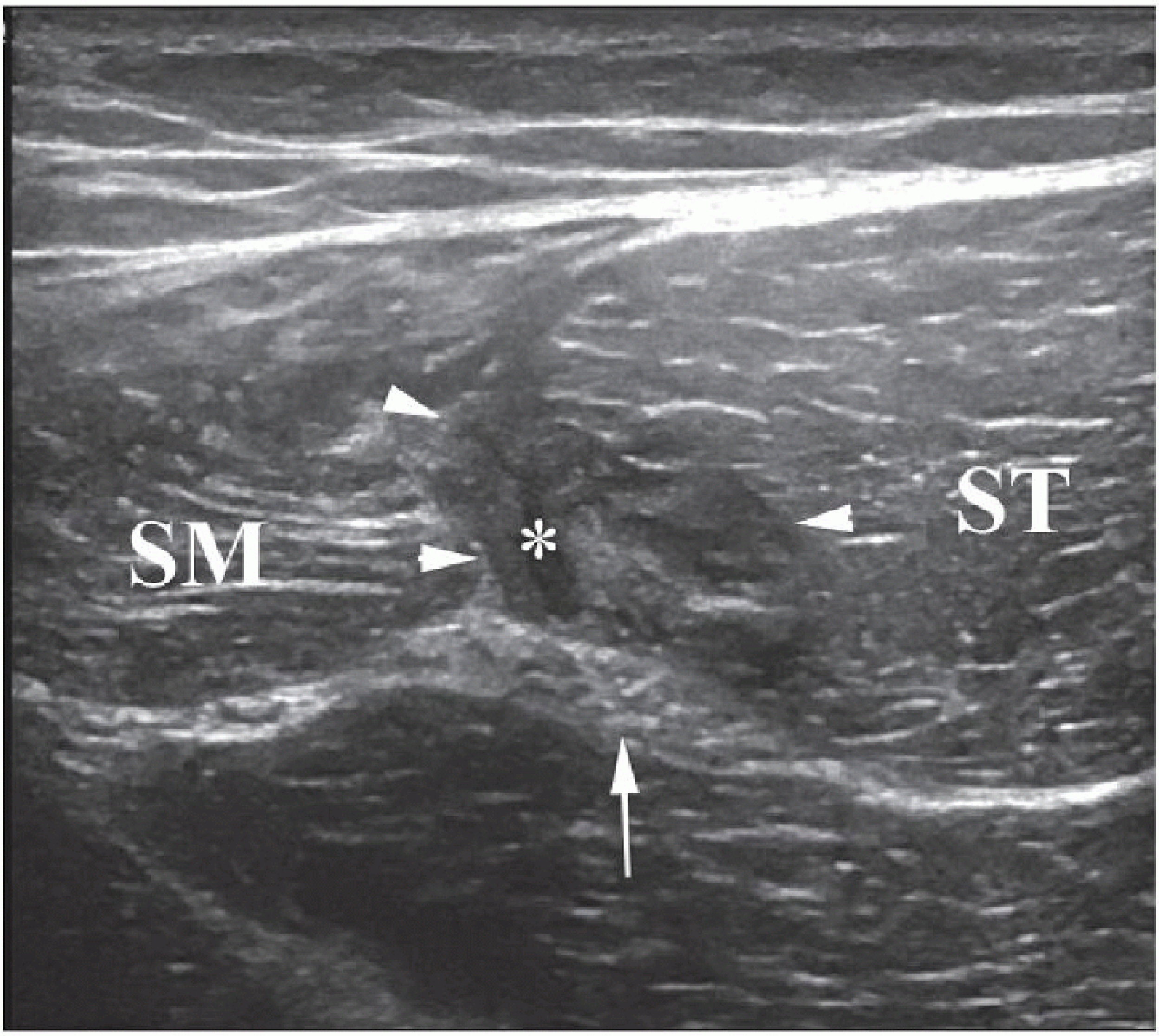

Figure 6.22. Acute hamstring injury. Transverse sonogram shows grade 2 tear (arrowheads) and hematoma (asterisk) in semitendinosus (ST) at margin with semimembranosus (SM) pushing on sciatic nerve (arrow).

The exact nature of the pathology is not fully understood, but commonly seen changes are those of tendinopathy, including thickening, hypoechogenicity, loss of fibrillar pattern, and sometimes calcification[39] (Fig. 6.23A). Partial thickness and full thickness tears are rare and tend to occur in elderly patients, especially following hip replacement surgery (Fig. 6.23B).

Even if the tendons appear normal, symptomatic patients may benefit from diagnostic/therapeutic ultrasound-guided injection. If a quick procedure is desirable, ultrasound can be used to mark the location at the skin surface, followed by "blind" injection after contact is made between needle tip and greater trochanter. Withdrawal of the needle by a few millimeters may be necessary first. Alternatively, a longitudinal, direct vision approach allows the steroid and the anesthetic to be targeted adjacent to the bony trochanter, between tendon layers, and at the superficial aspect of the tendon insertion. Place the patient in a decubitus position. A proximal to distal approach is advised with the probe in LS directly over the greater trochanter. Mark the desired needle entry point, apply skin prep, and give local anesthetic. A 22G spinal needle or a long 20G needle will suffice for most cases. Advance the needle adjacent to or directly on the trochanteric cortex, and withdraw slightly

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while injecting between tendons and associated bursa. Dry needling of the tendons can also be performed at the end of this procedure.

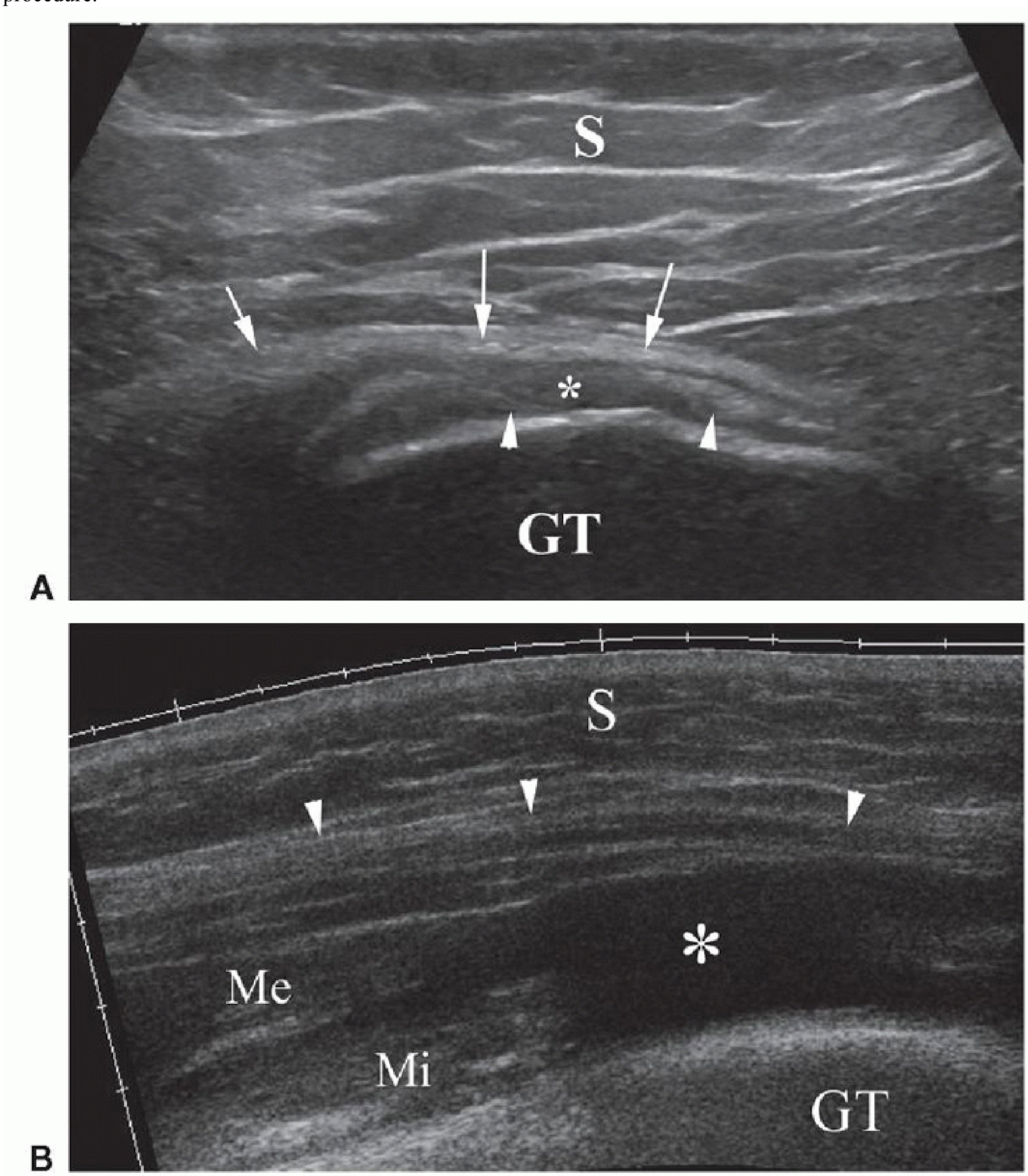

Figure 6.23. Gluteal tendon abnormality. A: Longitudinal sonogram shows normal gluteus medius tendon (arrows) and gluteus minimus tendinopathy (arrowheads) with hypoechoic swollen tendon (asterisk). Greater trochanter (GT) and subcutaneous fat (S) are shown here. B: Longitudinal sonogram shows complete tears of the gluteus medius (Me) and minimus (Mi) tendons with

hypoechoic hematoma (asterisk) in the gap. Greater trochanter (GT), subcutaneous fat (S), and overlying tensor fascia lata (arrowheads) are shown here.

Medial

The functions of the medial compartment are mainly adduction, with some contribution to hip flexion. Typical injury is due to forced abduction of the hip or occasionally forced external rotation. In sports, this is commonly seen where rapid changes of direction occur, for example, during soccer.

The myotendinous junction is the vulnerable point in the mechanical chain although tendon avulsions also occur in old patients in association with chronic tendinopathic changes. Of the three adductors, longus is the most commonly injured. It is also the most prominent muscle when the hip is externally rotated and abducted, allowing surface identification. Scan with the probe in the longitudinal position to visualize the myotendinous junctions and the common origin at the pubic body and inferior pubic ramus (Fig. 6.24).

In acute injuries, irregularity and hypoechogenicity of the origin indicate tears, and there may be a mixed echogenicity hematoma. In complete tears, the muscle may retract, giving the appearance of a soft tissue mass. History is then important in distinguishing between tears and other potential causes such as soft tissue sarcoma. Follow-up scans and/or MRI are useful if there is doubt.

Chronic adductor origin strains with low-grade edema are often not visible on ultrasound, and we do not ordinarily advise ultrasound examination. Specialist physiotherapy and nonsteroidal anti-inflammatory drugs (NSAIDs) are helpful. If imaging is required, MRI is more sensitive for capsular and adductor tendon edema.[40]

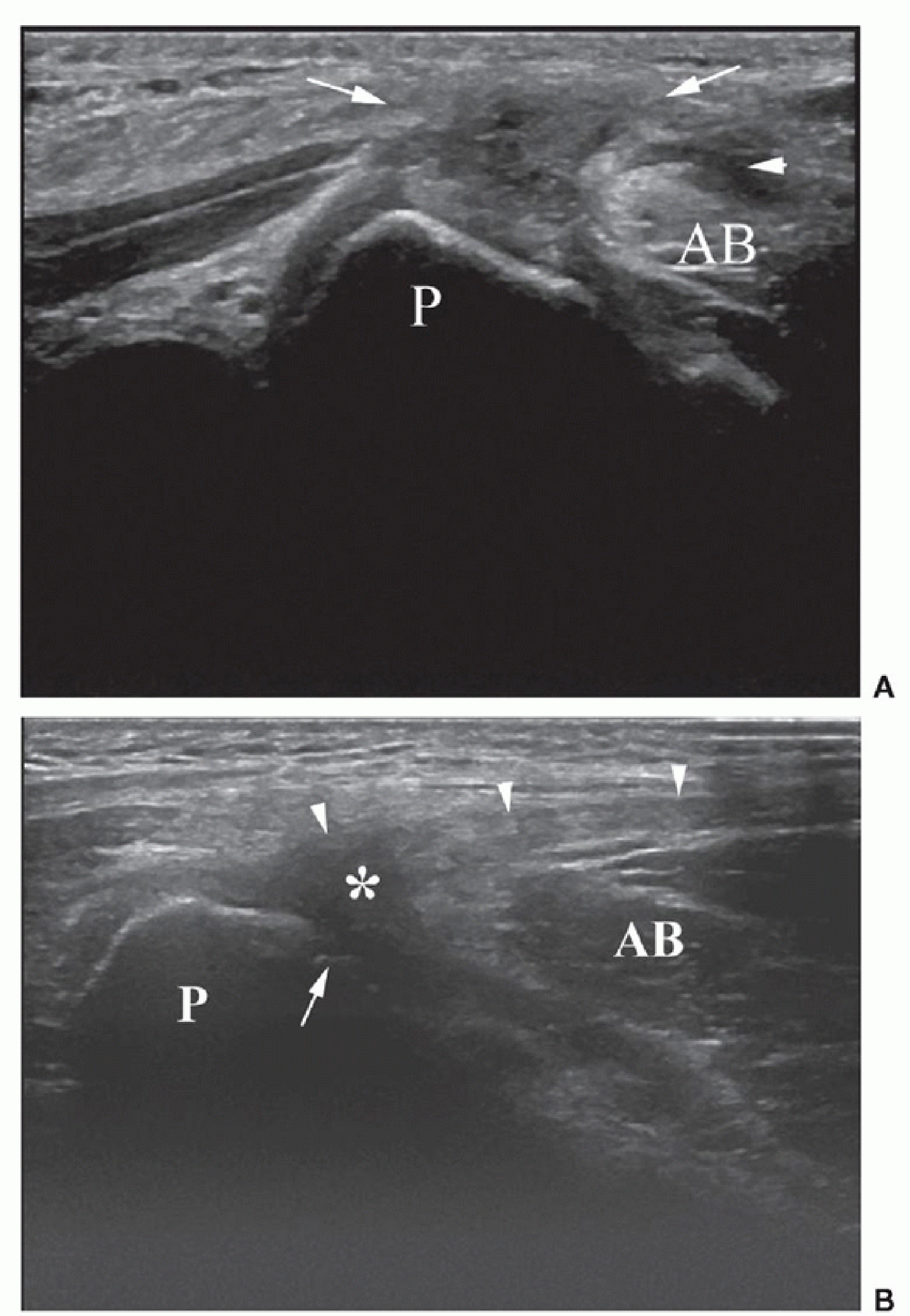

Figure 6.24. Adductor origin abnormality. A: Transverse sonogram shows acute hematoma (arrows) at the junction of the capsular and adductor tendon attachment. The edema extends into adductor brevis (AB) consistent with an acute tear; pubis (P). B: Longitudinal sonogram shows hypoechoic tendinopathy of the adductor longus origin (asterisk) with normal adductor brevis muscle (AB). Compared to (A) there is no acute change or swelling with a normal contour and more distal tendon (arrowheads). Pubis (P) cortical irregularity (arrow) is normal.
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Role of MRI in Pelvic Muscle Injury

The large field of view offered by MRI is of benefit when the location of the pathology is uncertain, for example, when the patient waves rather than points when asked to localize pain. MRI offers better evaluation of deep structures in large patients, for example, at the ischial tuberosity. Magnetic resonance imaging is also more sensitive than ultrasound in assessing minimally disruptive (Grade 1) injuries in the acute phase, and may be preferred in the professional athlete to detect subtle muscle edema.

The role of ultrasound in muscle and tendon assessment around the hip is for focused, dynamic examination with and without intervention.

HERNIAS

The role of ultrasound in hernia detection is to assist in cases where the clinical diagnosis is uncertain due to vague or conflicting examination findings. It also has a role in characterizing hernias and evaluating the contents of the sac. Accurate diagnosis is important, since hernias are associated with significant morbidity. Clinically obvious hernias do not require imaging. Where imaging is needed, several modalities exist.

Computed tomography is useful in acutely incarcerated hernias to confirm the diagnosis and assess for associated complication such as bowel obstruction. Valsalva CT has been used in the outpatient setting to identify hernias, which may reduce when the patient is supine and at rest. The disadvantages are the exposure to ionizing radiation and the inability to scan while the patient is standing. Dynamic MRI studies have also been reported, but are still not widely used in clinical practice.

In herniography, water soluble contrast is injected into the peritoneum, followed by patient maneuvers to fill the hernia sac, which is then demonstrated on fluoroscopy. The technique is invasive, and small hernias or those comprising only fat may not be demonstrated.[41]

Surgical exploration allows exclusion of nonreducing hernia and treatment, but has associated morbidity and can potentially miss hernias that have reduced while the patient lies relaxed in the supine position.

Ultrasound offers the advantages of easy dynamic assessment during Valsalva and posture changes. Sensitivities of 86% to 100% have been reported with 82% to 97% specificity, although accuracy for hernia classification is more varied (45% to 85%).[41] Hernias consisting only of fat are also more readily detected, but care must be taken not to misinterpret prominent fat or, more rarely, a lipoma as a hernia. The exquisite soft tissue detail also allows accurate diagnosis of differential diagnoses such as undescended testis, lymphadenopathy, neoplasm, and aneurysm. The various types of hernias found around the hip are now discussed.

Inguinal (Direct/Indirect)

The inguinal region, from deep to superficial, comprises the peritoneum, transversus abdominis, internal oblique, external oblique, subcutaneous fat, and skin (Fig. 6.25). The inguinal canal has a roof, floor, and anterior and posterior walls. The floor is formed by the inguinal ligament, which runs from the ASIS to the pubic tubercle. The posterior wall is formed from the muscle and fascia of transversus abdominis and part of the internal oblique. The anterior wall is formed from the fascia of external oblique. The roof of the canal is formed from the arching fibers of transversus abdominis and internal oblique. The canal commences at the deep inguinal ring located halfway along the inguinal ligament, just lateral to the origin of the inferior epigastric vessels. It runs obliquely in a medial and inferior direction for about 4 cm, to terminate at the superficial inguinal ring just superior and lateral to the pubic tubercle. Normally it transmits vessels, nerves, and lymphatics between the abdomen and external genitalia, the spermatic cord in men, and the round ligament in women.

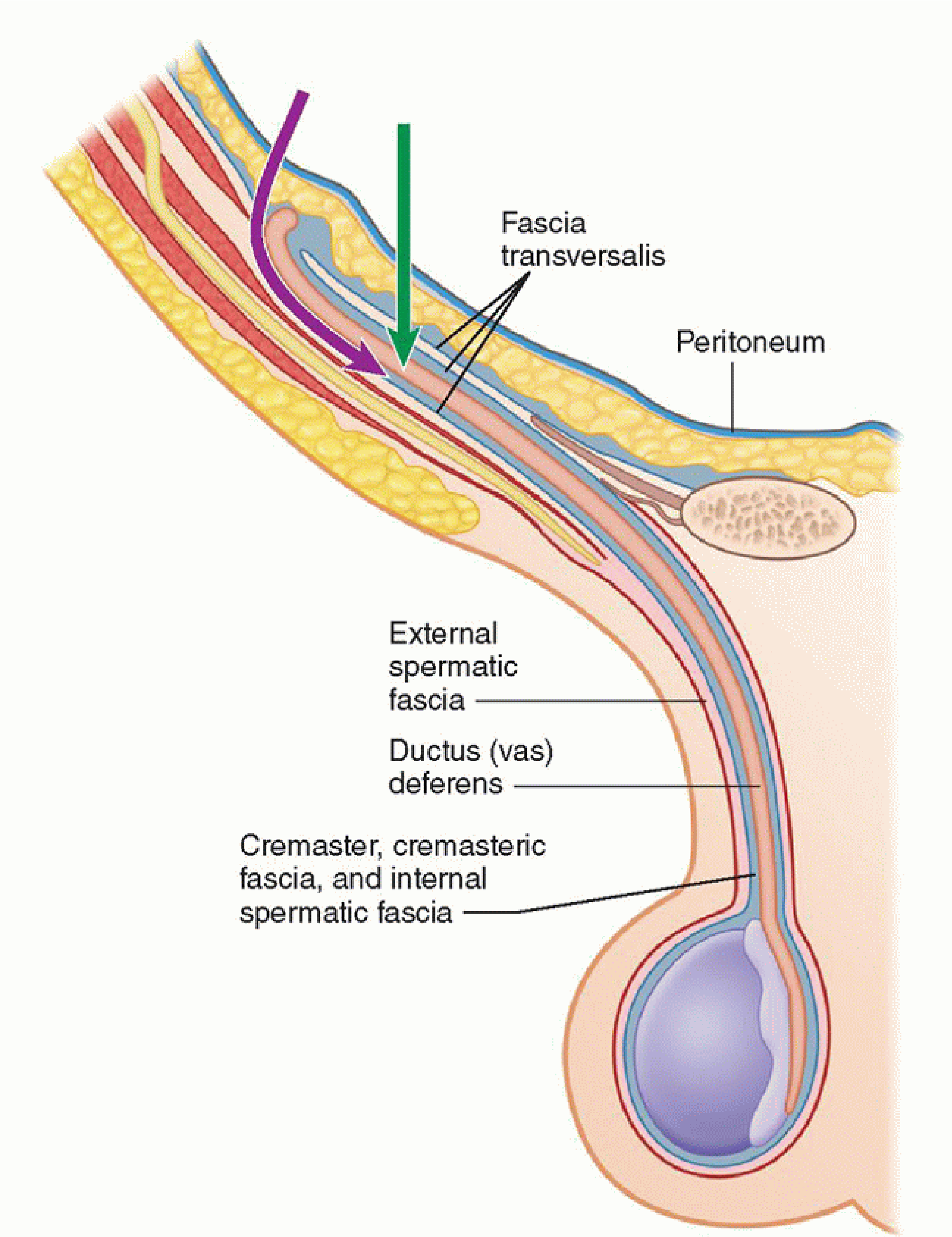

Figure 6.25. Cross-sectional anatomy of the inguinal canal and inguinal hernias. The inguinal canal is shown in cross section with the paths of the two types of hernia demonstrated by the arrows, indirect (purple arrow) and direct (green arrow).
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Posterior (deep) to the canal lie the femoral vessels, which give rise to the inferior epigastric vessels that course superior to the canal and deep to the rectus abdominis muscle. The origin of the inferior epigastric vessels (Fig. 6.26), just medial to the deep inguinal ring, is an important landmark in inguinal hernia identification and classification. Inguinal hernias that arise lateral to the inferior epigastric vessels therefore pass through the deep inguinal ring and are indirect. Hernias arising medial are direct. The inferior epigastric vessels, along with the lateral margin of rectus abdominis and the inguinal ligament, form Hesselbach's triangle, where direct inguinal hernias will be seen to arise (Fig. 6.26).

Scanning Technique

A linear probe of around 9 to 15 MHz is usually optimal, although higher frequencies provide better detail in slim patients. Begin by identifying the inferior epigastric vessels (Fig. 6.26) deep to the rectus abdominis muscles and following them inferiorly to their origin. Alternatively, scan along the femoral vessels below the inguinal ligament in a cephalad direction until the origins appear. The second method may be easier in large patients where the abdominal apron can disrupt scanning. Once the origin is located, angle the probe parallel to the inguinal ligament, which will be visible superficial to the vessel origins. The inguinal ligament is a linear echogenic band with an echogenic internal fibrillar structure. The contents of the inguinal canal can be appreciated deep and superior to the ligament as a mixture of hypo and hyperechoic serpentine structures (Figs. 6.27 and 6.28). They should be evaluated in long- and short-axis scans. Posterior and deep to the canal lie the psoas muscle, femoral vessels, and peritoneum. The peritoneum appears as an echogenic layer. The canal contents can be traced into the scrotum in males.

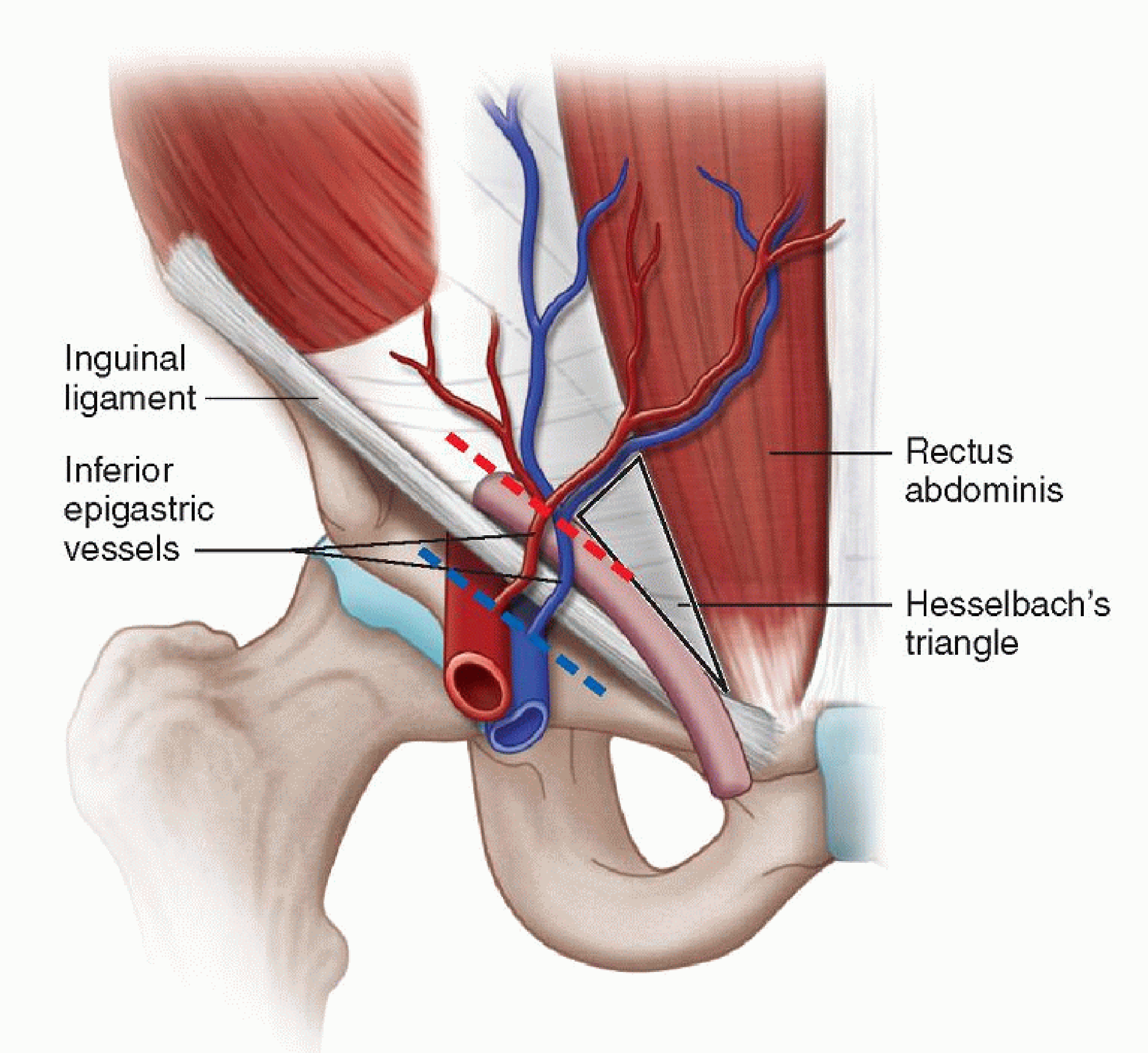

Figure 6.26. Anterior view of the inguinal canal and Hesselbach's triangle. The dotted lines show the optimal probe positions for imaging groin hernias. Inguinal hernias are best seen on the red dotted line and femoral hernias on the blue dotted line. The boundaries of Hesselbach's triangle, where direct hernias occur, are demonstrated; the lateral border of rectus abdominis, the inferior epigastric vessels, and the inguinal ligament.

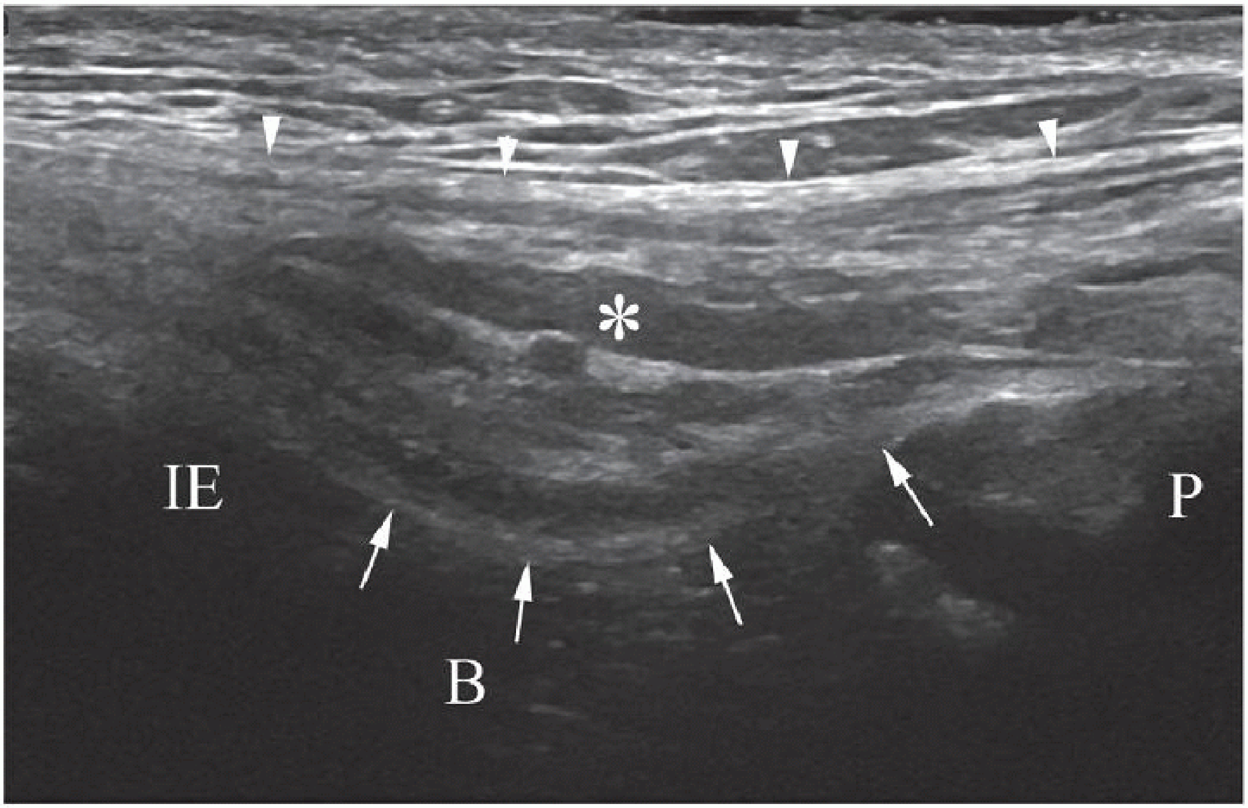

Figure 6.27. Normal inguinal canal (long axis). Longitudinal sonogram aligned parallel to the inguinal ligament demonstrates hyperechoic inguinal ligament (white arrowheads), inguinal canal contents (asterisk), inferior epigastric vessels (IE), and pubic tubercle (P). The hypoechoic area at the bottom of the picture represents bowel (B) deep to the posterior (deep) canal wall (arrows).

Both long- and short-axis evaluation is advised for inguinal hernias. Begin in the long axis. Unreduced hernias may be visible within the canal from the outset. The patient should be asked to perform a slow Valsalva

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maneuver. This can be achieved by gently raising their head from the bed or attempting to blow through their closed fist or an occluded straw. Avoid coughing, as this produces sudden motion that can be difficult to interpret.

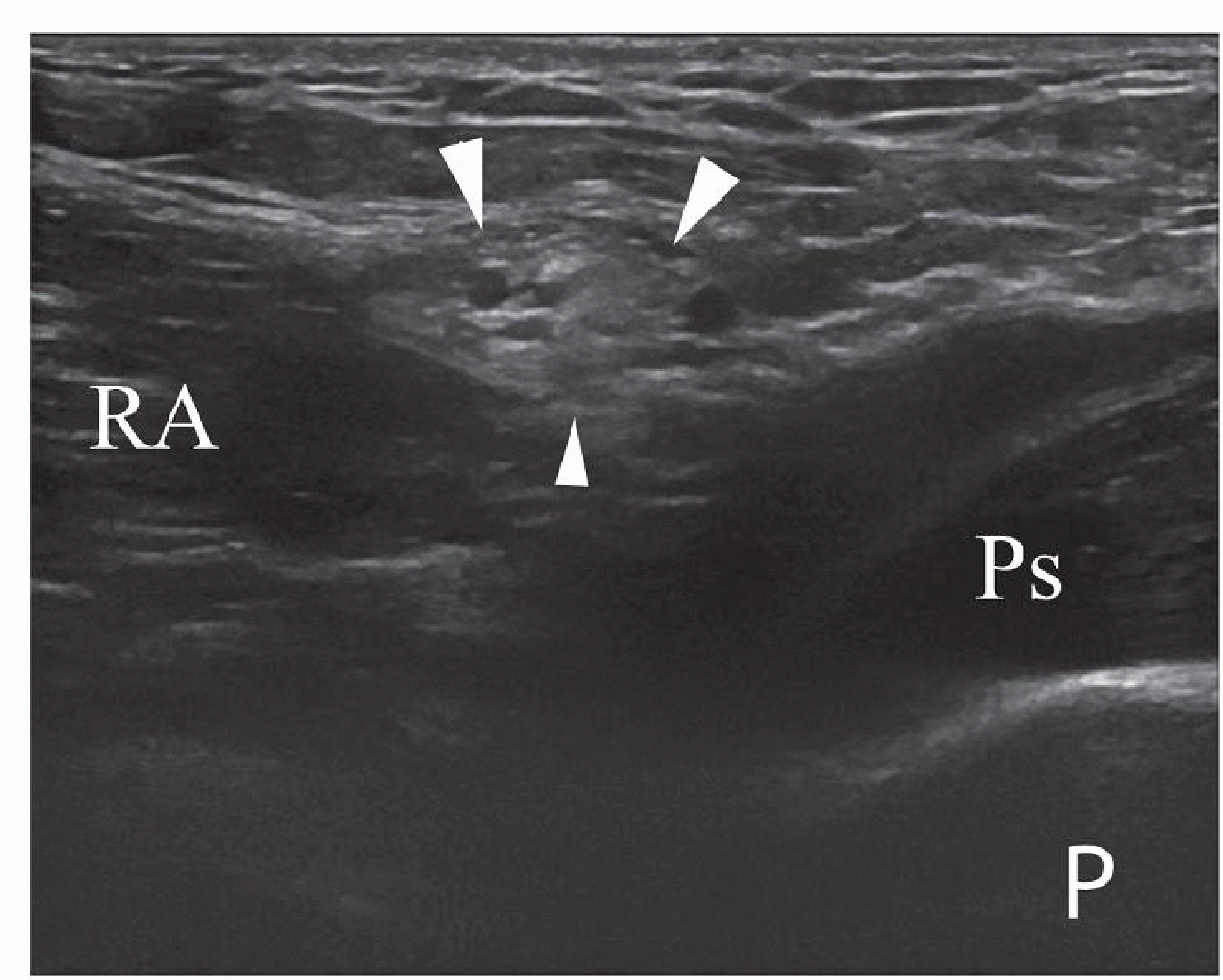

Figure 6.28. Normal inguinal canal (short axis). Transverse sonogram demonstrates the normal inguinal canal and contents (arrowheads). Iliopsoas muscle (Ps), rectus abdominis (RA), and pubic ramus (P).

Tip:

Take time to ensure the patient performs the Valsalva maneuver properly, as ineffective Valsalva can lead to false-negative result. Dilation of the femoral vein is indicative of an effective maneuver. Advise the clinician in the report if the patient is not able to perform this procedure effectively. Indirect inguinal hernias arise lateral to the inferior epigastric vessels and pass medially along the canal (Fig. 6.29). Direct inguinal hernias arise medially, bulge superficially toward the probe (Fig. 6.30), are seen within the boundaries of Hesselbach's triangle, and tend to be more localized.

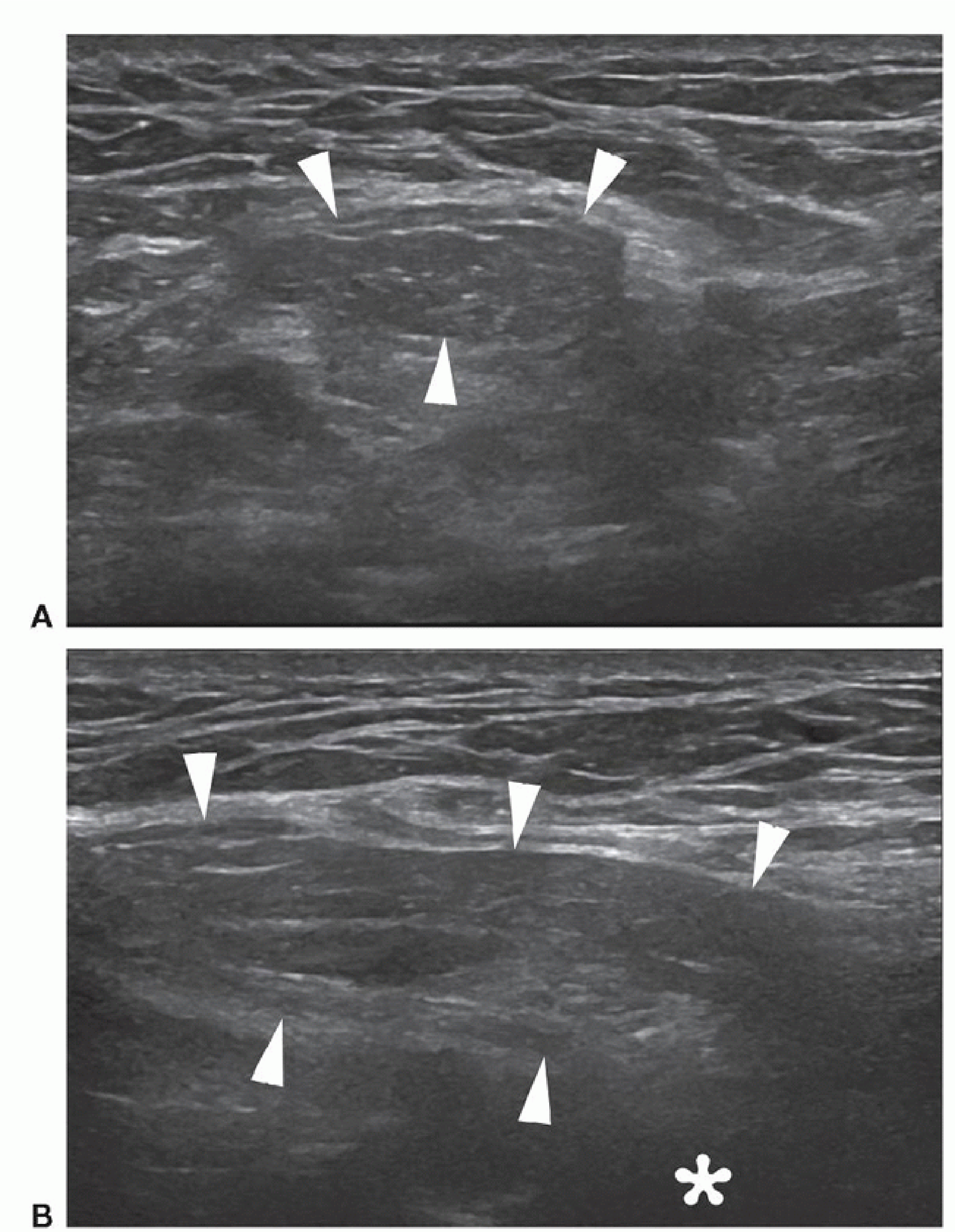

Figure 6.29. Indirect inguinal hernia. Sonograms of the inguinal canal. A: Short axis during Valsalva shows hernia containing fat (arrowheads) expanding the canal and effacing contents. B: Long axis during Valsalva shows hernia containing fat (arrowheads). The location of the inferior epigastric vessels is marked (asterisk) with the hernia arising laterally.

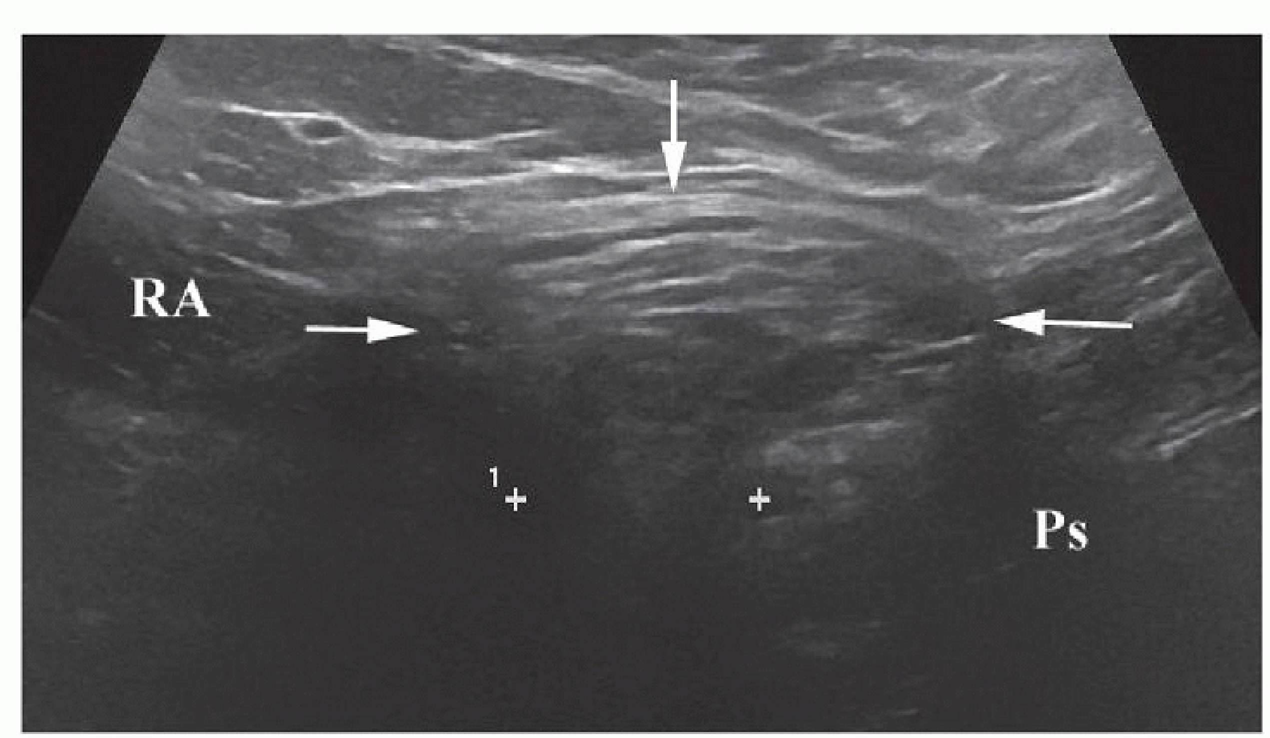

Figure 6.30. Direct inguinal hernia. Transverse sonogram of the inguinal canal shows direct inguinal hernia (arrows) extending though a posterior wall defect (calipers) into the canal. Note the rectus abdominis (RA) and iliopsoas (Ps).

Tip:

Be careful to avoid excessive transducer pressure as this can lead to reduction of the hernia and a false-negative result.

Some forward bulging of the peritoneal contents during Valsalva is normal but the inguinal canal should not be occluded. Bowel may approach the canal and cause a little prominence of the deep ring, but should not enter the canal. Mild vessel dilation and motion within the canal are also normal. The relaxation period after Valsalva can be an opportune moment to see the bowel slowly returning to the peritoneal cavity. Assess the canal in short axis next, looking for sudden canal distension with vessel effacement in indirect hernias. Direct hernias will bulge from deep to superficial, entering the canal.

When describing hernia contents, note that fat and peritoneum are relatively hyperechoic, and omental fat has a similar appearance to the adjacent subcutaneous fat (Fig. 6.29B). Bowel is hypoechoic, but can demonstrate hyperechoic mucosa/gas bubbles within (Fig. 6.30).

Tip:

An occasional cause of false-positive hernia reporting is increased preperitoneal fat or a lipoma of the spermatic cord. They appear as fatty projections adjacent to the cord vessels and slide like a hernia, but the inguinal canal does not increase in diameter during straining.[42]

There is discussion in the literature regarding the possible existence of a “pre-hernia” condition as a possible source of groin pain. This is characterized by bulging of the transversalis fascia such that the canal is almost occluded, but no actual herniation occurs. However, this has not been confirmed by ultrasound or herniography.[41] We advise caution when reporting such appearances.

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Femoral

The femoral canal is a small compartment within the femoral sheath medial to the femoral vein. It is a potential space that ordinarily only contains fatty connective tissue and lymphatics. Hernias enter the canal via the femoral ring that lies superiorly and is bounded by the inguinal ligament anteriorly, pectineus and pectineus fascia posteriorly, lacunar ligament medially, and femoral vein laterally. Femoral hernias are most prevalent in middle-aged female patients, but even in this group they are less frequent than inguinal hernias. Femoral hernias may consist of preperitoneal fat only or include bowel. The narrow neck makes them prone to incarceration and strangulation.

Begin scanning at the level of inguinal ligament at the intersection with the femoral vessels and the probe parallel to the ligament (Fig. 6.26). Move just inferior to the ligament, and ask the patient to perform a Valsalva maneuver. Normally, the femoral vein will distend by expanding into the potential space of the canal. If a hernia is present within the canal, the femoral vein will fail to distend and may be compressed. The hernia itself may be visualized as hypoechoic bowel or just hyperechoic fat/peritoneum (Fig. 6.31).

Postoperative

The presentation of a lump at the site of surgery following hernia repair may be due to recurrent hernia, hematoma (Fig. 6.32A), seroma, or abscess. Ideally, ascertain prior to scanning whether the repair involved mesh, which appears as a hyperechoic linear structure near the deep inguinal ring (Fig. 6.32B).

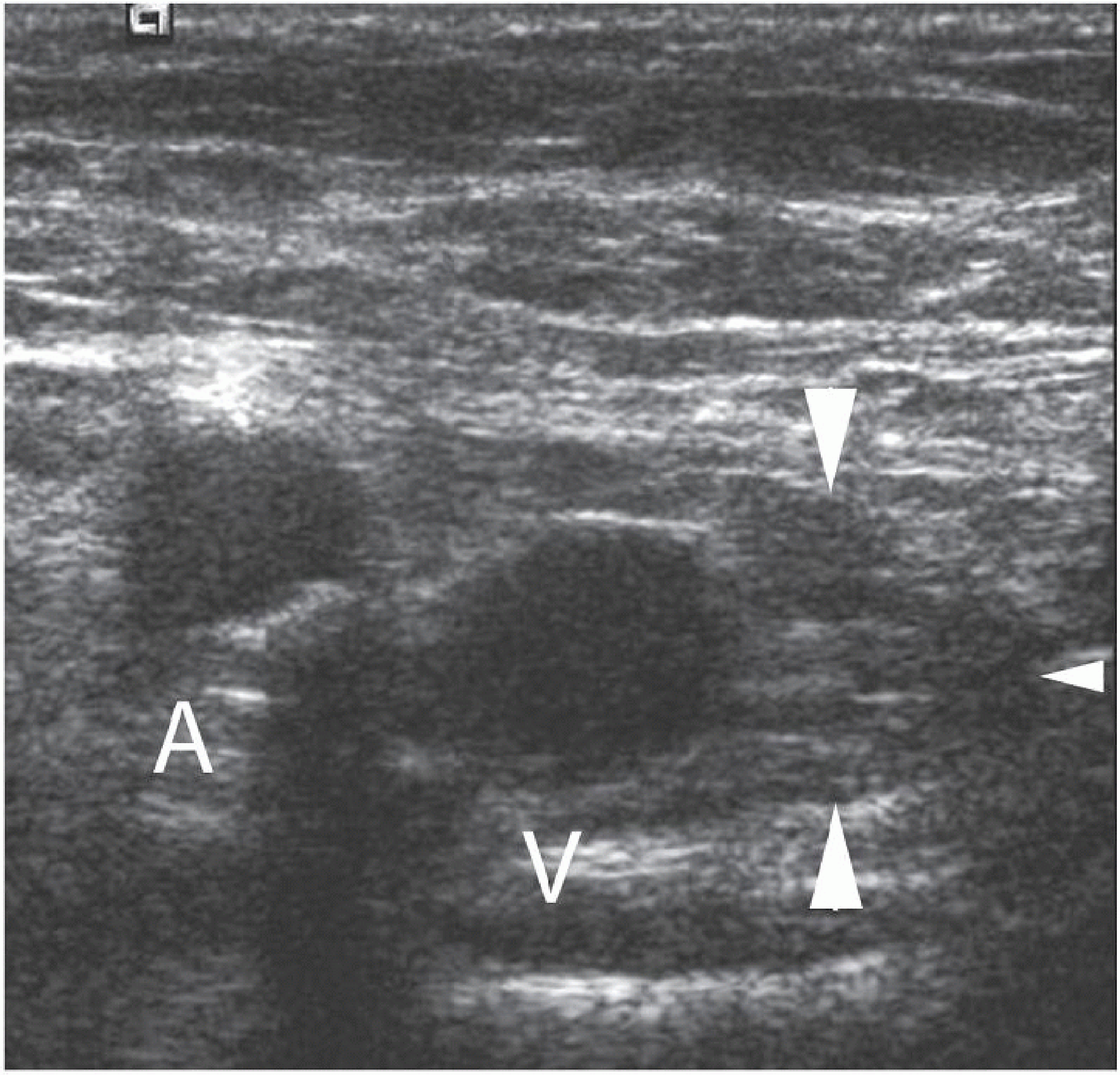

Figure 6.31. Femoral hernia. Transverse sonogram during Valsalva shows femoral hernia (arrowheads) medial to the femoral vein (V) and artery (A).

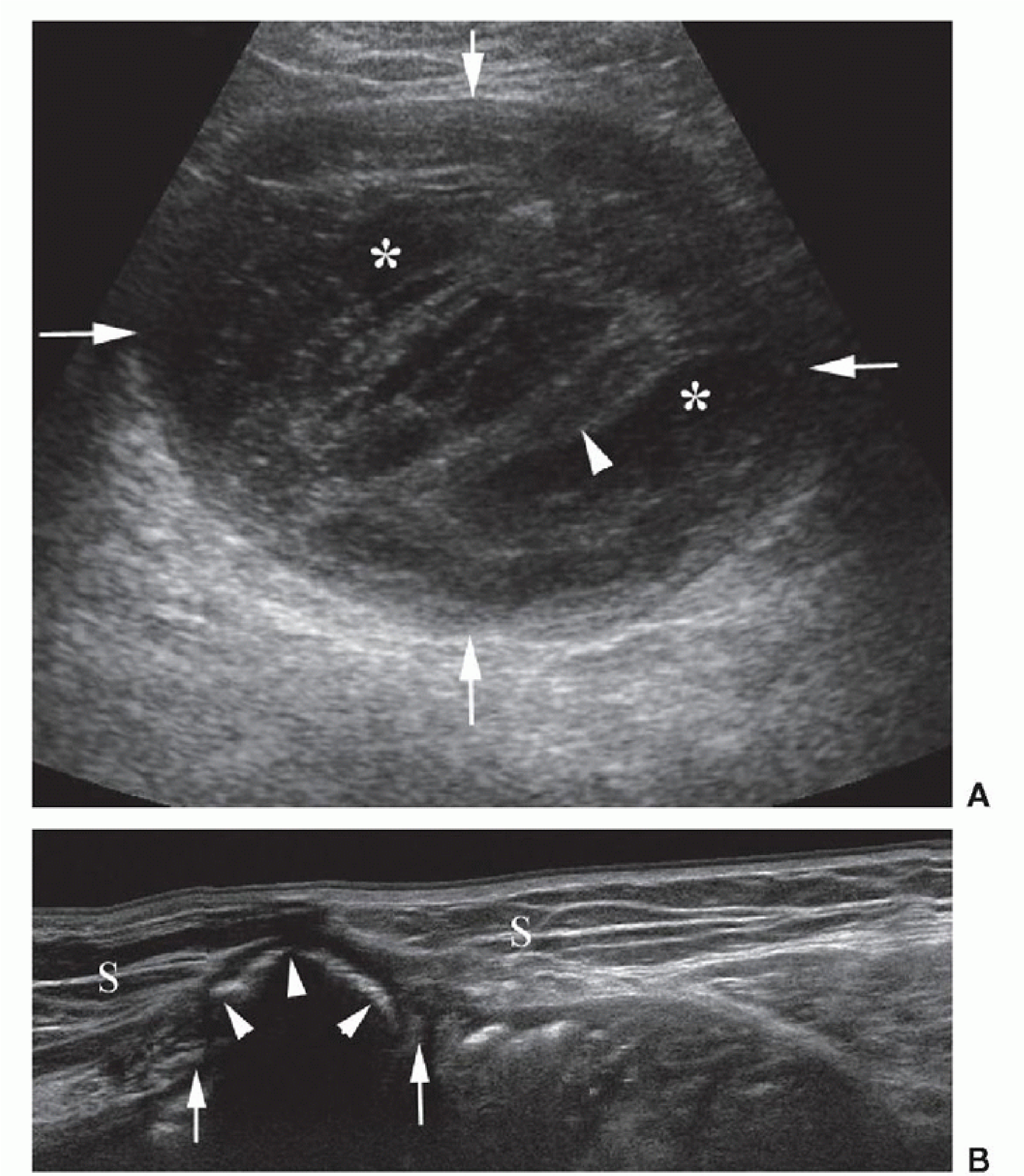

Figure 6.32. Postoperative changes. A: Transverse sonogram of the inguinal canal post direct hernia repair surgery shows hematoma (arrows) expanding the inguinal canal with echogenic stranding (arrowhead) and liquefied areas (asterisk). B: Longitudinal sonogram of a recurrent incisional hernia containing echogenic mesh (arrowheads) extending though a fascial defect (arrows) into the subcutaneous fat (S).

Fluid collections in the inguinal canal in the immediate postoperative period have an incidence of 0 to 17%, and are thought to be the result of surgical trauma or fluid in the hernia sac that remains after laparoscopic repair.[43] They can usually be left to reabsorb naturally unless they persist beyond 6 to 8 weeks, after which aspiration, or rarely resection, can be considered.[44] If a collection contains gas, it can be difficult to differentiate from hernia recurrence. In these cases, look for other ancillary features, such as herniated mesentery, the relationship of the mesh to the collection, and the presence of a hernia sac. CT with oral contrast may be useful.[45]

Sepsis rates after mesh repair have been reported as 0.2% to 0.8%.43 The important distinction is whether or not any resulting collection involves the mesh, as this usually calls for mesh removal.

Spermatic cord thickening is a relatively frequent finding in the immediate postoperative period and usually resolves on follow-up.[43] Testicular complications such as pain, ischemia, epididymitis, and atrophy have been reported in 0.03% to 5.0% after

laparoscopic repair.[44]
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Other postoperative findings associated with groin pain and easily identified at ultrasound include neuromas and stitch granulomas.
Spigelian
Spigelian hernias are mostly acquired and are associated with raised intra-abdominal pressure, chronic obstructive pulmonary disease, obesity, collagen disorders, and laparoscopy, although congenital cases occur.[46],[47],[48],[49] Presenting symptoms are varied, but pain with or without a palpable mass is the major presentation and may be provoked by a Valsalva maneuver. Detection and surgical correction are important due to the high incidence of strangulation (up to 21%).[47],[50]
The Spigelian fascia is the aponeurotic layer between the lateral border of the rectus abdominis muscle and the medial border of the transversus abdominis muscle. Herniation through this aponeurosis is known as a Spigelian hernia (Fig. 6.33). The majority occur within a 6-cm area inferior to the umbilicus.[47] They are particularly common where the inferior epigastric vessels penetrate the rectus sheath.[10] Scan with the probe transverse at the lateral margin of the rectus abdominis (linea semilunaris), from the level of the umbilicus, and move inferiorly. Careful attention should be given to the area just superior to where the inferior epigastric artery passes deep to the lateral border of rectus abdominis.[51] The report should comment on the size of any fascial defect and the nature of the contents where possible (i.e., fat or bowel).
Umbilical and Paraumbilical
These occur through and around the umbilicus in the midline, via defects in the linea alba and umbilical fascia. There is an association with abdominal distension (postpartum, ascites, and obesity). They may become more apparent if the patient is scanned while standing. Paraumbilical hernias are more common over the age of 35 years and in women than men. They are more prone to complications than true umbilical hernias and may be multiple.

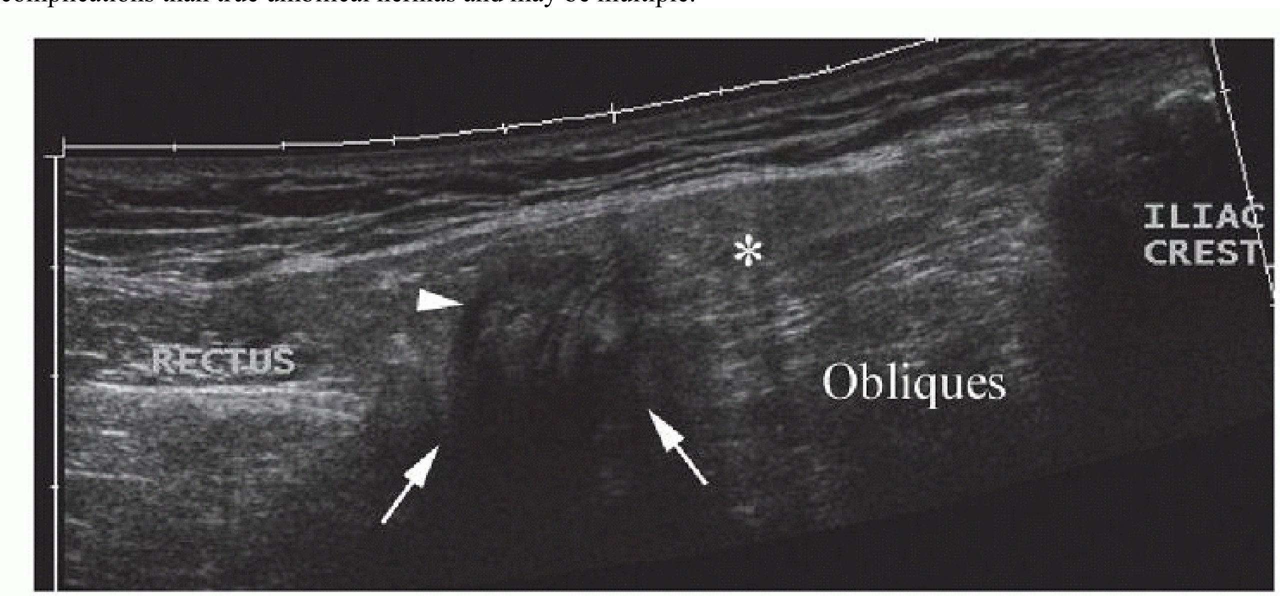

Figure 6.33. Spigelian hernia. Transverse sonogram shows Spigelian hernia of fat (asterisk) and edematous fat (arrowhead) emerging through the Spigelian fascia (arrows) between rectus and the oblique muscle group.
Incisional
Following surgery, the muscle and fascia commonly have residual weakness/defects through which hernias may pass. Care should be taken not to confuse hypoechoic scar tissue and collections with hernia. Evaluate the relationship between the “hernia” and the deep fascia and any mesh present (Fig. 6.32). If in doubt, CT can help, but is rarely needed unless there has been extensive surgery with an associated large fascial defect.
Sportsman’s Hernia
“Sportsman’s hernia” can also be known as athletic pubalgia, hockey groin, or “Gilmore’s groin.” These terms have arisen in association with chronic groin pain in athletes. The exact etiology and pathology are poorly understood, and there is no consensus as to what constitutes the diagnosis.[52]
Clinical presentation is typically groin pain that occurs during activity and is associated with stiffness following a rest period such as overnight sleep. Warm-up routines may provide relief, but more intense activities, such as kicking, exacerbate symptoms. Coughing, sneezing, and other sudden movements can also exacerbate the pain. Symptoms last for months and cause significant disruption to training schedules. Hip extension, twisting, turning, and sudden directional changes have all been implicated as biomechanical causes. Several potential underlying pathological processes have been proposed, with true hernia often being absent. Theories suggest that the injury occurs due to imbalance between the strong adductor muscles of the thigh and the weaker abdominal wall muscles.[53]
Gilmore described groin disruption comprising a combination of a torn external oblique aponeurosis with dilated superficial inguinal ring, torn conjoined tendon, and dehiscence between the inguinal ligament and conjoined tendon (Fig. 6.34).[54] Several

variations have been described.[52,54,55,56,57] A recent systematic review of the literature found that the most common surgical finding was posterior inguinal wall insufficiency resulting in an occult hernia that was not apparent on clinical examination.[52]
Other proposed causes of groin pain include rectus abdominis insertion tears, osteitis pubis, pubic stress fractures, adductor enthesis injury, and entrapment of the ilioinguinal nerve. Referred pain from the spine, hip, or even knee may also manifest as groin pain.
Conservative treatments involve rest, strengthening, and stretching exercises and NSAIDs. Surgical treatments involve strengthening the abdominal wall musculature and fascia around the inguinal ligament and are variations of the traditional inguinal hernia repair. The literature favors surgical outcomes, but there is a lack of clinical trials.[10,52,58,53]
The role of ultrasound is to exclude true inguinal hernia and assess for signs of significant acute muscle or
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tendon injury such as edema, hematoma, or retraction (Fig. 6.24A). However, these abnormalities are frequently absent at ultrasound in athletes with chronic pubalgia. Similarly, the adductor origin is usually “normal” at ultrasound. Tendon thickening and pubic cortical irregularity are commonly seen in athletes over the age of 20, making these findings nonspecific (Fig. 6.24B). Patients with suspected sports hernias often go on to surgery/laparoscopy, which can identify small aponeurotic, muscular, or tendinous tears not seen at ultrasound. During the examination, note any focal areas of tenderness under transducer pressure, as this may give clues to the affected structure.

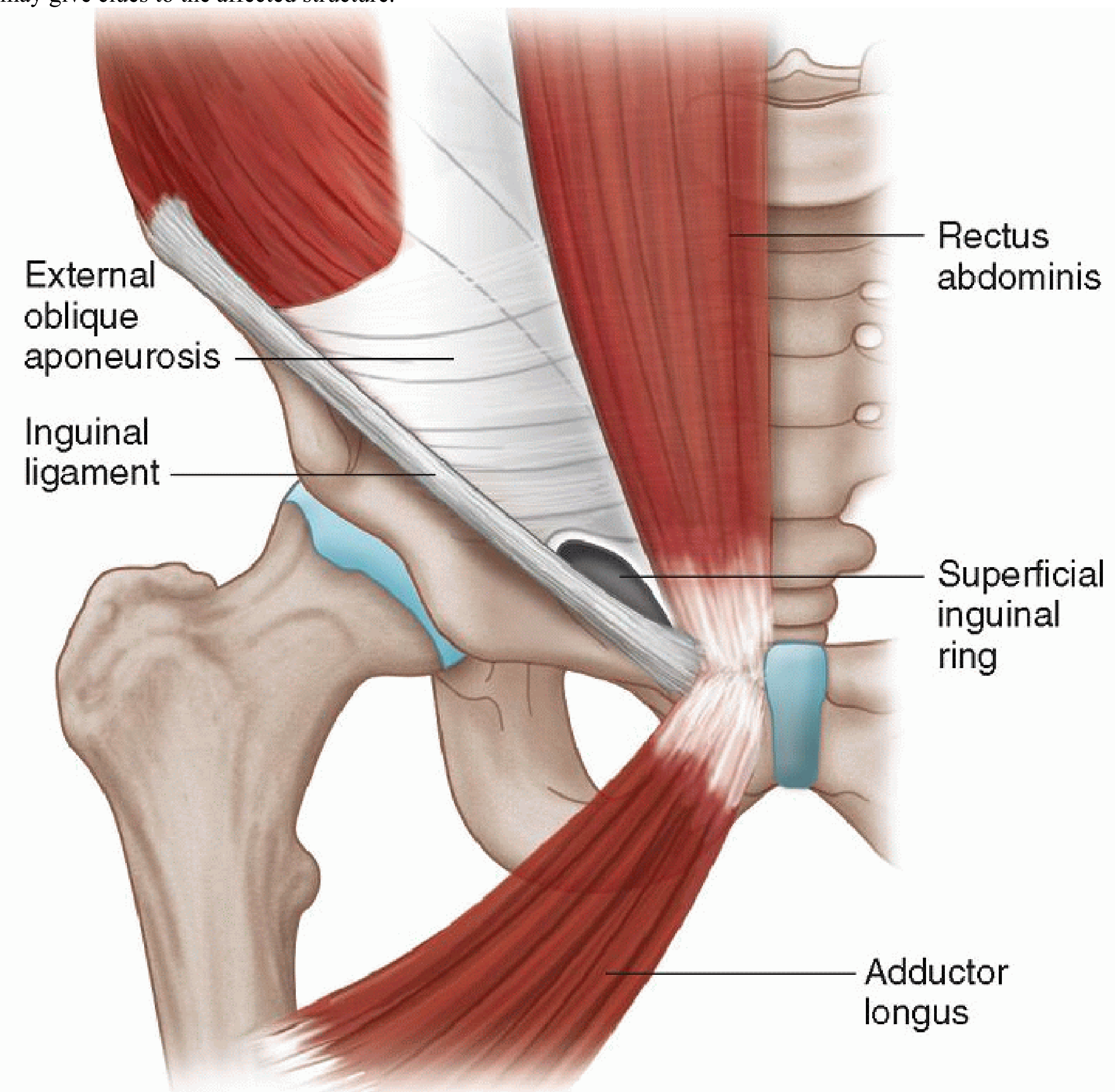

Figure 6.34. Anatomy of sportsman’s hernias. The potentially affected areas of the inguinal region are shown: external oblique aponeurosis, superficial inguinal ring, inguinal ligament, rectus abdominis, and adductor longus junction at the symphysis pubis.
Diagnostic/therapeutic injections to the pubic symphysis and adductor origin have been used in the setting of groin pain.[59,60,61]
Care should be taken to avoid the medial aspect of the inguinal canal.
The Role of MRI in Chronic Pubalgia

Magnetic resonance imaging is useful for detection of edema of the adductor enthesis and pubic symphysis, which are usually not apparent on ultrasound. The wide field of view is helpful in reviewing the multiple structures that may potentially be responsible, but inguinal canal abnormality is rarely demonstrated. Plain film may occasionally be useful in revealing suspected stress fractures, but degenerative symphyseal and remodeling changes are often seen in asymptomatic active subjects.[10,40] Herniography has also been described in this clinical context.[62]

NERVE PATHOLOGY

Femoral

The femoral nerve courses down the lateral border of psoas major and runs in the groove between psoas and iliacus. It runs lateral to the femoral artery as it enters the thigh deep to the inguinal ligament, where it then divides into multiple branches in the femoral triangle. Injuries can occur during lower abdominal surgery, such as appendectomy and hernia repair, pelvic fractures, hematoma, penetrating wounds, abscesses, tumors, or diabetic neuropathy. Clinical presentation includes groin pain, weakness of hip flexion and knee extension, and anterior thigh sensory deficit. The saphenous nerve arises from the femoral nerve, and sensation medially below the knee may also be affected. Scanning the nerve transversely along its superficial course allows detection of scars and masses, which may be causing symptoms. In the event of deeper/pelvic pathology, CT or MRI offer superior views of the pelvic contents or nerve origins respectively.

Sciatic

Sciatic nerve pathology at the level of the hip may present as posterior hip pain radiating down the back of the thigh or in the case of serious injury, paralysis of the hamstrings and muscles below the knee and sensory loss of the posterior/lateral calf and sole of the foot. The most common cause of pathology at this level is trauma, either fracture dislocation of the hip or iatrogenic injury as a result of hip replacement. Acute nerve injuries occur due to instrumentation, hip dislocation, and traction during surgery, or as a consequence of the resulting hematoma, or leg lengthening. Scar and callus formation adjacent to the nerve following injuries, prolonged bed rest, and the piriformis muscle (piriformis syndrome) have also been implicated in sciatic nerve impingement.

The role of ultrasound is to identify abnormality in the nerve such as disruption of the normal fibrillar architecture, swelling, or edema, and to assess for adjacent sources of compression such as a mass or scarring. The symptoms can be mimicked by ischiogluteal bursitis, and this area should be evaluated during scanning. Magnetic resonance imaging offers a superior alternative for the identification of deeper and more proximal lesions such as piriformis anomalies and can identify pathology arising from the nerve roots.

Lateral Cutaneous Nerve of the Thigh

Entrapment of this nerve results in pain and paresthesia in the lateral and anterolateral aspects of the thigh.

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It arises from L2 to L4, forms within the psoas, and courses over the iliacus and travels posterior to the inguinal ligament (Fig. 6.35). It is at this point that entrapment usually occurs. The nerve then continues over sartorius into the thigh. Nerve pathology may arise from intrapelvic causes such as masses or inflammatory processes like diverticulitis/appendicitis. Extrapelvic causes include trauma, for example, from seat belts in motor vehicle collisions and clothing (e.g., belts or pressure from obesity). Prolonged sitting and standing have also been implicated. Ultrasound may reveal the intrapelvic causes, though if these are suspected, CT/MRI may also be required. More superficially, the course of the nerve should be traced in transverse section as it is passed under the inguinal ligament, close to the ASIS, with a high-frequency probe. Look for hematomas, masses, and scarring in the adjacent tissue. However, appearances are often normal, but diagnostic injection can be performed with local anesthetic at the level of the ASIS just deep to the inguinal ligament. If positive, a more lasting effect may be achieved with steroid.

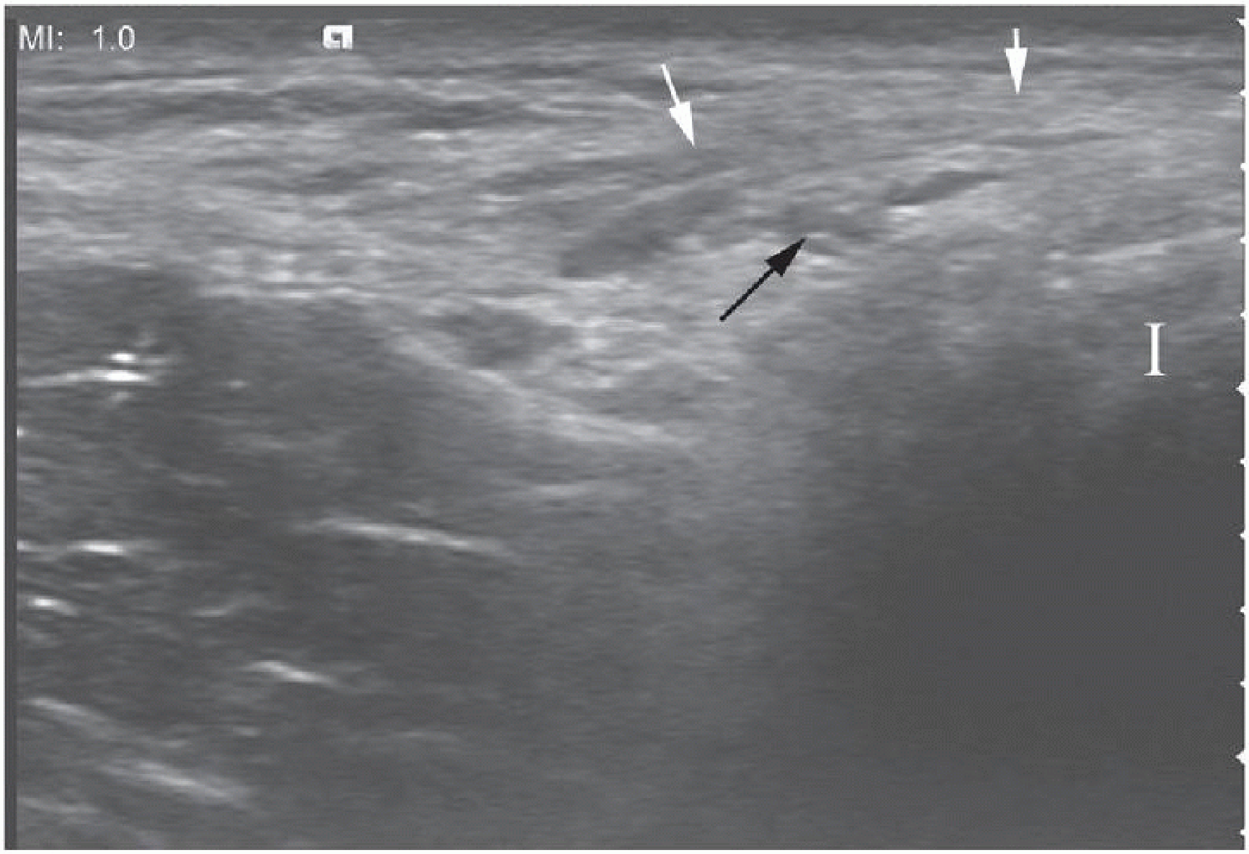

Figure 6.35. Lateral cutaneous nerve. Transverse sonogram shows normal lateral cutaneous nerve (black arrow) deep to the inguinal ligament (white arrows) inferior to the anterior superior iliac spine (I).

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