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Review

Thinking Beyond the Hip: A Clinico-Radiological Approach to Atypical Paediatric Hip Pain for the Generalist

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Abstract

Paediatric hip pain is a common clinical presentation and can be caused by a wide range of aetiologies, many of which are uniquely related to the growing immature skeletal system such as developmental hip dysplasia, Perthes disease and slipped capital femoral epiphysis. However, atypical or referred causes of hip pain often require a broader diagnostic approach beyond the hip joint itself, and can pose diagnostic challenges for clinicians. This article aims to provide a comprehensive review from an imaging perspective, highlighting common pathologies outside the hip that can also present with similar symptoms, including important pelvic, abdominal, and neoplastic pathologies, which are discussed. By expanding the diagnostic spectrum, we aim to improve the accuracy and timeliness of diagnosis and management in children with atypical causes of hip pain.

Keywords: hip pain; appendicitis; fracture; deep vein thrombosis; infection; tumour; hernia; paediatrics

1. Introduction

Atraumatic hip pain is a common reason for paediatric musculoskeletal consultation, with an estimated incidence of 148 per 100,000 children annually [1], mainly affecting children aged 3 to 10 years [2] . While transient synovitis is the most frequent cause, the differential of hip pain is broad, ranging from benign self-limiting conditions to serious pathologies such as infection, inflammatory disease, or malignancy. Septic arthritis tends to affect younger children, whereas slipped capital femoral epiphysis (SCFE) is more common in adolescents.

Diagnostic evaluation is often challenging due to overlapping clinical features and communication limitations in younger patients. Although history, examination, and laboratory markers help narrow the differentials, imaging frequently plays a pivotal role in establishing a diagnosis. Treatment varies widely, from conservative management in transient synovitis to urgent surgical or oncologic intervention in more serious conditions such as abscesses, SCFE, or tumours.

While the hip joint itself is often the primary focus of evaluation, referred pain from extra-articular structures such as the abdomen, pelvis and spine can mimic intra-articular pathology, hence complicating diagnosis and delaying care. A comprehensive clinico-radiological approach is therefore essential to avoid missed or late diagnoses that may result in significant morbidity.

This review highlights a section of relatively common, acute and non-articular conditions that may present as hip pain in children, based on valuable cases from our institution. Through integration of clinical context and key imaging features (Table 1 (Ref. [3–5]) and Fig. 1), we propose a practical framework to aid clinicians and radiologists in recognizing these entities, selecting appropriate imaging modalities and guiding timely management.

2. General Clinico-Radiological Approach to Atypical Hip Pain

A stepwise, multimodality imaging approach is key to refining the diagnosis in cases of atypical paediatric hip pain (Fig. 1). While the causes may vary by age group, infection and malignancy should always be actively considered across all ages.

Infants and toddlers with atypical hip pain often present with non-specific symptoms, such as refusal to weight bear or limb disuse, making localization challenging. While common causes such as undiagnosed hip dysplasia, and non-accidental injury must be excluded, distant pathologies such as distal limb or spinal disease, should also be considered when initial hip imaging is inconclusive.

In preschool and school-aged children, transient synovitis, early Perthes disease, and infectious causes are more common. Symptom localization improves in this age group, but atypical causes should still be explored, especially when symptoms persist or evolve. In adolescents, beyond common entities like SCFE, overuse and sports injuries, attention should be given to spinal pathology, referred pain from the abdomen or pelvis, and early-onset inflammatory conditions.

A thorough clinical history should be focused on pain characteristics, trauma history, mechanical symptoms, systemic or inflammatory signs, neurological deficits, gait dis-

Table 1. Key imaging features of atypical causes of hip pain in children.

Imaging modality & features	Lumbar spine & sacroiliac joint pathologies			Abdominal and inguinal pathologies			Muscular pathology beyond the hip		Vascular pathology
	Cord/Nerve compression	Vertebral Osseous Injuries	Sacroiliitis	Appendicitis	Pyelonephritis	Inguinal hernias (Direct or indirect)	Pyomyositis/intramuscular abscess	Intra-muscular haematoma	Deep vein thrombosis
		Pars interarticularis fracture	Inflammatory/Infective process						
Age group affected	• Can affect any age group depending on underlying aetiology. • Disc herniations are commoner in older/athletic teenagers [3].	• More common in school aged children and adolescents.	• More common in preschool and school aged children.	• More common in preschool and school aged children.	• More common in preschool and school aged children.	• More common in infants and toddlers.	• More common in preschool and school aged children.	• Can affect any age group depending on the underlying aetiology.	• Can affect any age group depending on the underlying aetiology which increases pro-thrombotic state.
Radiograph	• Detect vertebral fracture and bony retropulsion that narrows the bony spinal canal.	• Shows pars defects. • May require oblique views for subtle findings. • Dynamic flexion/extension views—assess degree of listhesis.	• Joint space narrowing. • Sclerosis. • Bony erosions. • Ankylosis.	• Not indicated, but a radio-dense appendicolith may be present as a clue.	• Not indicated.	• May show presence of bowel gas in the inguinal region to indicate a bowel containing hernia. • Presence of bowel dilatation may indicate strangulation.	• Psoas sign may be present (non-specific). • Not indicated usually.	• Not indicated.	• Not indicated.
Ultrasound	• Not indicated.	• Not indicated.	• Not indicated.	• Outer appendiceal diameter $\geq$6 mm. • Appendiceal mural thickening. • Appendicolith. • Peri-appendiceal free fluid. • Mesenteric nodes. • Hyperechoic surrounding fat. • Dilated bowel.	• Renal enlargement. • Altered renal echogenicity. • Loss of cortico-medullary differentiation. • Perinephric/renal collection.	• First modality of choice [5]—Confirms type of hernia and enables dynamic assessment for reducibility and strangulation (e.g., reduced bowel vascularity and pneumatosis which indicate ischemia).	• Detect superficial collections and guides window for drainage.	• Enables detection of haematoma and possible assessment of chronicity (e.g., varying echogenicity depending on temporal age).	• Non-compressibility of vein. • Absent colour flow. • Visualization of thrombus and extent. • Assessing thrombus chronicity may be possible.
CT	• Similar to radiographs. • Also, CT helps detect destructive spinal bony lesions or disc osteophytes that can narrow the bony spinal canal.	• CT has superior bony cortical resolution. • Bony displacement and fracture lines in pars defects are best depicted on CT.	• Similar to radiographic findings.	• Appendiceal mural thickening and dilatation. • Radio-dense appendicolith. • Peri-appendiceal inflammatory fat stranding. • Complications: perforation, peri-appendiceal abscess, ascending hepatic abscess, mesenteric venous thrombosis.	• CT is superior in assessing for secondary signs/definitive diagnosis and complications [4]. • Foci of hypoenhancing cortical regions. • Perinephric stranding. • Gerota fascia thickening. • Abscess formation.	• Enables assessment of involved mesenteric vessels and bowel segments in complicated hernias. • Enables better definition of hernia contents or anatomical relations, particular if the hernia is large—aids in pre-operative planning. • Useful in distinguishing between hernia types and from other mimicking pathologies.	• Evaluate for abscesses and extent. • Evaluate for possible aetiology (e.g., adjacent appendicitis, osteomyelitis).	• Enables further evaluation of size, extent, and complications. • Detects other sites of haematomas (if a systemic cause is suspected).	• Indicated if evaluating for underlying suspected aetiology such as a tumour or vascular compression syndromes e.g., May thurner syndrome (rare in children). • CT is useful to assess for presence of distal emboli, e.g., pulmonary emboli, and associated complications such as end organ infarcts.
MRI	• Detects site of compression, cord oedema/myelomalacia. • Characterises spinal cord lesions.	• Soft tissue & ligamentous injuries. • Intervertebral disc herniation.	• Bone marrow oedema. • Synovitis. • Capsulitis. • Enthesitis. • Bony erosion and sclerosis.	• Not indicated usually, unless in pregnant patients.	• Not indicated usually.	• Not indicated usually.	• Useful for delineating full extent of abscess as well as assessing for features of concomitant osteomyelitis and septic arthritis.	• Evaluation of associated soft tissue injuries (e.g., oedema, muscle tear, haematoma).	• Mainly to stage or characterize tumours, if detected.

MRI, magnetic resonance imaging; CT, computed tomography.

turbances, and prior interventions [2]. Awareness of risk factors such as malignancy, infection, inflammatory disorders, coagulopathies, and prior surgery helps narrow the differentials.

Red-flag symptoms including persistent pain unrelated to movement, a palpable mass, anorexia, weight loss, or neurological deficits should prompt further imaging to evaluate for malignancy or spinal disease. Systemic conditions such as leukaemia, lymphoma, or metastatic disease should be considered in cases of bilateral or diffuse bone pain.

Imaging Techniques

Imaging strategies should be tailored accordingly: ultrasound and radiographs are typically first-line across all age groups, with cross sectional imaging reserved for inconclusive cases or suspected deeper pathology. Magnetic resonance imaging (MRI) is invaluable for assessing marrow, joints, and soft tissues.

Conventional radiography with anteroposterior and lateral or frog-leg views remains the initial imaging modality of choice in the evaluation of hip pain to exclude gross bony pathologies such as fracture, osteonecrosis or bony lesions. Both hips should routinely be imaged for comparison for asymmetry [6]. Normal radiographic findings however do not exclude underlying significant pathologies and should not delay further imaging evaluation in the presence of persistent symptoms.

Ultrasound (US) is a preferred imaging modality in paediatrics due to its accessibility, absence of ionising radiation, and ability to provide real-time dynamic assessment. In infants, it offers the unique advantage of visualising predominantly cartilaginous bony structures that are not yet ossified and thus poorly seen on radiographs. This makes US particularly useful for early evaluation of the hip. US is highly sensitive in detecting joint effusions, synovial thickening, and musculotendinous injuries [7]. Beyond the musculoskeletal system, it is also valuable for evaluating acute extra-articular causes of hip pain, such as appendicitis, inguinal hernias, and deep venous thrombosis.

Cross-sectional imaging should be reserved for cases where initial radiographs or ultrasound are inconclusive. Computed tomography (CT), while used sparingly in paediatrics due to radiation concerns, can be helpful in specific situations, such as detecting occult fractures, evaluating complex bony lesions, assessing for appendicitis not visualized on ultrasound, or identifying complications of inguinal hernias (e.g., strangulation).

Magnetic resonance imaging (MRI) is the gold standard for evaluating soft tissue and bone marrow abnormalities, especially in suspected infection/inflammation (e.g., osteomyelitis, sacroiliitis), marrow-infiltrative or neoplastic conditions. Fluid-sensitive sequences are particularly effective for detecting marrow oedema in early disease. At least one sequence with a wide field of view covering the pelvis and both hips is recommended to enable comparison of both sides and to assess for inflammatory conditions arising from the sacroiliac (SI) joints or spine, which can cause referred hip pain [6]. MRI is also useful for identifying alternative intra-abdominal or pelvic causes, such as appendicitis or psoas myositis. Whole-body MRI is increasingly used to detect multifocal disease and shows comparable sensitivity to nuclear medicine studies. However, its role in children is limited by long acquisition times and the frequent need for sedation or anaesthesia [8].

Nuclear medicine studies play a key role in children with suspected systemic or multifocal pathology such as leukaemia, chronic recurrent multifocal osteomyelitis (CRMO), or metastatic disease [9]. Bone scintigraphy using technetium-99m aids in evaluating multifocal skeletal involvement, while fluorodeoxyglucose—positron emission tomography—computed tomography (FDG-PET-CT) is used in oncologic settings to assess metabolic activity, disease burden, and guide biopsy or treatment planning. These modalities can complement MRI and may be particularly valuable when marrow infiltration, multifocal bone pain, or constitutional symptoms are present.

3. Spinal and Sacroiliac Joint Pathologies

3.1 Spinal Cord/Nerve Compression

Referred hip pain due to spinal cord or nerve compression is often a neurosurgical emergency. In children, the most common non-traumatic cause of cord compression is spinal neoplasms, which may be benign or malignant [10]. Acute spinal cord or cauda equina compression affects 3% to 5% of children with cancer [11]. Patients often present with back pain exacerbated by movement, with radiation to the buttocks, hips or legs. Severe cases may exhibit neurological deficits, including limb weakness, numbness, or bladder and bowel dysfunction. Gait abnormalities or frequent falls may be present. On examination, coordination difficulties and, in chronic cases, muscle atrophy may be evident. Presence of associated systemic symptoms such as weight loss, night sweats, and fatigue, may indicate malignancy.

MRI is the modality of choice for evaluating discovertebral and cord pathologies in children [12], with a reported sensitivity and specificity of 93% and 97% respectively for diagnosing metastatic cord compression [13]. It allows direct visualization of the compression site, detection of spinal cord injury (e.g., cord oedema or myelomalacia), identification of underlying aetiologies such as tumours or extrinsic disc compression as well as assessment of disease extent and spinal canal narrowing. Detailed imaging features of intramedullary tumours vary by pathology and are beyond the scope of this review.

Figs. 2,3 illustrate two distinct cases of spinal cord compression presenting with hip pain and numbness: traumatic posterior disc protrusion and an intradural extramedullary tumour detected only on MRI. The latter un-

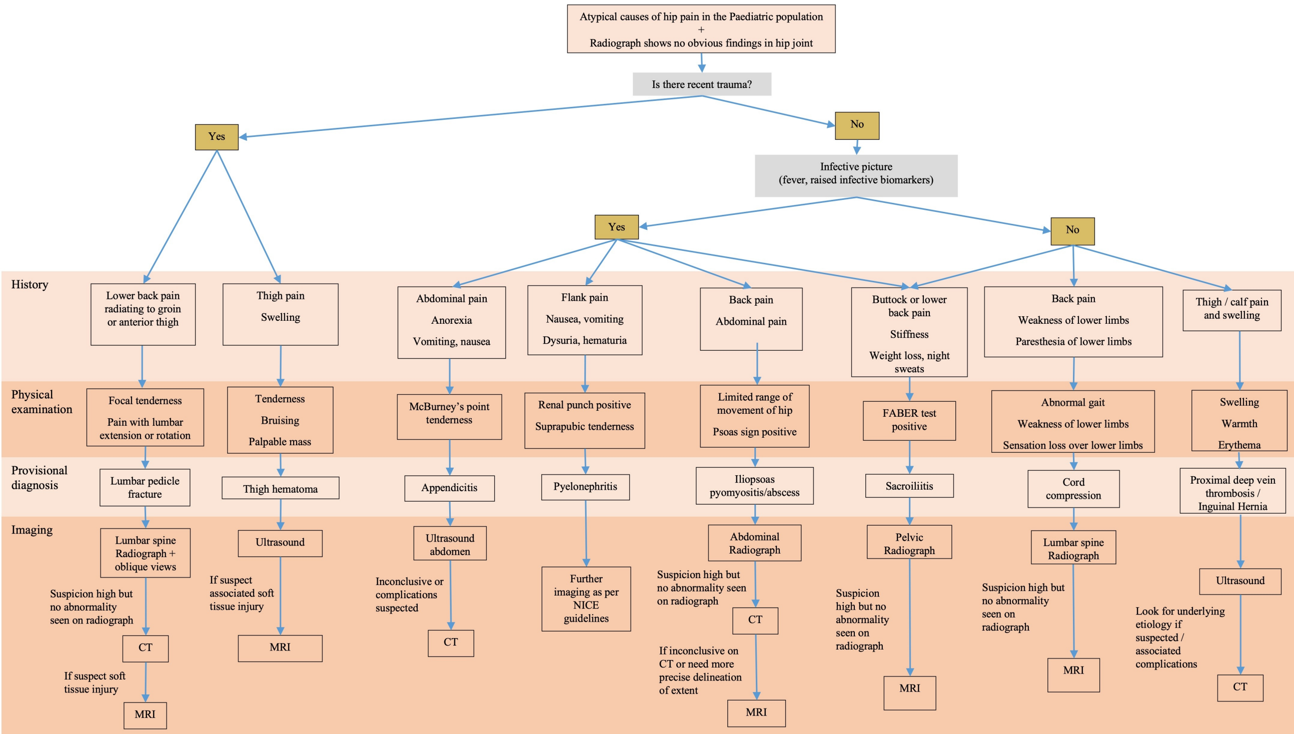

Fig. 1. Clinico-radiological approach to atypical causes of paediatric hip pain. This flowchart provides a simplified stepwise approach to guide clinicians and radiologists in the systematic evaluation of atypical paediatric hip pain, integrating clinical findings with appropriate imaging pathways. This figure was created by the authors using Microsoft PowerPoint 2025 (Microsoft Corporation, Redmond, Washington, USA) based on institutional practice and experience. MRI, magnetic resonance imaging; CT, computed tomography; FABER, Flexion, Abduction, External Rotation.

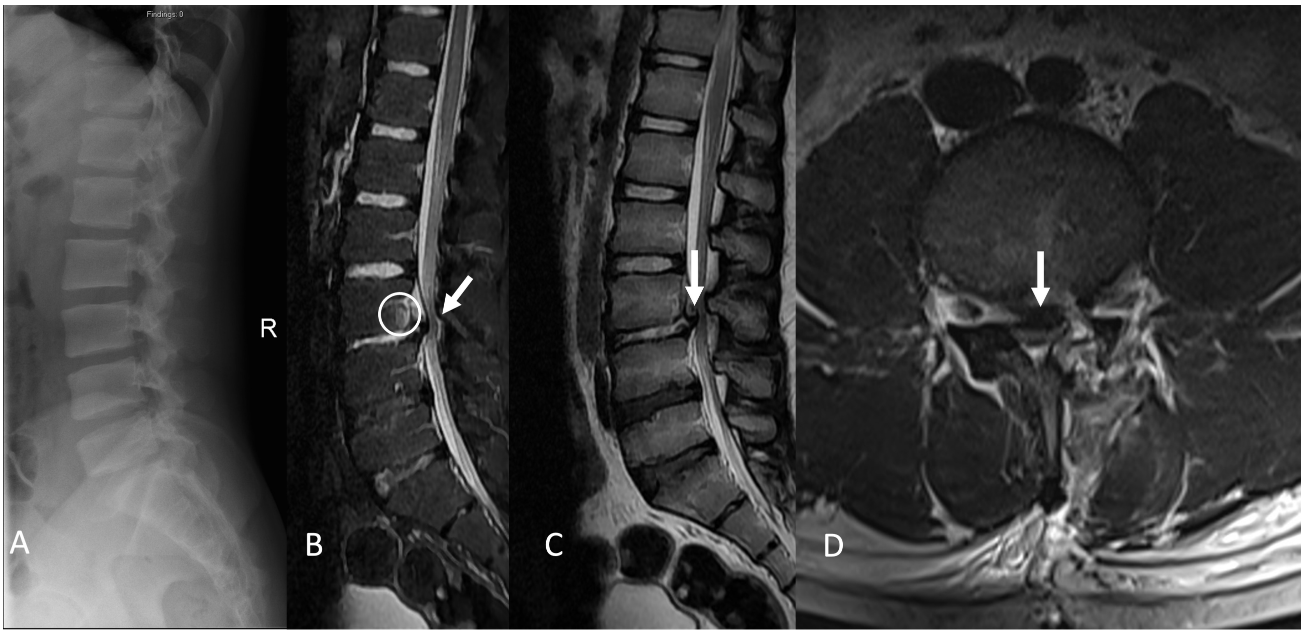

Fig. 2. Traumatic posterior disc protrusion causing cauda equina compression. 15-year-old male with a lower back injury after a road traffic accident, presents with radicular pain and limb weakness. Lumbar spine radiograph (A) was unremarkable. Sagittal short tau inversion recovery (STIR) (B), sagittal (C), and axial T2-weighted (D) MRI sequences show posterior protrusion with superior migration of the L3/L4 disc (white arrows), compressing the cauda equina. Mild L3 height loss with marrow oedema (white circle, B) suggests a recent mild compression fracture. Longitudinal ligaments are intact. R, right.

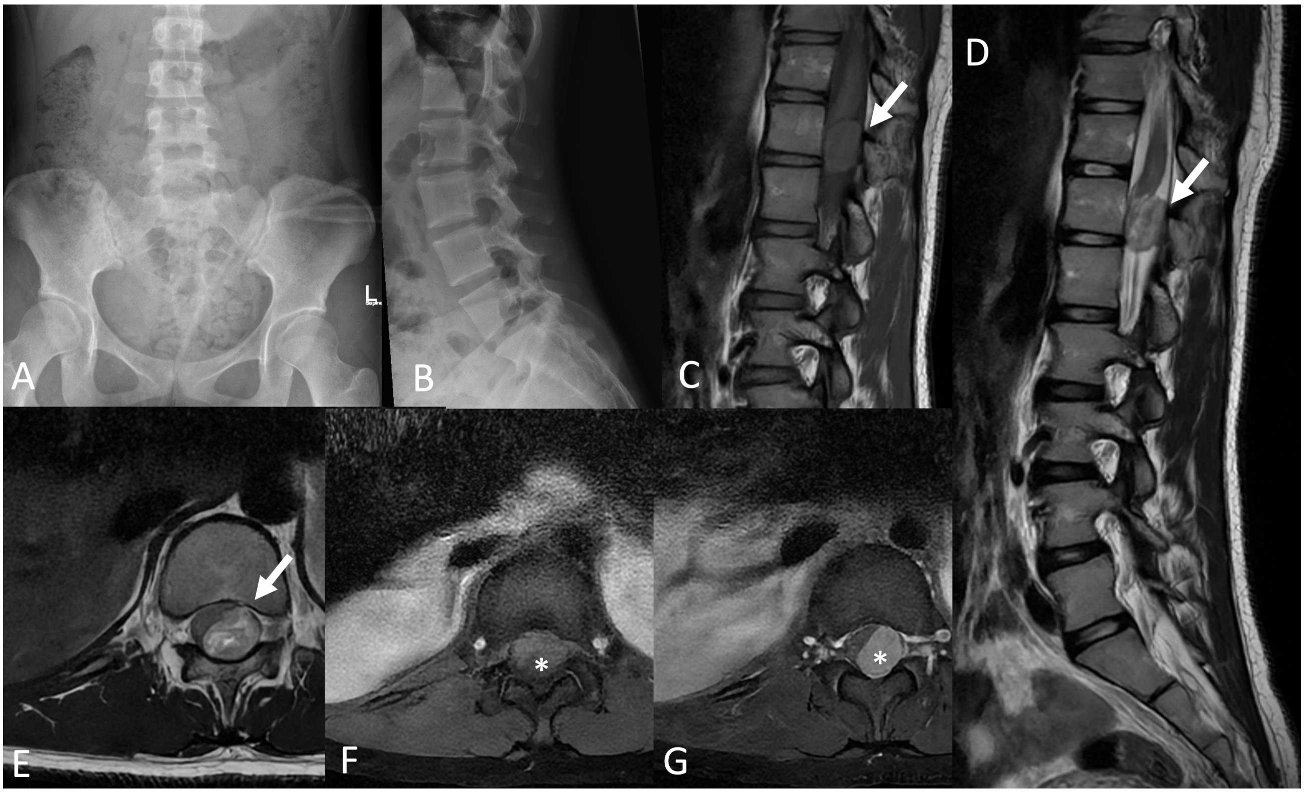

Fig. 3. Intradural extramedullary spinal tumour presenting as hip pain. 16-year-old female presenting with 6 weeks of lower back, hip and leg pain as well as intermittent paraesthesia, made worse with left hip flexion and knee extension. Lumbar spine radiographs (A,B) were normal. Sagittal and axial magnetic resonance (MR) images reveal a circumscribed intradural extramedullary spinal mass extending from T12 to L1 vertebral level showing T1w isointense (C), T2w intermediate signal (D,E) relative to spinal cord with internal heterogeneity (white arrows). The lesion showed homogeneous avid enhancement on the axial post contrast T1-weighted fat-suppressed (T1wFS) sequence (G) relative to its pre-contrast sequence (F) (*). This lesion was histologically confirmed to be a clear cell meningioma. L, left.

derscores the importance of maintaining a high index of suspicion.

Given the risk of permanent neurological deficits, spinal cord compression necessitates prompt intervention, typically through surgical decompression [14] and management of the underlying aetiology.

3.2 Vertebral Injuries

Vertebral fractures, particularly those involving the facet joints, pedicles or pars interarticularis of the lumbar spine with associated listhesis [15], can present with symptoms of radiculopathy due to compression or irritation of the lumbosacral nerve roots [16]. Lumbar spondylolysis is more common in athletic adolescents, with a reported prevalence of 39.7% in patients under 19 years of age with persistent low back pain [17]. These injuries often result from repetitive stress or high-energy trauma, such as sports injuries or falls. The pain may be localized to the lower back but can also radiate to the groin or anterior thigh, mimicking primary hip pathology. Sharp shooting leg pains may be exacerbated with activities that involve back extension.

Plain radiographs are typically the first imaging modality used to evaluate for spondylolysis, but their sensitivity is limited and lesions may be missed, especially in acute cases, with a reported maximum sensitivity of 75% [18,19]. CT and MRI offer higher sensitivity (approximately 80–85%) and better diagnostic reliability [19]. CT is widely regarded as the gold standard for detecting pars interarticularis defects due to its superior depiction of fracture lines and bone detail, although no universal consensus exists [18]. MRI (Fig. 4) matches CT in detecting established fractures and has the added advantage of identifying early stress reactions such as bone marrow oedema without radiation exposure. However, small defects may be missed on MRI, with studies reporting miss rates of between 25% to 64% [20] compared to CT.

Delayed diagnosis increases the risk of non-union, leading to chronic pain and functional impairment, with some cases requiring surgical intervention. Management is largely dependent on spinal stability, aetiology, and clinical status. Most patients with spondylolysis or stable fractures can be managed conservatively with analgesia, activity modification, bracing, and physiotherapy to support

Fig. 4. Lumbar pars defects in an adolescent with chronic hip pain. 15-year-old female with chronic lower back and bilateral hip pain, made worse with bending. Straight leg raise test was negative. Initial hip radiographs were normal. Lateral lumbar spine radiograph (A) shows pars interarticularis defects at L3 and L5 (white arrows). MRI (B–D) confirms left L3 and left (C) and right (D) L5 pars defects with mild surrounding marrow oedema (white circles), suggesting recent injury. No significant listhesis was present.

early mobilization and core strengthening. Surgical interventions are reserved for cases of unstable fractures, at least grade 3 spondylolisthesis or progressive neurological symptoms [21].

3.3 Sacroiliitis

Sacroiliac joint inflammation is an important differential diagnosis for hip pain in children. It may result from mechanical stress (e.g., contact sports, overuse, or repetitive microtrauma) or underlying rheumatologic conditions such as juvenile idiopathic arthritis, ankylosing spondylitis, and psoriatic arthritis [22]. Infective sacroiliitis is less common and occurs via haematogenous spread from distant infections or direct extension from adjacent osteomyelitis, abscesses, or trauma [23]. While a rare cause of septic arthritis in children, sacroiliitis is common in paediatric spondyloarthropathy, affecting up to 78% of cases [24]. Fig. 5 depicts an uncommon case of infective sacroiliitis following acupuncture, emphasizing the need to elicit prior treatment history, including iatrogenic causes.

Children typically present with buttock or lower back pain radiating to the groin or thigh, often mimicking hip pathology. Systemic symptoms such as weight loss and night sweats may be reported. Clinical signs include antalgic gait, limited hip mobility, and a positive FABER (Flexion, Abduction, External Rotation) test [25].

Early sacroiliitis may not be apparent on radiographs, though progressive disease can manifest as joint space narrowing, erosions, and sclerosis with variable sensitivity (25–77.8%) and specificity (60.8–92.2%) [26]. CT better depicts bony structural changes with a 60% sensitivity and 84% specificity [27]. MRI is however, the preferred modality, as it can reveal bone marrow oedema, synovitis, and capsulitis [28], with a reported sensitivity and specificity of about 90% for axial spondylo-arthritis and related disorders [29]. Posterior extracapsular oedema with periarticular soft tissue involvement and fluid collections are highly specific for pyogenic sacroiliitis [30,31].

Management depends on the underlying cause and may involve rest, physical therapy, and anti-inflammatory medications, with antibiotics or abscess drainage required in infectious cases [32]. Rheumatologic cases are managed with disease-modifying antirheumatic drugs, short-term corticosteroids, and intra-articular injections. Refractory cases may require biologics, interventional procedures, or rarely, surgical fusion [25,33].

4. Abdominal and Inguinal Pathologies

4.1 Appendicitis

Appendicitis is the commonest paediatric surgical emergency, with a lifetime risk of 12–25%. Annually, up to 250,000 cases of appendicitis are reported, peaking in the second decade of life, typically between ages 10 and 19 [34]. Acute appendicitis should be considered in paediatric hip pain, especially with a retrocecal appendix, which can irritate the iliopsoas muscle, causing referred pain or even a fixed flexion deformity. Classic symptoms include periumbilical pain migrating to the right lower quadrant (RLQ), nausea, vomiting, anorexia, and fever. Clinical signs include RLQ tenderness at McBurney's point, guarding if peritonitis is present, and positive psoas (pain with passive

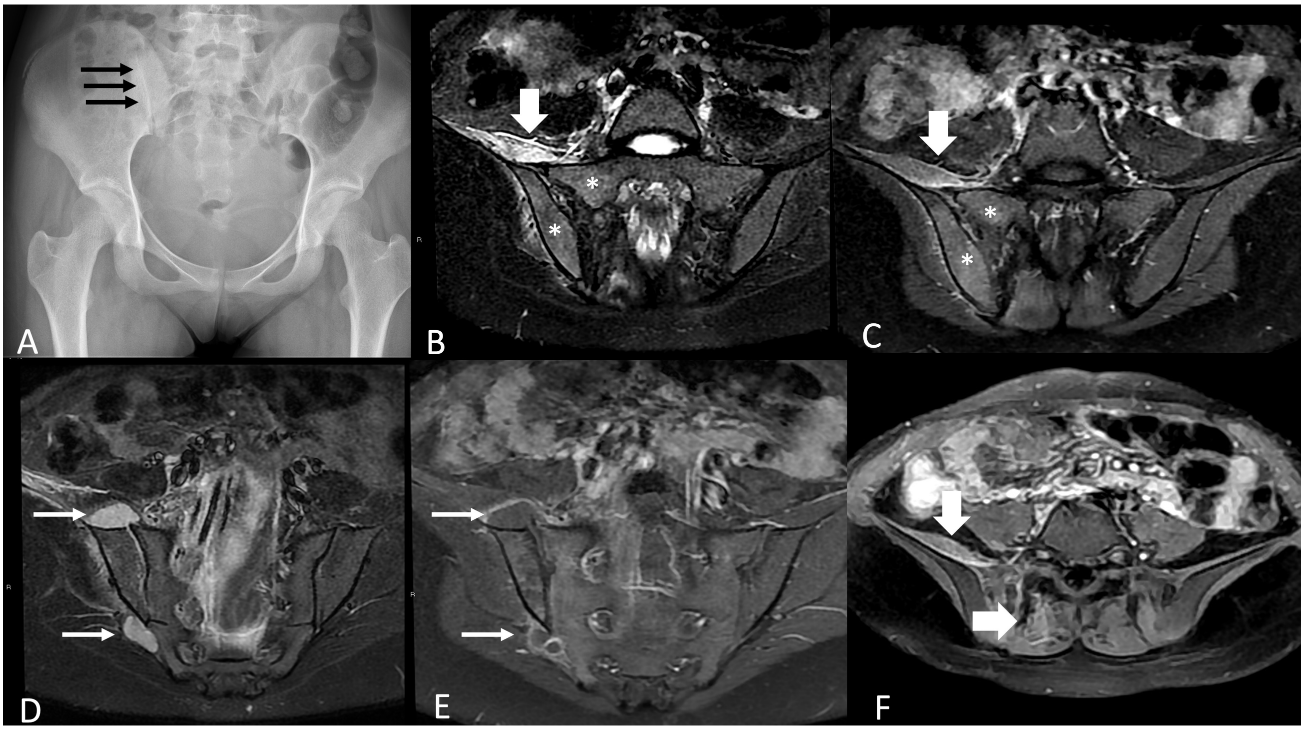

Fig. 5. Infective sacroiliitis with periarticular abscesses post-acupuncture. 16-year-old female with acutely worsening right lower and gluteal back pain with fever post-acupuncture therapy. Her pelvic radiograph (A) showed mild right sacroiliac joint space narrowing with mild subchondral sclerosis (black arrows). MRI showed patchy marrow oedema around the right sacroiliac joint on coronal T2-weighted (T2w) short tau inversion recovery (STIR) (B) with corresponding enhancement on (*) coronal T1-weighted (T1w) fat saturated post contrast images (C), consistent with sacroiliitis. Surrounding loculated fluid collections (D) showing rim enhancement (E) are also noted decompressing from the right sacroiliac joint, suspicious for periarticular abscesses (thin white arrows). MRI images also show features of myositis involving the right iliacus on coronal sequences (B,C) and quadratus lumborum on axial sequence (F) (thick white arrows).

right hip extension) and obturator (pain with right hip rotation) signs, indicating inflammatory irritation of the iliopsoas and obturator muscles. These signs have high specificities of 97% and 94%, respectively for detecting appendicitis [35].

On radiographs, the presence of a right iliac fossa radio-dense appendicolith with right psoas muscle shadow enlargement may be helpful clues. However, ultrasound is the first-line imaging modality for suspected appendicitis in children with a 97% sensitivity and 95% specificity [36] in 92% of visualized appendices. Key sonographic findings include an outer appendiceal diameter $\geq$6 mm, mural thickening, and an appendicolith [37]. Ancillary findings, such as peri-appendiceal free fluid, mesenteric lymphadenopathy, echogenic surrounding fat, and dilated, hypoactive bowel loops, can support the diagnosis, even when the appendix is not directly visualized. An important limitation of US is that it is highly operator dependent and can have a low sensitivity in diagnosing perforated appendicitis [38]. Fig. 6 illustrates these sonographic clues, later confirmed on CT.

CT is mainly reserved for cases with inconclusive ultrasound findings or suspected complications. CT features of appendicitis include appendiceal wall thickening, hyperenhancement, and peri-appendiceal inflammatory changes [39], with a reported sensitivity of 94% and specificity of 95% [40]. MRI is a second-line, radiation-free option, demonstrating a high sensitivity of 90.6% and specificity of 97.7% for appendicitis [41].

Early diagnosis is essential to prevent complications such as perforation, peri-appendiceal abscess, or hepatic abscess due to ascending infection along the mesenteric–portal venous system [42]. Management of appendicitis depends on presentation [43,44]. While appendectomy remains standard for acute cases, non-operative treatment with antibiotics is increasingly accepted for selected patients, despite recurrence risk [45,46]. Complicated cases (e.g., perforation with abscess or phlegmon) often require IV antibiotics, percutaneous drainage, and delayed appendectomy [47].

4.2 Pyelonephritis

Similarly, ascending urinary tract infections (UTIs) leading to pyelonephritis can present atypically as hip pain, often due to referred pain from the inflamed kidney or irritation of the adjacent psoas muscle. An estimated 7% of

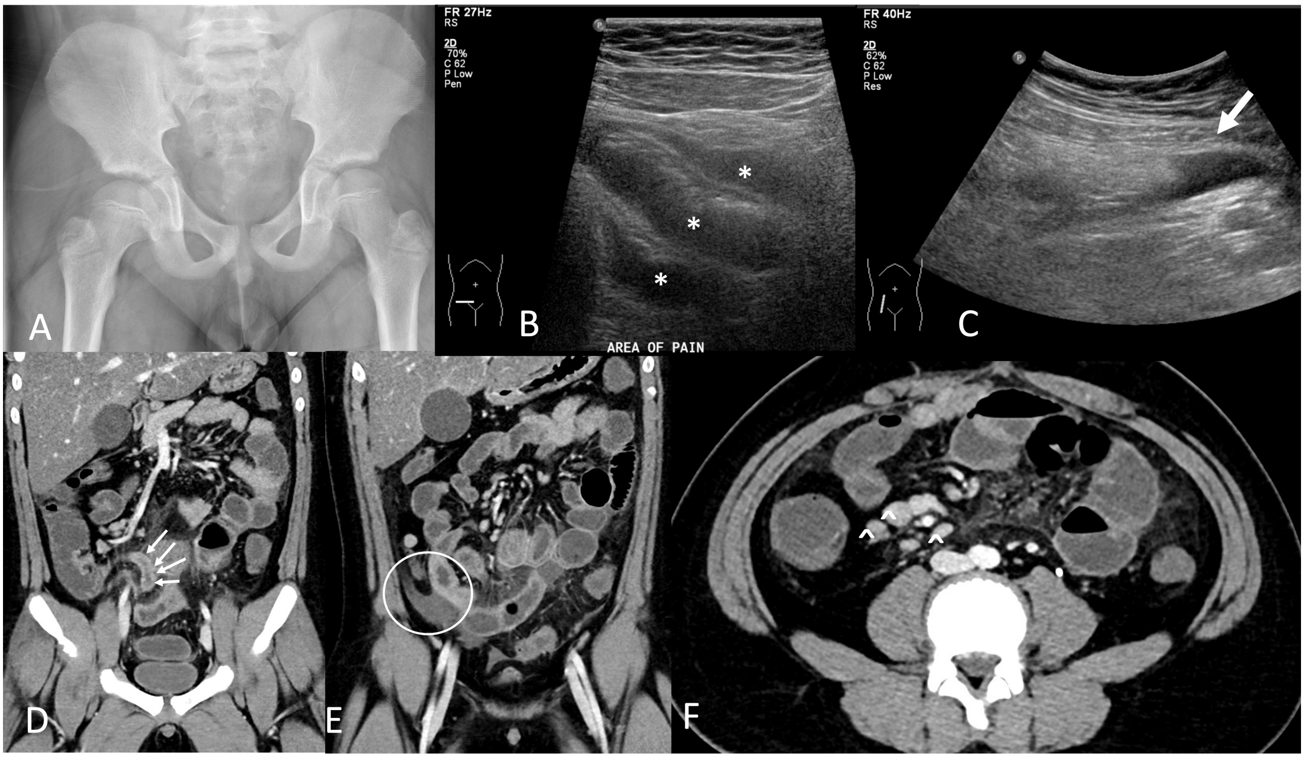

Fig. 6. Acute appendicitis mimicking hip pain on ultrasound and CT. 9-year 5-month-old boy with fever, right lower abdominal and hip pain, and raised inflammatory markers. Pelvic radiograph (A) was unremarkable. Targeted abdominal ultrasound (B,C) shows dilated small bowel loops (*) and adjacent echogenic fat with free fluid (white arrow, C). CT (D–F) confirms acute appendicitis with peri-appendiceal fat stranding (white arrows, D), reactive ileal thickening (white circle, E), and reactive ileocolic nodes (^ in F). No perforation or abscess.

girls and 2% of boys develop UTI by the age of 6, with pyelonephritis being a severe form of UTI [48]. While fever, flank pain, and urinary symptoms such as dysuria and frequency are common in older children, younger patients may exhibit more subtle signs, including irritability, poor feeding, and vomiting. Clinical examination may reveal a positive renal punch test (costovertebral tenderness), suggesting upper urinary tract involvement [49].

Urinalysis and urine culture remain the primary diagnostic tools, but imaging is essential to assess renal involvement and complications. The National Institute for Health and Care Excellence (NICE) recommends imaging in paediatric UTIs based on age and clinical presentation [50]. Ultrasound is the first-line modality, often revealing renal parenchymal changes such as focal or diffuse enlargement, altered echogenicity, loss of corticomedullary differentiation, and poorly defined renal sinus [51]. Dimercaptosuccinic acid scintigraphy is useful for detecting renal parenchymal defects and scarring [52], while a micturating cystourethrogram may be indicated for evaluating bladder and urethral abnormalities (e.g., vesicoureteral reflux, posterior urethral valves), particularly in recurrent infections [53].

CT is useful in assessing complications such as perinephric collections, thickening of Gerota's fascia, and renal abscess formation [4]. It also enables evaluation of psoas muscle involvement, which can contribute to hip pain. MRI is rarely indicated in this setting. Fig. 7 illustrates a case of left pyelonephritis complicated by a renal abscess, presenting as hip pain with probable psoas involvement. Recognizing ascending UTIs as a potential musculoskeletal mimic is crucial for accurate diagnosis and timely intervention, reducing the risk of long-term complications such as renal scarring, hypertension, and chronic kidney disease [54].

Antimicrobials are the mainstay of pyelonephritis treatment with choice of antibiotics depending on local resistance and clinical presentation. Intravenous antibiotics and hospitalization are reserved for severely ill or vomiting children. Long-term care includes monitoring for renal scarring and evaluating for urinary tract anomalies [55].

4.3 Inguinal Hernia

Inguinal hernias, though often considered a straightforward surgical diagnosis, can present as atypical referred hip and groin pain, particularly when there is entrapment of the ilioinguinal or genitofemoral nerves [56]. This is particularly relevant in cases of small or occult hernias that lack an obvious groin bulge. Inguinal hernias can affect 1% to 5% of term infants [57]. Clinically, these hernias may

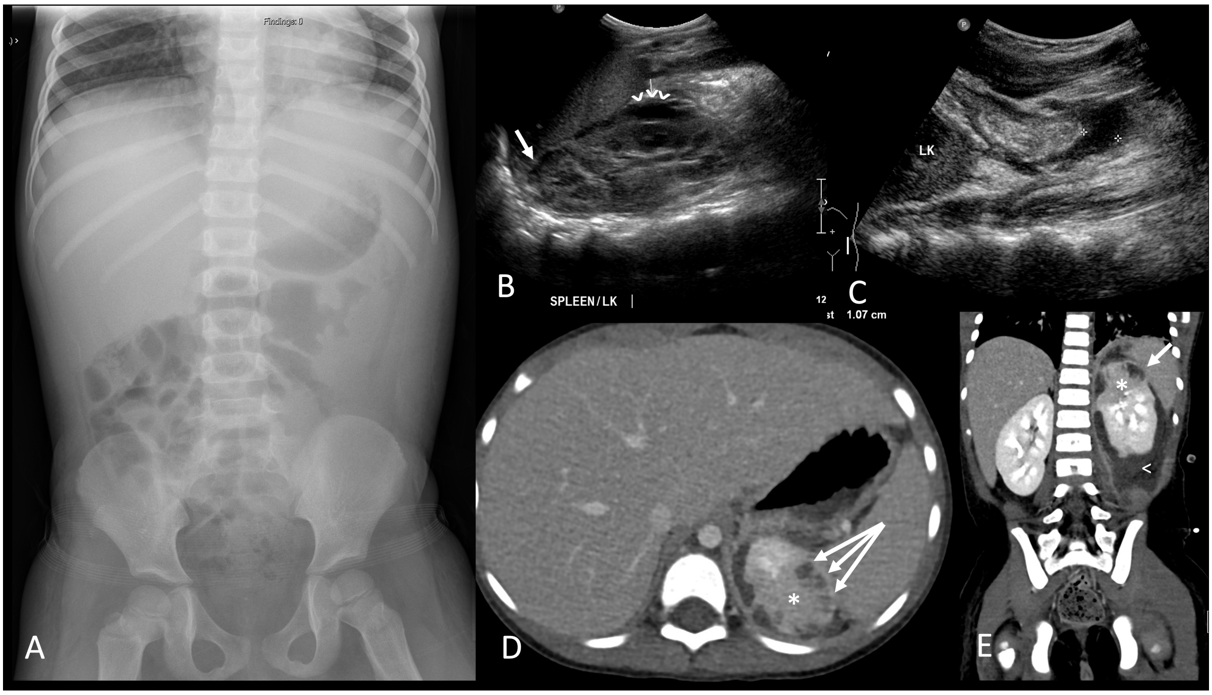

Fig. 7. Left pyelonephritis with renal abscess and psoas involvement. 4-year 5-month-old girl with acute left hip and flank pain. Abdominal radiograph (A) including the hips was normal. Abdominal ultrasound (B) showed left renal upper pole enlargement with increased parenchymal echogenicity (white arrow). Perinephric fluid with internal echoes (white chevrons in B) was also present tracking down along the left posterior pararenal space (C), with increased echogenicity of surrounding fat suggestive of inflammation. Further axial (D) and coronal (E) contrast enhanced CT reveals a focal hypo-enhancing left renal upper pole cortex (*) with several subcentimetre hypodensities within (white arrows) and extensive perinephric fluid (<). Overall findings were consistent with left pyelonephritis complicated by renal microabscesses and perinephric collection. The left psoas muscle was also mildly inflamed.

mimic musculoskeletal or orthopaedic conditions. Incarcerated or strangulated hernias can further complicate the presentation, resulting in acute groin or lower abdominal pain radiating to the hip, sometimes accompanied by nausea or vomiting.

Ultrasound is the primary imaging modality, capable of detecting herniated bowel loops or omental fat within the inguinal canal, often with dynamic assessment revealing exaggerated peristalsis or impaired vascularity on Doppler in cases of strangulation [5]. It has detection rates of 95–97% when using criteria such as an internal inguinal ring width greater than 4 mm or the presence of fluid or organs within the canal [58]. Fig. 8 demonstrates sonographic features of an uncomplicated inguinal hernia. CT is useful when the diagnosis is unclear, as it delineates groin anatomy and helps identify other causes of groin masses or complicated hernias. It detects inguinal hernias with 80% sensitivity and 65% specificity and also better depicts features of bowel ischemic change [59]. MRI offers a higher sensitivity of 95% and specificity of 96% but is costly and less accessible, hence rarely used for routine diagnosis. When indicated, MRI can help differentiate sports-related injuries from inguinal hernias [59].

Timely recognition is crucial, as delayed diagnosis increases the risk of bowel ischemia, necessitating emergent surgical repair. Surgical repair, either via open herniotomy or laparoscopic repair, is the definitive treatment for inguinal hernias [60].

5. Muscular Pathologies Outside the Hip

Pyomyositis and Abscess Formation

Pyomyositis is an acute skeletal muscle infection that may lead to abscess formation. Iliopsoas involvement is a notable cause of atypical hip pain, most commonly affecting boys aged 5 to 9 years [2]. Psoas abscesses are rare and often overlooked in younger, non-verbal children, with reported cases from 18 months to 14 years [61,62]. Classic symptoms of fever, limp, and back pain occur in fewer than 30% of cases [63]. While commonly associated with *Staphylococcus aureus*, other pathogens such as Streptococcus species and Gram-negative bacteria may be implicated, particularly in immunocompromised patients (e.g., malignancies, prolonged immunosuppressive therapy, or primary immunodeficiencies), often presenting with more insidious disease course and multifocal or atypical presentations [64].

The iliopsoas muscle is particularly vulnerable due to its retroperitoneal location and proximity to spread of adjacent infections such as appendicitis, pyelonephritis,

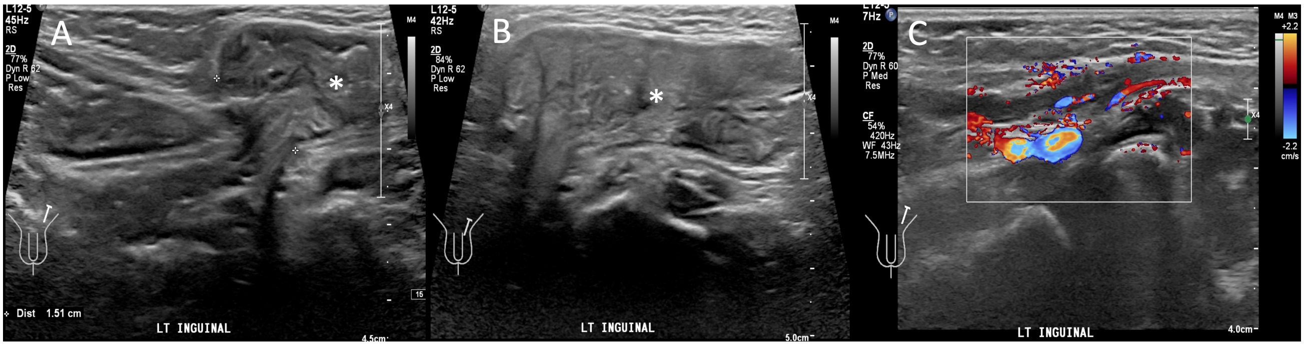

Fig. 8. Reducible indirect inguinal hernia demonstrated on ultrasound. 2-year-old boy with left groin pain and swelling, worse with straining. Targeted ultrasound (A,B) reveals a reducible left indirect inguinal hernia containing non-dilated bowel (*). Colour Doppler (C) confirms bowel wall vascularity, with no strangulation.

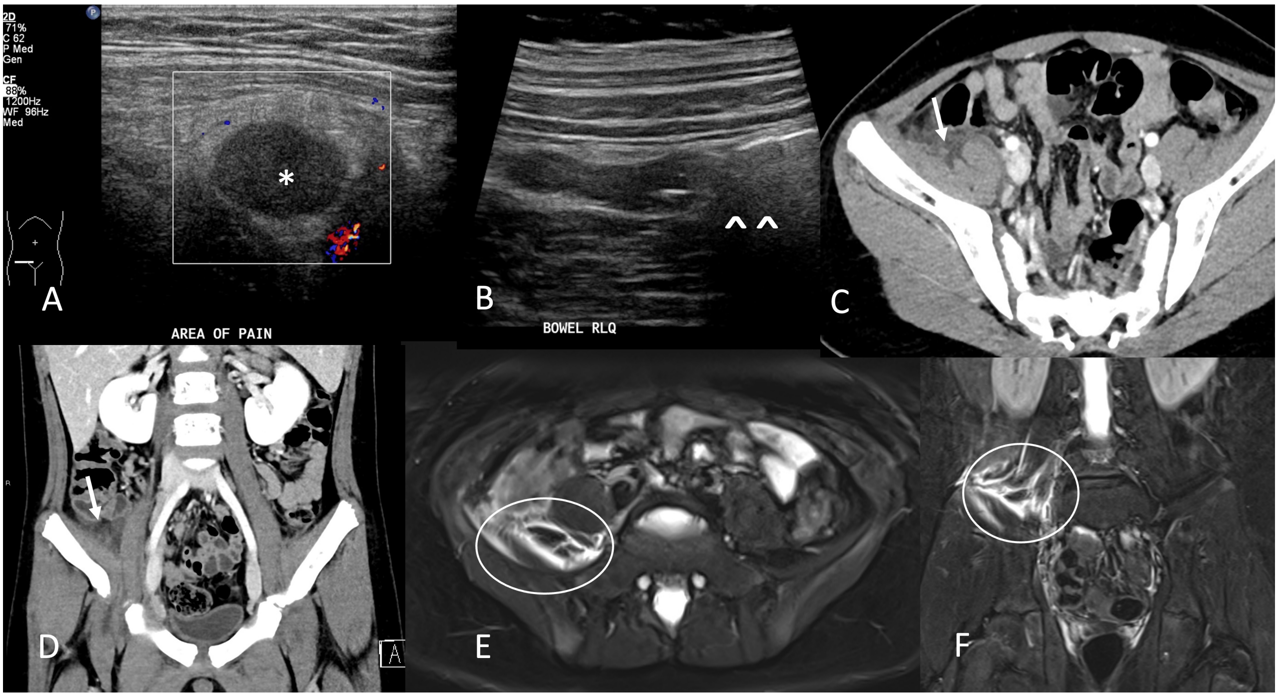

Fig. 9. Right iliopsoas myositis mimicking appendicitis. 11-year-old boy with acute right iliac fossa pain with limited hip movement. Targeted ultrasound (A) showed an enlarged mesenteric lymph node (*). The visualized adjacent appendix (B) appears normal. However, there was evidence of adjacent inflammatory change, particularly around the appendiceal tip (white chevrons in B). Contrast enhanced CT (C,D) and MRI (E,F) showed evidence of right iliopsoas myositis (white arrows in C,D) with extensive oedema and inflammatory changes in the fascial tissues surrounding the right psoas and iliacus muscles (white circles). Mild inflammatory changes surrounding the normal appearing appendix with adjacent reactive peritoneal thickening were present.

sacroiliitis, or osteomyelitis [65]. Atypical muscle group involvement in immunocompromised children can mimic conditions like septic arthritis, deep vein thrombosis or malignancy.

Radiographs have limited value in cases of pyomyositis, though the "psoas sign" (obscuration of lateral psoas margin) may raise suspicion but is nonspecific [66]. Ultrasound is limited in detecting deep collections but may aid in guiding drainage if a collection is visualized [67]. CT, although useful for detecting underlying causes, or guiding intervention, is less sensitive than MRI for marrow and soft tissue involvement [68]. Moreover, inflammation from an iliopsoas myositis presents a potential pitfall as it can mimic primary appendicitis on CT by causing reactive appendiceal wall thickening and peri-appendiceal fat stranding (Fig. 9).

MRI is the most sensitive (91.4%) imaging modality for detecting deep-seated abscesses, muscle oedema and adjacent bony involvement, guiding both medical and surgical management [69]. It also enables the assessment for associated features of osteomyelitis or septic arthritis. Figs. 9,10,11,12 illustrate iliopsoas and iliacus myositis, some with intra-muscular abscesses, in patients presenting

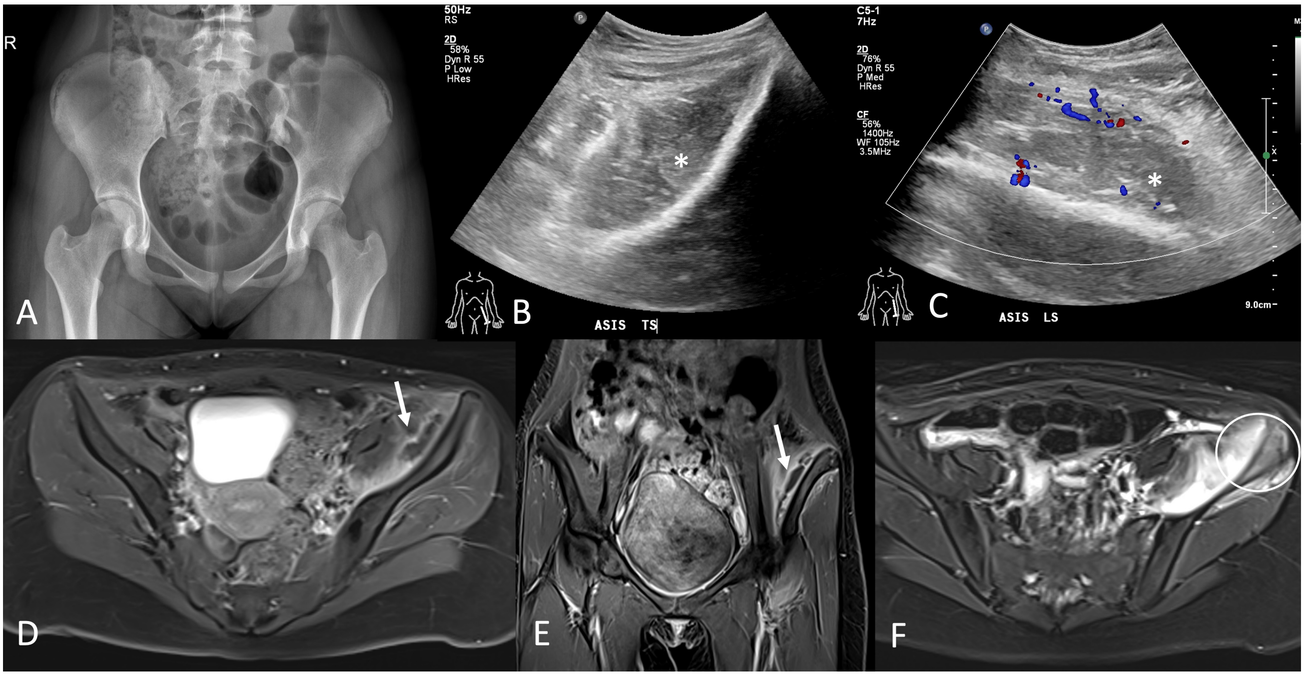

Fig. 10. Iliacus pyomyositis with intra-muscular abscess formation. 13-year-old girl with 4 days of left hip and thigh pain with fever. Pelvic radiograph (A) was unremarkable. Targeted left hip ultrasound (B,C) shows left iliacus swelling with hypervascularity and raised echogenicity (*). MRI (D–E) reveals rim-enhancing intra-muscular collections (white arrows) within the iliacus muscle. Findings are consistent with iliacus pyomyositis with abscesses. Adjacent marrow oedema in the left iliac bone (white circle, F) may indicate osteomyelitis.

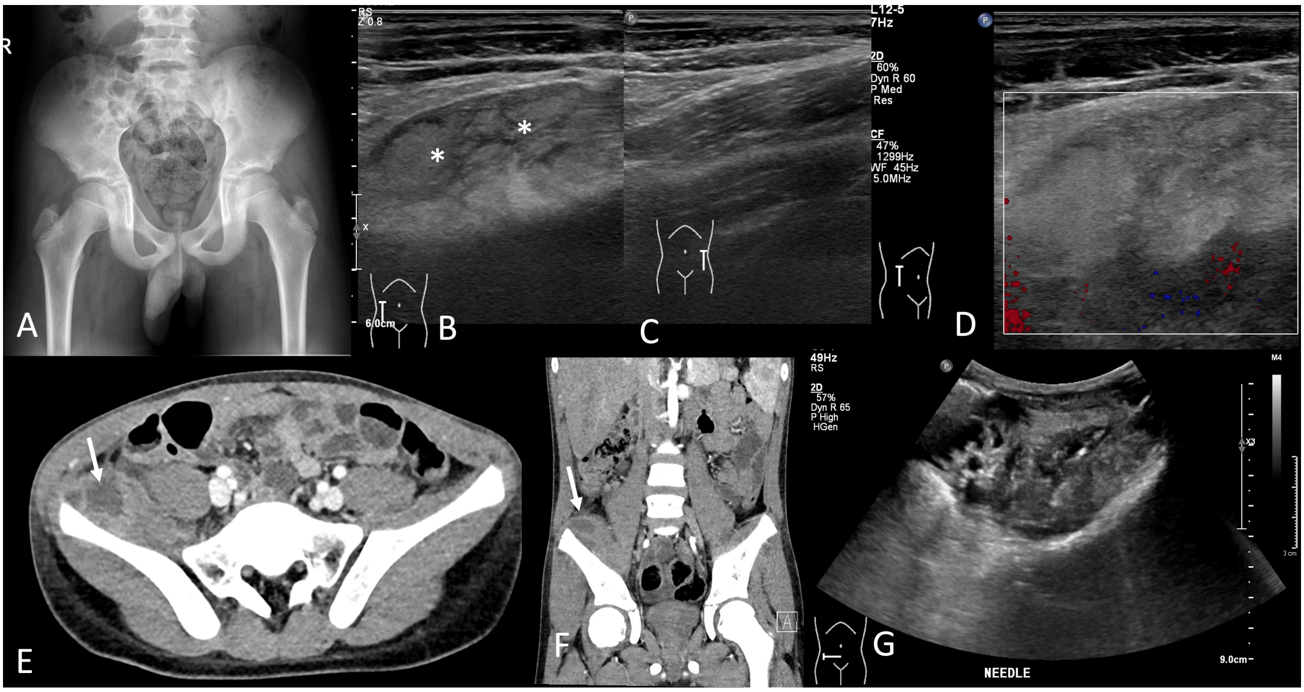

Fig. 11. Right iliacus abscess requiring image-guided drainage. 11-year-old boy with right iliac fossa and hip pain, fever, and raised inflammatory markers. Pelvic radiograph (A) was unremarkable. Targeted ultrasound (B) shows an enlarged, echogenic right iliopsoas (*) compared to its left counterpart (C) without overt hypervascularity (D). Axial (E) and coronal (F) contrast enhanced CT shows enlarged right iliacus muscle, with a rim enhancing intra-muscular hypodense abscess at its lateral aspect (white arrows). He subsequently underwent successful percutaneous drainage of abscess (G) and responded well to antibiotics. The appendix was unremarkable (not shown).

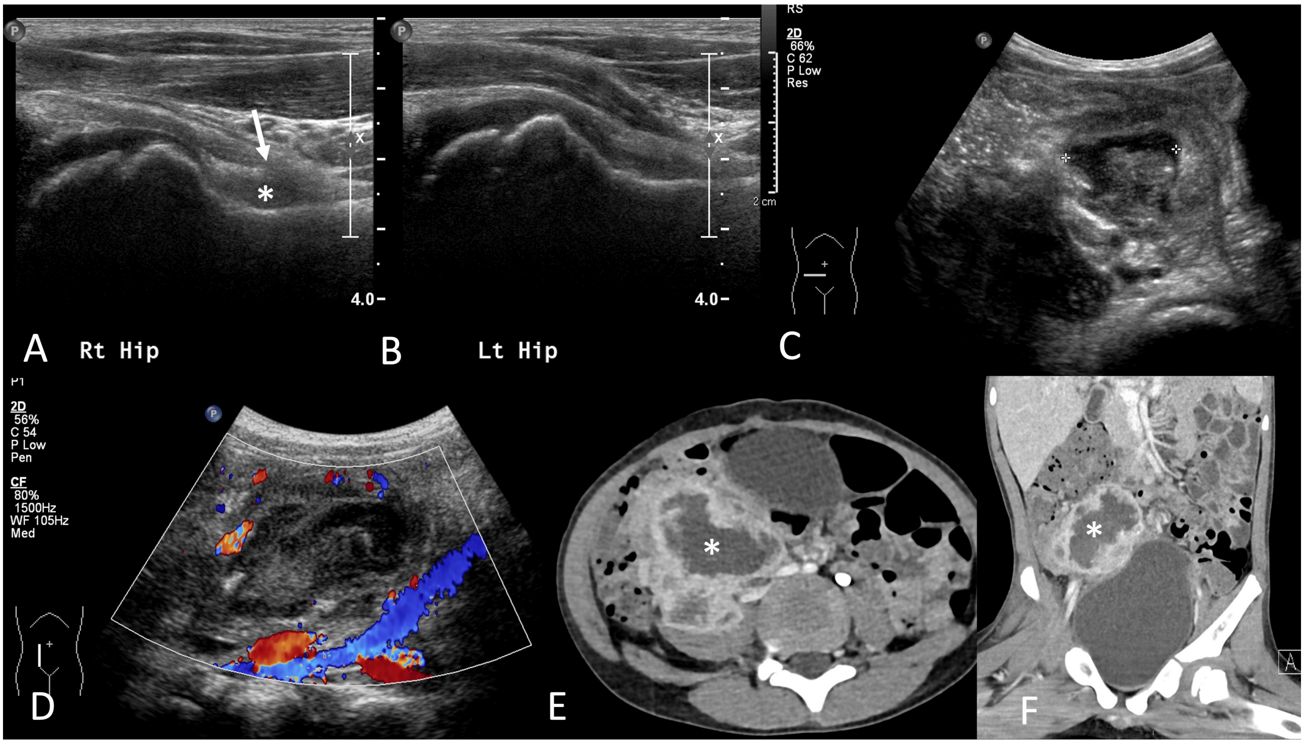

Fig. 12. Iliopsoas abscess mimicking hip septic arthritis with ureteral involvement. 6-year-old boy with fever, right iliac fossa and inguinal tenderness with hip restriction. Ultrasound of his right hip (A) show a small right hip effusion containing internal echoes (*) and mild synovial thickening (white arrow). Contralateral left hip ultrasound (B) was normal. Incidentally, in the right iliac fossa, there was a heterogeneous solid-cystic mass-like structure with marked surrounding inflammation (C) and peripheral hypervascularity (D). Contrast enhanced CT (E,F) confirms this structure to be a thick walled multiloculated rim-enhancing right iliopsoas intra-muscular abscess (*). The right ureter was involved by the collection with upstream moderate right hydroureteronephrosis (not shown). Appendix was normal.

with hip pain, showcasing the utility of multimodality imaging. Fig. 13 demonstrates an uncommon case of myositis from disseminated fungal infection affecting the bilateral short external rotator muscles in an immunocompromised child, highlighting the importance of considering deeper pelvic muscles in this vulnerable population.

Early diagnosis and prompt treatment with broad-spectrum antibiotics and, if necessary, percutaneous or surgical drainage, are essential to prevent progression to severe sepsis, disseminated infection, or chronic osteomyelitis [69,70].

6. Intra-Muscular Haematoma

Intra-muscular haematomas can be an under-recognized cause of hip pain. Whilst trauma is the most common aetiology, non-traumatic haematomas should raise suspicion for underlying bleeding disorders such as haemophilia [71], von Willebrand disease [72], or platelet dysfunction [73], particularly in cases of recurrent unexplained bruising. Patients on anticoagulation therapy are also at increased risk. Clinically, thigh haematomas present with localized pain, swelling, and bruising, often restricting hip movement due to discomfort and muscle stiffness. Given the potential for an undiagnosed coagulopathy, children with unexplained or recurrent haematomas should undergo further haematologic evaluation, including coagulation studies and platelet function tests.

Ultrasound may delineate the size and extent of the haematoma, though its appearance varies with stages of blood degradation. A CT angiogram aids in localizing an active source of bleeding with a sensitivity of 80% and specificity of 67% [74], potentially identifying a target culprit vessel for angioembolisation. MRI provides superior soft tissue characterization, particularly on fluid-sensitive sequences, where findings may include muscle oedema, a discrete haematoma (Fig. 14), and associated bone contusion, helping differentiate it from other structural causes [75].

Whilst, most haematomas resolve with conservative management, which includes rest and compression, larger or deep-seated haematomas may require further evaluation to prevent complications such as superimposed infection, myositis ossificans [74], or rarely, compartment syndrome [76]. Timely recognition of an underlying bleeding disorder is essential to guide appropriate management and prevent recurrent episodes.

Fig. 13. Disseminated pelvic fungal myositis in an immunocompromised child. 9-year-old boy with T-cell lymphoblastic lymphoma, presenting with right hip pain and fever. Initial pelvic radiograph (A) was unremarkable. MRI (B,C) shows evidence of oedema and swelling of the bilateral short external rotator muscles of the hip, right more than left (*). T1-weighted fat-suppressed (T1wFS) pre-contrast (D) and post-contrast (E) images confirm muscle enhancement in the bilateral short external rotator muscles of the hip (* in E), consistent with myositis. This was due to underlying disseminated fungal infection (aspergillosis) in an immunocompromised patient. There was no intra-muscular abscess or osteomyelitis.

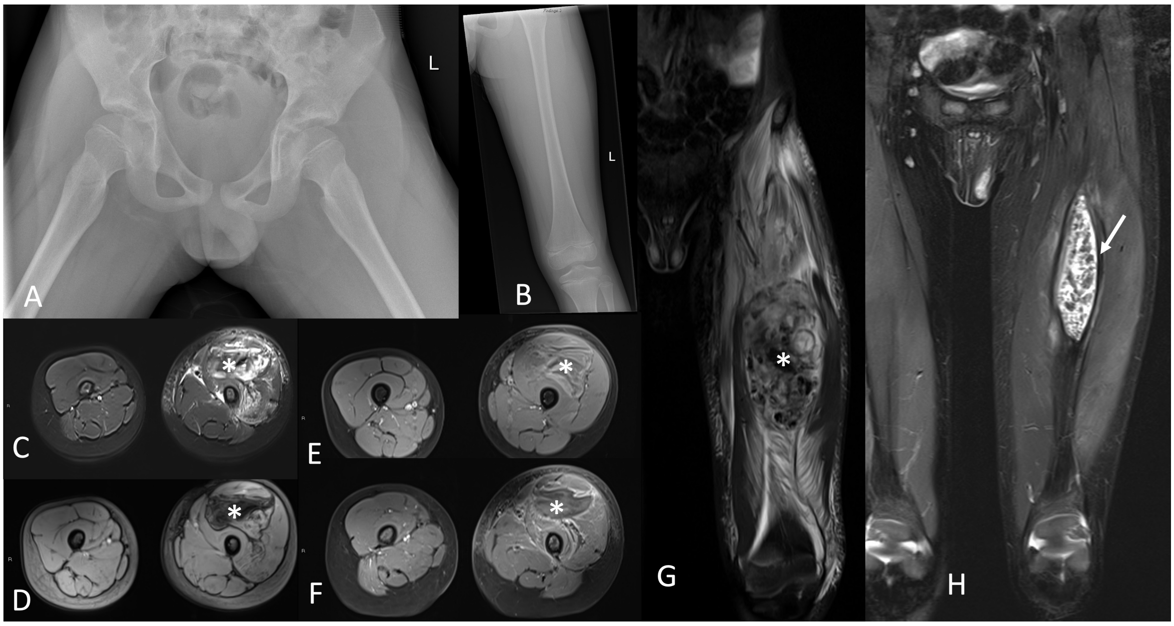

Fig. 14. Intermuscular thigh haematoma in a child with undiagnosed haemophilia. 9-year 3-month-old boy with acute left hip and thigh pain after a fall. His pelvic and left femur radiographs (A,B) show left thigh soft tissue swelling without bony fracture. Further evaluation with MRI revealed a large intermuscular heterogeneous mass in the left mid-thigh appearing iso-to-hyperintense on T2w fat saturated sequences (* in C) with associated susceptibility on Gradient Echo (GRE) sequences (* in D). Pre-contrast (E) and post-contrast (F) T1wFS images show mild peripheral enhancement of the lesion (* in E and F). Extensive intermuscular/interfascial fluid was also noted in the left thigh anterior compartment (C) tracking up to the left hip (* in G). He was managed conservatively and follow up MRI one month later showed the lesion to be smaller in size with resolution of surrounding muscle changes (white arrow in H). Overall features favor an intermuscular haematoma, and the child was subsequently worked up and found to have haemophilia A.

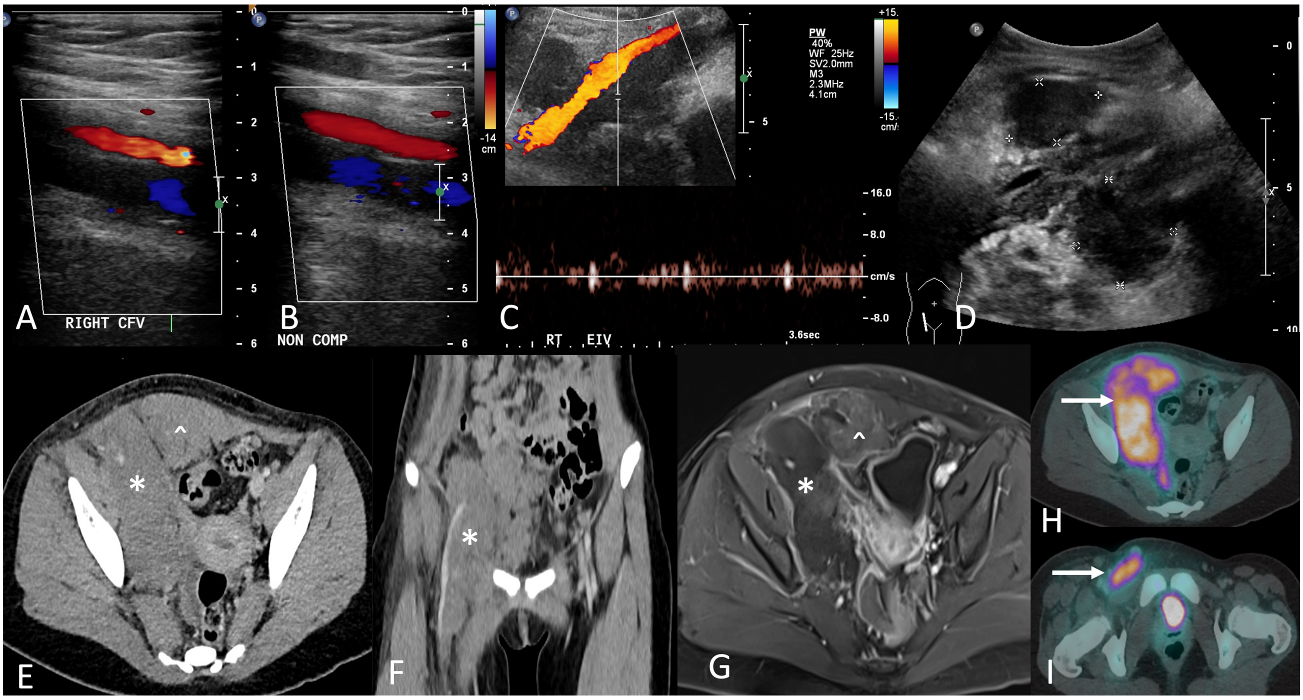

Fig. 15. Proximal deep vein thrombosis secondary to pelvic malignancy. 12-year 10-month-old girl presents with right hip pain, diffuse right lower limb swelling and constitutional symptoms. Ultrasound Doppler study of her lower limbs showed paucity of venous flow within the right common femoral vein (A) which was non-compressible (B). The right external iliac vein also showed absent venous waveform (C). Incidentally, abnormal enlarged right inguinal nodes were noted on ultrasound (D). Contrast enhanced CT axial (E) and coronal images (F) show a lobulated soft tissue mass centered at the right retroperitoneal, pelvic and inguinal region (*), effacing the right iliac and femoral veins, extending to the right anterior abdominal wall (^). On MRI (G), the mass shows heterogeneous enhancement and was thought to arise from the right rectus abdominis muscle (^), contiguous with conglomerate retroperitoneal, right pelvic and right inguinal adenopathy (*). These masses show corresponding avid tracer uptake (white arrows) on fluorodeoxyglucose-positron emission tomography-computed tomography (FDG-PET-CT) (H,I) and were suspicious for malignancy with nodal disease. The abdominal wall mass was histologically proven to be an alveolar rhabdomyosarcoma with arising from the right rectus muscle.

7. Vascular Causes

Proximal Deep Vein Thrombosis

Whilst rare in children, with a reported incidence of between 5.3 per 10,000 (0.05%) hospital admissions or 0.07 to 0.14 per 10,000 children aged between 1 month and 18 years old [77], proximal deep vein thrombosis (DVT) may be an overlooked cause of atypical hip pain.

Thrombosis involving the iliac and common femoral veins can present with deep-seated hip or groin pain, sometimes without the classic signs of limb swelling, warmth, or erythema, leading to potential misdiagnosis as a musculoskeletal condition.

Risk factors such as malignancy, prolonged immobility (e.g., post-surgery, long-haul travel), trauma, obesity, and underlying thrombophilia should raise suspicion for DVT in children with unexplained hip pain [78]. Compression ultrasonography with Doppler is the first-line investigation, with a sensitivity of 94.2% and specificity of 93.8% when performed by radiologists [79,80]. Further evaluation for a prothrombotic state may be warranted. Early detection is essential to prevent complications such as pulmonary embolism. Fig. 15 shows a proximal DVT involving the external iliac and common femoral vein, with malignancy later identified as the cause.

DVT is primarily treated with anticoagulation [81]. In severe, limb- or life-threatening cases, thrombolysis or thrombectomy may be required [82], with inferior vena cava filters reserved for select situations [81]. Comprehensive care also involves addressing underlying risk factors, providing supportive measures, and encouraging early mobilization.

8. Conclusion

Atypical hip pain in children encompasses a spectrum of extra-articular pathologies that can mimic common hip musculoskeletal conditions. A high index of suspicion and thorough clinical evaluation, supported by targeted imaging, are essential for early and accurate diagnosis, timely intervention, and optimal outcomes. Our proposed diagnostic algorithm aims to streamline the evaluation of these complex cases.

Future research should validate structured diagnostic algorithms combining clinical, laboratory, and imaging data, correlated with clinical outcomes through longitudinal studies. Incorporating advanced imaging techniques and artificial intelligence assisted tools may further improve diagnostic precision and guide evidence-based management.

Key Points

• Atypical hip pain in children can originate from extra-articular sources such as the spine, pelvis, abdomen, or soft tissue, mimicking primary hip pathology and complicating diagnosis.

• A structured clinico-radiological approach is essential for accurate diagnosis, particularly when red-flag indicators—such as persistent pain, neurological signs, or systemic symptoms—warrant further imaging to exclude sinister pathology.

• Ultrasonography remains a first-line imaging tool for many paediatric conditions due to its accessibility and dynamic capabilities, while MRI offers superior soft tissue and marrow characterization in complex or inconclusive cases.

• Understanding the strengths and limitations of each imaging modality enables precise differentiation of hip pain causes, facilitating early intervention and better outcomes.

Availability of Data and Materials

Not applicable.

Author Contributions

TSET conceived the manuscript. TSET and SCZ acquired, analyzed and interpreted the images. AYXS analyzed the clinical evidence and conceptualized the clinical approach and algorithm. SCZ wrote the initial draft. All authors critically revised it for important intellectual content. All authors read and approved the final manuscript. All authors participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study followed the principles of the Declaration of Helsinki. All patient images included in this article have been anonymized and used with informed consent from the patients and their families.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Yagdiran A, Zarghooni K, Semler JO, Eysel P. Hip Pain in Children. Deutsches Arzteblatt International. 2020; 117: 72–82. https://doi.org/10.3238/arztebl.2020.0072.

[2] Ribeiro SC, Barreto KSS, Alves CBS, Almendra Neto OL, da Nóbrega MV, Braga LRDC. Hip pain in childhood. Radiologia Brasileira. 2020; 53: 63–68. https://doi.org/10.1590/0100-3984.2018.0042.

[3] Qi L, Luo L, Meng X, Zhang J, Yu T, Nie X, *et al*. Risk factors for lumbar disc herniation in adolescents and young adults: A case-control study. Frontiers in Surgery. 2023; 9: 1009568. https://doi.org/10.3389/fsurg.2022.1009568.

[4] Craig WD, Wagner BJ, Travis MD. Pyelonephritis: radiologic-pathologic review. Radiographics. 2008; 28: 255–277; quiz 327–328. https://doi.org/10.1148/rg.281075171.

[5] Wu WT, Chang KV, Lin CP, Yeh CC, Özçakar L. Ultrasound imaging for inguinal hernia: a pictorial review. Ultrasonography. 2022; 41: 610–623. https://doi.org/10.14366/usg.21192.

[6] Jain N, Sah M, Chakraverty J, Evans A, Kamath S. Radiological approach to a child with hip pain. Clinical Radiology. 2013; 68: 1167–1178. https://doi.org/10.1016/j.crad.2013.06.016.

[7] Tzatzairis T, Skarentzos K, Grammatikos C, Karamalis C, Korakianitis K, Kourempeles R, *et al*. Ultrasound Applications in Pediatric Orthopedics. The Archives of Bone and Joint Surgery. 2024; 12: 457–468. https://doi.org/10.22038/ABJS.2024.59904.2950.

[8] Goo HW. Whole-Body MRI in Children: Current Imaging Techniques and Clinical Applications. Korean Journal of Radiology. 2015; 16: 973–985. https://doi.org/10.3348/kjr.2015.16.5.973.

[9] Parisi MT, Otjen JP, Stanescu AL, Shulkin BL. Radionuclide Imaging of Infection and Inflammation in Children: a Review. Seminars in Nuclear Medicine. 2018; 48: 148–165. https://doi.org/10.1053/j.semnuclmed.2017.11.002.

[10] Cunha NSC, Malvea A, Sadat S, Ibrahim GM, Fehlings MG. Pediatric Spinal Cord Injury: A Review. Children. 2023; 10: 1456. https://doi.org/10.3390/children10091456.

[11] Lenga P, Kühlwein D, Grutza M, Issa M, Hinz F, Sahm F, *et al*. Decoding pediatric spinal tumors: a single-center retrospective case series on etiology, presentation, therapeutic strategies, and outcomes. Neurosurgical Review. 2024; 47: 557. https://doi.org/10.1007/s10143-024-02770-w.

[12] Tempest-Mitchell J, Hilton B, Davies BM, Nouri A, Hutchinson PJ, Scoffings DJ, *et al*. A comparison of radiological descriptions of spinal cord compression with quantitative measures, and their role in non-specialist clinical management. PLoS ONE. 2019; 14: e0219380. https://doi.org/10.1371/journal.pone.0219380.

[13] Kuah T, Vellayappan BA, Makmur A, Nair S, Song J, Tan JH, *et al*. State-of-the-Art Imaging Techniques in Metastatic Spinal Cord Compression. Cancers. 2022; 14: 3289. https://doi.org/10.3390/cancers14133289.

[14] Loblaw DA, Mitera G, Ford M, Laperriere NJ. A 2011 updated systematic review and clinical practice guideline for the management of malignant extradural spinal cord compression. International Journal of Radiation Oncology, Biology, Physics. 2012; 84: 312–317. https://doi.org/10.1016/j.ijrobp.2012.01.014.

[15] Shamrock AG, Donnally III CJ, Varacallo MA. Lumbar Spondylolysis and Spondylolisthesis. StatPearls Publishing: Treasure Island (FL). 2023.

[16] Gagnet P, Kern K, Andrews K, Elgafy H, Ebraheim N. Spondylolysis and spondylolisthesis: A review of the literature. Journal of Orthopaedics. 2018; 15: 404–407. https://doi.org/10.1016/j.jor.2018.03.008.

[17] Nitta A, Sakai T, Goda Y, Takata Y, Higashino K, Sakamaki T, *et al*. Prevalence of Symptomatic Lumbar Spondylolysis in

Pediatric Patients. Orthopedics. 2016; 39: e434–e437. https://doi.org/10.3928/01477447-20160404-07.
[18] Mansfield JT, Wroten M. Pars Interarticularis Defect(Archived). StatPearls Publishing: Treasure Island (FL). 2023.
[19] Tofte JN, CarlLee TL, Holte AJ, Sitton SE, Weinstein SL. Imaging Pediatric Spondylolysis: A Systematic Review. Spine. 2017; 42: 777–782. https://doi.org/10.1097/BRS.0000000000001912.
[20] Yamaguchi KT, Jr, Skaggs DL, Acevedo DC, Myung KS, Choi P, Andras L. Spondylolysis is frequently missed by MRI in adolescents with back pain. Journal of Children's Orthopaedics. 2012; 6: 237–240. https://doi.org/10.1007/s11832-012-0409-z.
[21] McDonald BT, Hanna A, Lucas JA. Spondylolysis. StatPearls Publishing: Treasure Island (FL). 2023.
[22] Baronio M, Sadia H, Paolacci S, Prestamburgo D, Miotti D, Guardamagna VA, *et al*. Etiopathogenesis of sacroiliitis: implications for assessment and management. The Korean Journal of Pain. 2020; 33: 294–304. https://doi.org/10.3344/kjp.2020.33.4.294.
[23] Scotti N, Russo G, Carlomagno R, Forni C, Orlando F, Casa MGD, *et al*. Septic sacroiliitis in children-a diagnostic challenge. Pediatric Rheumatology. 2011; 9: P233. https://doi.org/10.1186/1546-0096-9-S1-P233.
[24] Chan OM, Lai BMH, Leung ASY, Leung TF, Ho ACH. High prevalence of sacroiliitis and early structural changes in the sacroiliac joint in children with enthesitis-related arthritis: findings from a tertiary centre in Hong Kong. Pediatric Rheumatology Online Journal. 2023; 21: 45. https://doi.org/10.1186/s12969-023-00825-8.
[25] Lee A, Gupta M, Boyinepally K, Stokey PJ, Ebraheim NA. Sacroiliitis: A Review on Anatomy, Diagnosis, and Treatment. Advances in Orthopedics. 2022; 2022: 3283296. https://doi.org/10.1155/2022/3283296.
[26] Weiss PF, Xiao R, Brandon TG, Biko DM, Maksymowych WP, Lambert RG, *et al*. Radiographs in screening for sacroiliitis in children: what is the value? Arthritis Research & Therapy. 2018; 20: 141. https://doi.org/10.1186/s13075-018-1642-8.
[27] Wantz W, Le Roy J, Lukas C, Cyteval C, Pastor M. Tomosynthesis performance compared to radiography and computed tomography for sacroiliac joint structural damage detection in patients with suspected axial spondyloarthritis. Research in Diagnostic and Interventional Imaging. 2023; 8: 100034. https://doi.org/10.1016/j.redii.2023.100034.
[28] Al-Mnayyis A, Obeidat S, Badr A, Jouryyeh B, Azzam S, Al Bibi H, *et al*. Radiological Insights into Sacroiliitis: A Narrative Review. Clinics and Practice. 2024; 14: 106–121. https://doi.org/10.3390/clinpract14010009.
[29] Canella C, Schau B, Ribeiro E, Sbaffi B, Marchiori E. MRI in seronegative spondyloarthritis: imaging features and differential diagnosis in the spine and sacroiliac joints. AJR. American Journal of Roentgenology. 2013; 200: 149–157. https://doi.org/10.2214/AJR.12.8858.
[30] Cohen SA, Biko DM, Kaplan SL, Barrera CA, Russo ME, Nguyen JC. MRI Findings of Infectious Sacroiliitis in Children: Are There Age-Dependent Differences? AJR. American Journal of Roentgenology. 2020; 214: 923–929. https://doi.org/10.2214/AJR.19.22131.
[31] Tsoi C, Griffith JF, Lee RKL, Wong PCH, Tam LS. Imaging of sacroiliitis: Current status, limitations and pitfalls. Quantitative Imaging in Medicine and Surgery. 2019; 9: 318–335. https://doi.org/10.21037/qims.2018.11.10.
[32] Vardi Y, Levy I, Ashkenazi-Hoffnung L, Sherman G, Berger I, Rom E, *et al*. Pediatric Infectious Sacroiliitis: Characterization and Differentiation from Noninfectious Etiologies. The Pediatric Infectious Disease Journal. 2019; 38: e134–e137. https://doi.org/10.1097/INF.0000000000002340.
[33] Ringold S, Angeles-Han ST, Beukelman T, Lovell D, Cuello CA, Becker ML, *et al*. 2019 American College of Rheumatology/Arthritis Foundation Guideline for the Treatment of Juvenile Idiopathic Arthritis: Therapeutic Approaches for Non-Systemic Polyarthritis, Sacroiliitis, and Enthesitis. Arthritis & Rheumatology. 2019; 71: 846–863. https://doi.org/10.1002/art.40884.
[34] Gadiparthi R, Waseem M. Pediatric Appendicitis. StatPearls Publishing: Treasure Island (FL). 2023.
[35] Rastogi V, Singh D, Tekiner H, Ye F, Mazza JJ, Yale SH. Abdominal Physical Signs and Medical Eponyms: Movements and Compression. Clinical Medicine & Research. 2018; 16: 76–82. https://doi.org/10.3121/cmr.2018.1422.
[36] Cundy TP, Gent R, Frauenfelder C, Lukic L, Linke RJ, Goh DW. Benchmarking the value of ultrasound for acute appendicitis in children. Journal of Pediatric Surgery. 2016; 51: 1939–1943. https://doi.org/10.1016/j.jpedsurg.2016.09.009.
[37] Quigley AJ, Stafrace S. Ultrasound assessment of acute appendicitis in paediatric patients: methodology and pictorial overview of findings seen. Insights into Imaging. 2013; 4: 741–751. https://doi.org/10.1007/s13244-013-0275-3.
[38] Tseng P, Berdahl C, Kearl YL, Behar S, Cooper J, Dollbaum R, *et al*. Does Right Lower Quadrant Abdominal Ultrasound Accurately Identify Perforation in Pediatric Acute Appendicitis? The Journal of Emergency Medicine. 2016; 50: 638–642. https://doi.org/10.1016/j.jemermed.2015.10.007.
[39] Kim HY, Park JH, Lee YJ, Lee SS, Jeon JJ, Lee KH. Systematic Review and Meta-Analysis of CT Features for Differentiating Complicated and Uncomplicated Appendicitis. Radiology. 2018; 287: 104–115. https://doi.org/10.1148/radiol.2017171260.
[40] Doria AS, Moineddin R, Kellenberger CJ, Epelman M, Beyene J, Schuh S, *et al*. US or CT for Diagnosis of Appendicitis in Children and Adults? A Meta-Analysis. Radiology. 2006; 241: 83–94. https://doi.org/10.1148/radiol.2411050913.
[41] Tung EL, Baird GL, Ayyala RS, Sams C, Herliczek TW, Swenson DW. Comparison of MRI appendix biometrics in children with and without acute appendicitis. European Radiology. 2022; 32: 1024–1033. https://doi.org/10.1007/s00330-021-08120-4.
[42] Ward TE, Mangal RK, Stead TS, Ganti L. Hepatic Abscess Following Acute Appendicitis. Cureus. 2022; 14: e26867. https://doi.org/10.7759/cureus.26867.
[43] Jaschinski T, Mosch CG, Eikermann M, Neugebauer EA, Sauerland S. Laparoscopic versus open surgery for suspected appendicitis. The Cochrane Database of Systematic Reviews. 2018; 11: CD001546. https://doi.org/10.1002/14651858.CD001546.pub4.
[44] Lamm R, Kumar SS, Collings AT, Haskins IN, Abou-Setta A, Narula N, *et al*. Diagnosis and treatment of appendicitis: systematic review and meta-analysis. Surgical Endoscopy. 2023; 37: 8933–8990. https://doi.org/10.1007/s00464-023-10456-5.
[45] Saluja S, Sun T, Mao J, Steigman SA, Oh PS, Yeo HL, *et al*. Early versus late surgical management of complicated appendicitis in children: A statewide database analysis with one-year follow-up. Journal of Pediatric Surgery. 2018; 53: 1339–1344. https://doi.org/10.1016/j.jpedsurg.2017.09.012.
[46] Tan APP, Yap TL, Cheong YL, Rai R, Choo C, Ong C, *et al*. Conservative antibiotic treatment of pediatric acute uncomplicated appendicitis during the COVID-19 pandemic: a prospective comparative cohort study. Pediatric Surgery International. 2022; 39: 60. https://doi.org/10.1007/s00383-022-05344-3.
[47] Zavras N, Vaos G. Management of complicated acute appendicitis in children: Still an existing controversy. World Journal of Gastrointestinal Surgery. 2020; 12: 129–137. https://doi.org/10.4240/wjgs.v12.i4.129.
[48] Li C, Tang F, Xi L, Wang X. Influence of meteorological and environmental factors on pediatric urinary tract infections: insights

from a 6-year retrospective study in Central China. Frontiers in Public Health. 2025; 13: 1512403. https://doi.org/10.3389/fpubh.2025.1512403.

[49] Tan JKW, Tan JMC, How CH, Leow EHM. Primary care approach to urinary tract infection in children. Singapore Medical Journal. 2021; 62: 326–332. https://doi.org/10.11622/smedj.2021090.

[50] NICE GUIDELINES: Urinary tract infection in under 16s: diagnosis and management. National Institute for Health and Care Excellence (NICE): London. 2022.

[51] Sim KC. Ultrasonography of acute flank pain: a focus on renal stones and acute pyelonephritis. Ultrasonography. 2018; 37: 345–354. https://doi.org/10.14366/usg.17051.

[52] Hosokawa T, Uchiyama M. Complete Remission of Renal Scarring in Follow-Up DMSA Renal Scintigraphy After Urinary Tract Infection. Clinical Pediatrics. 2024; 63: 1123–1131. https://doi.org/10.1177/00099228231206707.

[53] Kim YJ, Cho BS, Lee J, Ryu H, Byun H, Yeon M, *et al*. The ABCs of Voiding Cystourethrography. Taehan Yongsang Uihakhoe Chi. 2020; 81: 101–118. https://doi.org/10.3348/jksr.2020.81.1.101.

[54] Chishti AS, Maul EC, Nazario RJ, Bennett JS, Kiessling SG. A guideline for the inpatient care of children with pyelonephritis. Annals of Saudi Medicine. 2010; 30: 341–349. https://doi.org/10.4103/0256-4947.68549.

[55] Kaufman J, Temple-Smith M, Sanci L. Urinary tract infections in children: an overview of diagnosis and management. BMJ Paediatrics Open. 2019; 3: e000487. https://doi.org/10.1136/bmjpo-2019-000487.

[56] Holzheimer RG, Gresser U. Inguinal hernia vs. arthritis of the hip in sporting adolescents–case report and review of the literature. European Journal of Medical Research. 2007; 12: 314–319.

[57] Alqahtany LY, Alsharif A, Alsharif A, Alanazi O, Altaf M, Kaleemullah A, *et al*. Impact of Surgical Timing on Outcomes in Neonatal Inguinal Hernia Repairs: A Systematic Review. Pediatric Reports. 2025; 17: 12. https://doi.org/10.3390/pediatric17010012.

[58] Chen KC, Chu CC, Chou TY, Wu CJ. Ultrasonography for inguinal hernias in boys. Journal of Pediatric Surgery. 1998; 33: 1784–1787. https://doi.org/10.1016/s0022-3468(98)90284-6.

[59] Hammoud M, Gerken J. Inguinal Hernia(Archived). StatPearls Publishing: Treasure Island (FL). 2023.

[60] Haladu N, Alabi A, Brazzelli M, Imamura M, Ahmed I, Ramsay G, *et al*. Open versus laparoscopic repair of inguinal hernia: an overview of systematic reviews of randomised controlled trials. Surgical Endoscopy. 2022; 36: 4685–4700. https://doi.org/10.1007/s00464-022-09161-6.

[61] Idris I, Aburas M, Ibarra Martinez F, Osei-Kuffuor E, Adams K, Dizadare T, *et al*. Primary Psoas Abscess in a Pediatric Patient: A Case Report. Cureus. 2022; 14: e26206. https://doi.org/10.7759/cureus.26206.

[62] Pérez-López LM, Vara-Patudo I, Torner-Rubies F, Moreno-Romo D, Cabo LDSD, Fortuny C, *et al*. Pediatric Psoas Abscess, Early Diagnosis of a Challenging Condition. Journal of Acute Medicine. 2017; 7: 158–166. https://doi.org/10.6705/j.jacme.2017.0704.004.

[63] Keny S, Parekh H, Chaudhary J, Gokhale N, Modi N. Primary Pyogenic Abscess in an Immunocompetent Child: An Indian Perspective. Journal of Orthopaedic Case Reports. 2025; 15: 177–182. https://doi.org/10.13107/jocr.2025.v15.i02.5274.

[64] Radcliffe C, Gisriel S, Niu YS, Peaper D, Delgado S, Grant M. Pyomyositis and Infectious Myositis: A Comprehensive, Single-Center Retrospective Study. Open Forum Infectious Diseases. 2021; 8: ofab098. https://doi.org/10.1093/ofid/ofab098.

[65] Shields D, Robinson P, Crowley TP. Iliopsoas abscess–a review and update on the literature. International Journal of Surgery. 2012; 10: 466–469. https://doi.org/10.1016/j.ijsu.2012.08.016.

[66] Williams SM, Hultman SA, Harned RK, Quaife MA. The psoas sign: A reevaluation. Radiographics. 1985; 5: 525–536. https://doi.org/10.1148/radiographics.5.4.525.

[67] Vij N, Ranade AS, Kang P, Belthur MV. Primary Bacterial Pyomyositis in Children: A Systematic Review. Journal of Pediatric Orthopedics. 2021; 41: e849–e854. https://doi.org/10.1097/BPO.0000000000001944.

[68] Gonzalez Moran G, Garcia Duran C, Albiñana J. Imaging on pelvic pyomyositis in children related to pathogenesis. Journal of Children's Orthopaedics. 2009; 3: 479–484. https://doi.org/10.1007/s11832-009-0206-5.

[69] Verma S. Pyomyositis in Children. Current Infectious Disease Reports. 2016; 18: 12. https://doi.org/10.1007/s11908-016-0520-2.

[70] Mitsionis GI, Manoudis GN, Lykissas MG, Sionti I, Motsis E, Georgoulis AD, *et al*. Pyomyositis in children: early diagnosis and treatment. Journal of Pediatric Surgery. 2009; 44: 2173–2178. https://doi.org/10.1016/j.jpedsurg.2009.02.053.

[71] Gamage M, Weerasinghe S, Nasoor M, Karunarathne AMPW, Abeyrathne SP. Progressive Intramuscular Haematoma in a 12-Year-Old Boy: A Case of Acquired Haemophilia A. Case Reports in Hematology. 2018; 2018: 6208597. https://doi.org/10.1155/2018/6208597.

[72] Abe K, Dupervil B, O'Brien SH, Oakley M, Kulkarni R, Gill JC, *et al*. Higher rates of bleeding and use of treatment products among young boys compared to girls with von Willebrand disease. American Journal of Hematology. 2020; 95: 10–17. https://doi.org/10.1002/ajh.25656.

[73] Seo JG, Yang JC, Kim TW, Park KH. Intramuscular Hematoma on the Psoas Muscle. Korean Journal of Neurotrauma. 2019; 15: 234–238. https://doi.org/10.13004/kjnt.2019.15.e29.

[74] Davis DD, Kane SM. Muscular Hematoma. StatPearls Publishing: Treasure Island (FL). 2023.

[75] Thierfelder KM, Gerhardt JS, Gemescu IN, Notohamiprodjo S, Rehnitz C, Weber MA. Imaging of hip and thigh muscle injury: a pictorial review. Insights into Imaging. 2019; 10: 20. https://doi.org/10.1186/s13244-019-0702-1.

[76] Meshram P, Joseph J, Zhou Y, McFarland EG. Acute compartment syndrome caused by hematoma after shoulder surgery: a case series. Journal of Shoulder and Elbow Surgery. 2021; 30: 1362–1368. https://doi.org/10.1016/j.jse.2020.07.048.

[77] Aabideen K, Ogendele M, Ahmad I, Amegavie L. Deep vein thrombosis in children. Pediatric Reports. 2013; 5: 48–49. https://doi.org/10.4081/pr.2013.e12.

[78] Goldhaber SZ. Risk factors for venous thromboembolism. Journal of the American College of Cardiology. 2010; 56: 1–7. https://doi.org/10.1016/j.jacc.2010.01.057.

[79] Baker M, Anjum F, dela Cruz J. Deep Venous Thrombosis Ultrasound Evaluation. StatPearls Publishing: Treasure Island (FL). 2023.

[80] Goodacre S, Sampson F, Thomas S, van Beek E, Sutton A. Systematic review and meta-analysis of the diagnostic accuracy of ultrasonography for deep vein thrombosis. BMC Medical Imaging. 2005; 5: 6. https://doi.org/10.1186/1471-2342-5-6.

[81] Betensky M, Bittles MA, Colombani P, Goldenberg NA. How We Manage Pediatric Deep Venous Thrombosis. Seminars in Interventional Radiology. 2017; 34: 35–49. https://doi.org/10.1055/s-0036-1597762.

[82] Tarango C, Manco-Johnson MJ. Pediatric Thrombolysis: A Practical Approach. Frontiers in Pediatrics. 2017; 5: 260. https://doi.org/10.3389/fped.2017.00260.