

## Point-of-Care Ultrasound (POCUS) in Pediatric Scrotal Emergencies

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### Abstract

Acute scrotum is a frequent occurrence in the pediatric emergency department, and ultrasound is often utilized to narrow the difference in diagnosis. Point-of-care ultrasound (POCUS) is gradually utilized and has the potential to detect pediatric testicular torsion.

The term "acute scrotum" refers to "the occurrence of new-onset pain, swelling, and/or tenderness in the intrascrotal contents." Depending on the etiology, cases might document the onset of symptoms as quickly as a few minutes or as long as one to two days. A range of disease processes are encompassed by the term "acute scrotum." "Acute scrotum." Acute testicular torsion is a serious condition that is reversible, but its time dependency necessitates rapid evaluation and diagnosis. A median raphe subdivides the scrotum into two compartments, which are fibromuscular sacs. The wall consists of skin, cremasteric fascia, internal and external spermatic fascia, superficial fascia, and dartos muscle ranging from superficial to deep. Along with the dartos muscle, the raphe is continuous. The testes are characterized by a homogeneous structure composed of fine, medium-level echoes and take on an ovoid shape at US. Prepubertal testes have lower echogenicity. In elderly cases, the testicular parenchyma may exhibit a "striated" pattern, that is believed to be the result of increasing interstitial fibrosis and atrophy of glandular elements.

**Key words:** Point-of-care ultrasound, paediatric, scrotal emergencies

### INTRODUCTION

In the emergency department [ED], scrotal and testicular complaints account for a minimum of 0.5 percent of every visit. To prevent the loss of testicular tissue, acute scrotal pain is a true emergency [1]. The term "acute scrotum" is defined as "the occurrence of new-onset pain, swelling, and/or tenderness in the intrascrotal contents." Depending on the etiology, cases can report the onset of symptoms as rapidly as a few minutes or as long as one to two days. A range of disease processes are encompassed by the term "acute scrotum." "Acute scrotum." Acute testicular torsion is a serious condition that is reversible, but its time dependency necessitates rapid evaluation and diagnosis [2].

Emergency physicians can enhance the accuracy of their diagnoses and improve the quality of patient care by utilizing POCUS. When a patient experiences scrotal or testicular pain, the utilize of point-of-care ultrasound to ensure the testicular torsion diagnosis may prevent delays in care as well as provide consultants with additional

objective information by examining for reduced or absent vascular flow [3].

This study aimed to characterize the acute scrotum using a safe, faster, and inexpensive ultrasound and determine the accuracy of Point-of-care ultrasound in evaluating children who came to the emergency department with scrotal pain. The investigation also aimed to assist in diagnosis and prevent surgical intervention in cases of scrotal pain.

### Radiological anatomy of scrotum contents

#### *Anatomical background:*

A median raphe subdivides the scrotum into 2 compartments, which are fibromuscular sacs. Scrotal wall is comprised of the following layers (from deep to superficial):

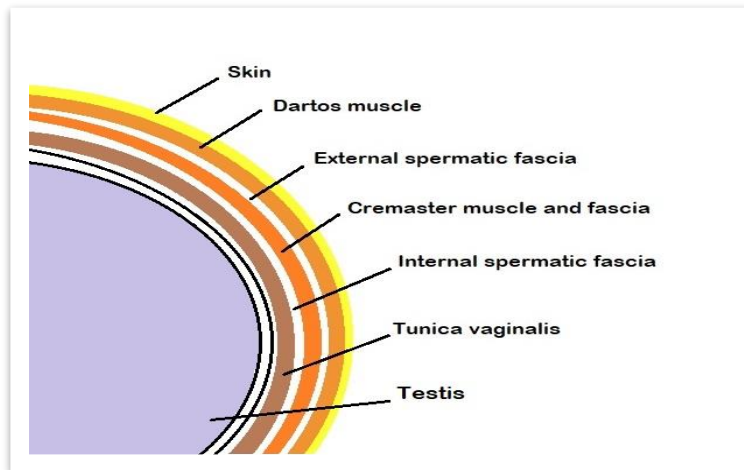
- Internal spermatic fascia
- Cremasteric muscle and fascia
- External spermatic fascia
- Dartos muscle
- Superficial fascia
- Skin

Along with the dartos muscle, the raphe is continuous [4].

The testicular parenchyma is divided into between two hundred and four hundred lobules by a variety of thin fibrous septa that spread into it [5]. One to three seminiferous tubules are present within every lobule. These tubules open at the mediastinum by the tubuli recti into dilated spaces known as the rete testis, as well as subsequently discharge into the epididymis within ten to fifteen efferent ductules. The size of the testicles is dependent on the individual's age and sexual development stage. The testes are around 1.5

centimetres in length and one centimetre in width at birth. In clinical terms, a male individual is deemed having reached puberty when the testis reaches a volume of four cubic centimeters. They grow slowly until puberty. The post-pubertal testes are symmetric ovoid structures that measure around five × three × two centimetres [1].

The epididymis is a tubular structure that is situated superior to and adjacent to the posterior part of the testis. It consists of a tail, a head, and a body [4].



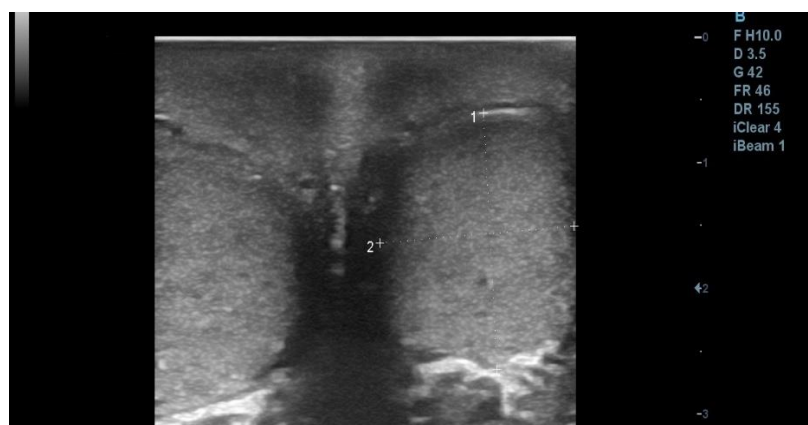
**Figure (1):** Scrotal wall layers.

**Scrotal ultrasound:**

US is the preferred imaging modality within cases involving scrotal as well as penile issues. Transducers with color and spectral Doppler abilities have been employed to conduct the examination, which is conducted at high frequency and resolution [6].

The patient typically elevates the scrotum by putting a towel behind the sac, while Penis is pressed up against the wall of the abdominal cavity. It is essential to acquire both axial and sagittal views; however, the axial plane view of both testes is particularly critical for the purpose of comparing the testicular parenchymal echostructure, which is

referred to as the spectacle view. In order to establish a correlation between clinical findings and images, it is necessary to conduct a simultaneous palpation and examination of the scrotal content [7]. The inguinal region's structures are superficial and may be effectively assessed using linear transducers at frequencies of ten megahertz or lesser (seven megahertz). The dynamic evaluation of the region is facilitated by the Valsalva maneuver, which is an essential aspect of the investigation. This is particularly important in cases of suspected hernias, as hernias may disappear totally when the case is at rest, which makes them hard to identify [8].



**Figure (2):** Spectacle view of both testicles.

**Ultrasound Scrotal Anatomy:**

The testes are characterized by a homogeneous structure composed of fine, medium-level echoes and take on an ovoid shape at US. Prepuberal testes have lower echogenicity. In elderly cases, the testicular parenchyma may exhibit a "striated" pattern, that is believed to be the result of increasing interstitial fibrosis and atrophy of glandular elements [4].

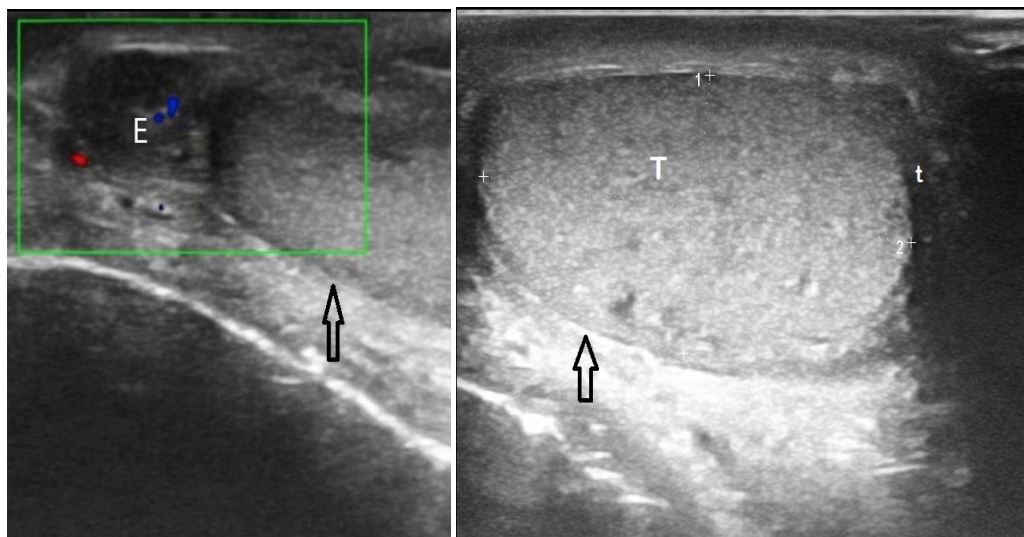
The tunica albuginea is a thin echogenic line that encircles the testis, while the mediastinum testis is a visible echogenic line that is parallel to the testicular main axis in sagittal as well as axial images [5].

The epididymis is a pyramidal structure with a slightly hyperechoic or isoechoic head, a slightly hypoechoic body, and a curved tail. It is typically 2-4 mm in diameter and tough to differentiate from surrounding peri-testicular tissue. It forms the proximal part of the ductus deferens [5].

It is possible to observe the normal appendix testis as well as the epididymis of the appendix when it

is surrounded by fluid. An ovoid structure may be seen in the groove that is located among the testis as well as the epididymis. This structure is known as the appendix testis. It is possible for it to take the form of a tiny cystic nodule and it is isoechoic to the testis. There is a higher incidence of pedunculation in the appendix epididymis [5].

Color Doppler ultrasound is a simple method for identifying testicular vessels. At the testis's outer margins, capsular arteries are evident. Intratesticular arteries are most easily observed along certain "vascular" planes, which are typically oblique to the standard axial as well as sagittal examination planes. They have a relatively straight course. In many cases, it is possible to identify centripetal arteries as well as their recurrent rami. They exhibit a low-resistance flow pattern, with an average RI of sixty one hundredths (ranging from 0.48 to 0.75) [4]. In the upright position, images of the spermatic cord and inguinal canal may be acquired through the Valsalva maneuver to assess inguinal hernias and varicoceles, respectively [4].

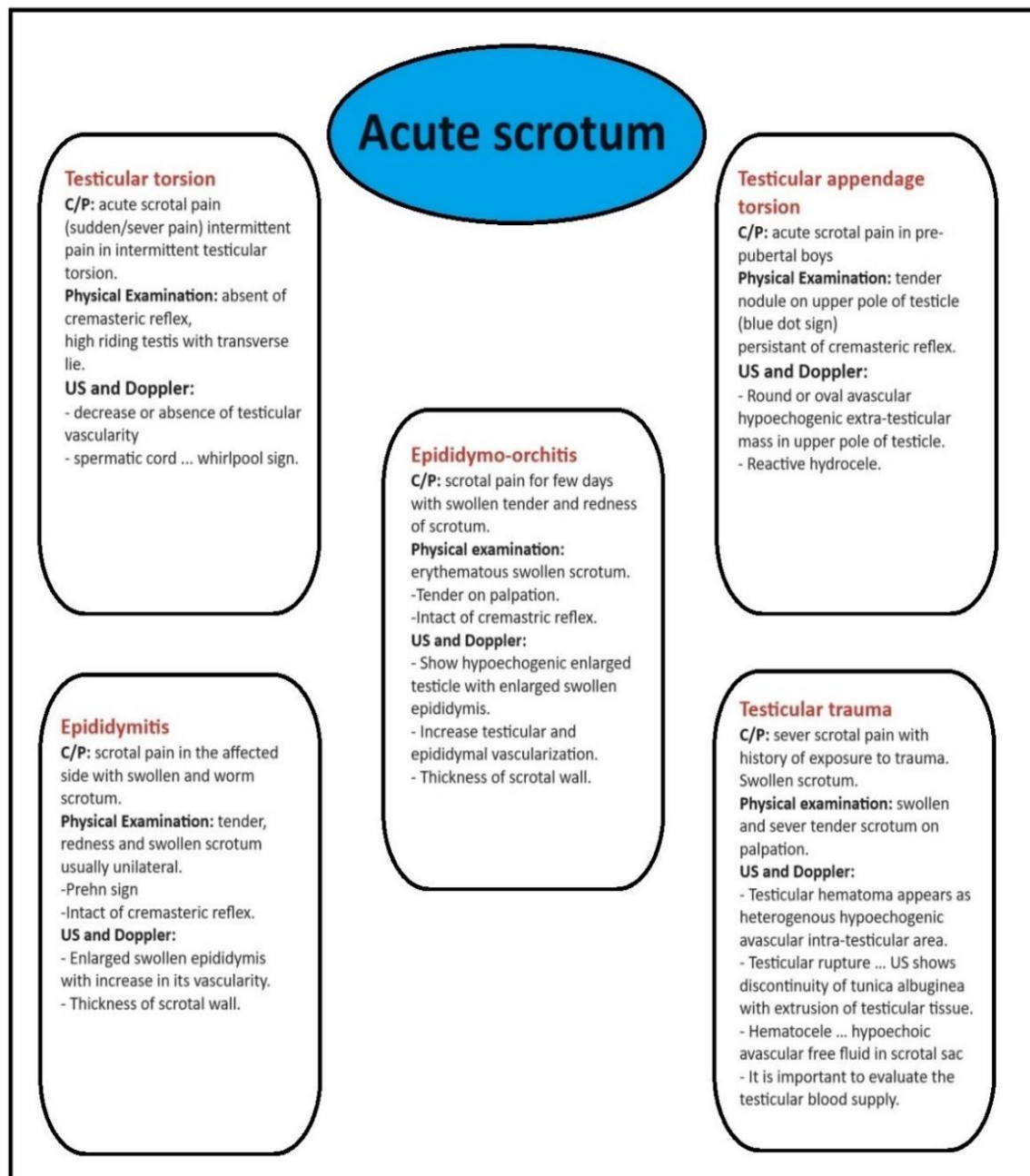


**Figure (3):** Normal scrotal anatomy and testicular vascularization in a boy aged fifteen. A longitudinal ultrasound image demonstrates the testis (T) is moderately homogeneous and echogenic. The epididymis (E) head is located above the testis and has comparable echogenicity. The epididymis's body is situated behind the testis, while the tail (t) is situated at the inferior pole of the testis. The tunica albuginea (arrows) has been observed as a peripheral echogenic line.

**Pathology of Acute Scrotum Disease**

Acute scrotal disease is typically classified into vascular, infectious, traumatic and miscellaneous causes. Acute scrotal disease is usually caused by torsion of the testicular appendage or the spermatic

cord, and epididymo-orchitis or acute epididymitis. Additional acute identifications include Fournier gangrene, acute idiopathic scrotal oedema, and segmental testicular infarction [6].



• **Infectious aetiologies of acute scrotum**

***1-Epididymitis and epididymo-orchitis:***

In cases with epididymitis, ultrasound outcomes involve an enlarged and hypoechoic epididymis as a result of oedema. Secondary outcomes include reactive hydroceles and scrotal wall thickening. Colour Doppler imaging demonstrates hyperaemia, the primary diagnostic criterion for epididymitis, as evidenced by a rise in blood flow [9]

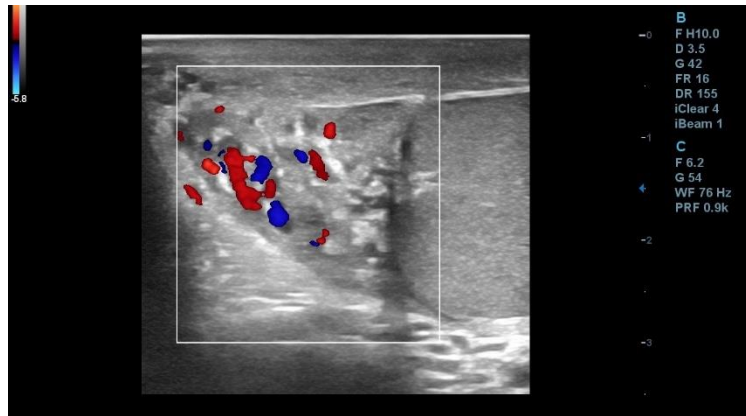
The most prevalent reason for acute scrotal pain is Infection, that might affect the testicle (orchitis), epididymis (epididymitis), otherwise the two (epididymo-orchitis). The infection extends within the urogenital tract in a retrograde fashion, progressing from the tail to the head via the

epididymis and subsequently reaching the testicle [10].

The primary cause of epididymitis in children under the age of fourteen is the reflux of urine into the ejaculatory ducts. The most prevalent pathogens in sexually active males are Chlamydia trachomatis and Neisseria gonorrhoeae [11].

It is possible for epididymitis and epididymo-orchitis to cause consequences like the creation of an abscess, pyocele, and testicular ischemia if they remain untreated. Abscesses are focal, complex fluid collections, pyocele are pus-filled, and testicular ischemia restricts spermatic cord flow [10].





**Figure (5):** Color flow mapping on right epididymis shows swollen hypervascularized epididymis.

**2-Fournier gangrene:**

Fournier gangrene refers to the condition of necrotizing fasciitis impacting the external genitalia, perianal, and perineum areas. Cases commonly exhibit symptoms such as fever and a pain that comes on suddenly, oedema, and erythema [12]. Fournier gangrene is a clinical diagnosis with high suspicion. Physical examination reveals gas-forming organisms, causing crepitus in 19% to sixty-four percent of cases. Myositis, cellulitis, and deep vein thrombosis all have symptoms that are very similar to one another [13]. Typically, this disease affects middle-aged males (average ages fifty to sixty years) who have an immunocompromised state, history of alcoholism, or diabetes. However, women and children may also be susceptible [12]. Ultrasound is effective for early recognition of Fournier gangrene in emergency departments, revealing diffuse tissue thickening, echogenic foci, and perifascial fluid accumulation [14]. Emergent computed tomography is the greatest imaging modality for the definitive diagnosis of Fournier gangrene. This technique detects the sources of infection and demonstrates results like subcutaneous emphysema, fat stranding, and soft tissue thickening [12]. Ultrasound isn't usually utilized as the initial imaging method for this disorder; however, it was demonstrated to be efficient at enabling early identification in the emergency department. Fournier gangrene is detected by perifascial fluid accumulation, diffuse subcutaneous tissue thickening, as well as bright echogenic foci with dirty shadowing also reverberation artifacts that correlate with the underlying soft tissue gas [13]

**3- BCG-related epididymitis:**

Epididymitis and epididymo-orchitis associated with BCG are uncommon; however, they may manifest up to ten years following the final intravesical BCG medication. The appropriate

management of a mycobacterial scrotal infection necessitates distinguishing the infection from that resulting from more prevalent bacterial pathogens. Empiric antimycobacterial management ought to be initiated if routine antibiotics don't work in a case that is identified to have undergone BCG therapy and is suspected of having a BCG-related infection [14]. Mycobacterial infections generate heterogeneous masses that correspond to the formation of granulomas, as well as hypochoic epididymal enlargement on ultrasound images. In the context of non-mycobacterial infection, these granulomas may appear less obvious than would be predicted due to the reduced internal flow seen on colour Doppler images, which are accompanied by hyperaemia [15]

- **Vascular aetiologies of the acute scrotum:**

**1- Testicular torsion:**

Vascular occlusion and subsequent infarction may result from testicular torsion, which is characterised by the testis as well as spermatic cord twisting throughout the scrotum, if not immediately resolved. Although torsion may arise at any age, it is more frequently seen in young males in a bimodal distribution, with peaks occurring during the 1<sup>st</sup> year of life as well as in the early stages of puberty [16]. Bell-clapper deformity is a congenital anatomical variation in which the tunica vaginalis fails, encircling the distal spermatic cord, epididymis, as well as testis, elevating the testicular torsion risk due to spermatic cord twisting [9]. Venous flow is either absent or reduced on colour Doppler imaging is the initial indication of torsion, which is subsequent by a decline or absence of arterial flow. The degree of ischemia has an impact on grayscale ultrasound imaging characteristics. The testicle might remain normal in cases that present quickly following the onset of symptoms. Testicular enlargement,

heterogeneity, and hypochogenicity, which are indicative of oedema, are observed through the acute phase, which commences within 24h of the onset of symptoms. Testicular salvageability is affected directly by late exhibitions as well as misdiagnoses of cases having testicular torsion who present over 24h following the onset of symptoms (subacute phase). Unusual patients are more likely to result in late exhibition as well as management, including cases with isolated abdominal pain, cases with developing, social, or cognitive conditions, young cases that typically hide otherwise reduce scrotal pain, and cases with a history of current trauma to genitals [16]. High TWIST scores in children require prompt urological consultation to minimise time for manual or surgical detorsion, with a 100% chance of viability after six hours. Delayed detorsion reduces viability to 0%–20% [16].

### **2- Torsed testicular appendage:**

The primary reason for an acute scrotum in paediatric cases is the testicular appendage torsion. The vascularized connective tissue that spreads along the epididymis and testicle is what makes up the testicular appendages, which are vestigial remnants of the mesonephric as well as paramesonephric ducts. In most cases, the appendages are structures that are sessile, stalk-like, or pedunculated; however, they may also take on other forms [17]. Appendages are more easily visible on ultrasound images when a hydrocele is present. Flow is evident on colour Doppler imaging, and normal appendages appear isoechoic to the epididymis. When the appendages are torsed, they appear as rounded, enlarged, extra testicular masses with a heterogeneous echotexture as well as mixed hyperechoic, which is contingent upon the severity of the ischemia [9].

**There are 5 defined appendages:** The appendix testis, also recognized as the appendix epididymis, is the hydatid of Morgagni; the cranial vas aberrans, also known as the caudal vas aberrans; the cranial organ of Haller, also known as the caudal organ of Haller; as well as the paradidymis, more often known as the organ of Giralde [18].

The caudal as well as cranial vas aberrans arise from the epididymal body and tail, whereas the paradidymis is connected to the lower part of the spermatic cord. However, these structures are rarely observed. The clinical therapy of torsion does not require distinguishing between the appendices [17]. Self-limiting appendage torsion is typically treated with NSAIDs and bed rest, with pain typically resolving in a week. Consequently, it is crucial to obtain a precise ultrasound diagnosis, as this may reduce the necessity for surgical exploration [17].

### **3- Inguino-scrotal hernia**

#### **(obstructed/strangulated):**

The fascia of the abdominal wall contains abnormal bulges or openings known as hernias. These defects have been observed in any region of the abdominal wall fascia that exhibits anatomical weakening. The groin regions (inguinal, femoral) and anterior abdominal wall (umbilical) are the most prevalent areas for hernias. Reducible hernias are those in which the contents of the hernia may be inserted intra-abdominally through the layers of the abdominal wall. The hernia is categorized as incarcerated if the contents are unable to be decreased. A strangulated hernia is characterized by an ischemic state of the hernia contents as a result of a compromised blood supply [19]. Ultrasonography has become the preferred imaging procedure for diagnosing inguinal hernias as a result of its advantages, including its portability and the absence of radiation [20]. Ultrasound outcomes that indicate a small bowel obstruction include "back-and-forth" peristalsis and dilated loops of bowel with a max diameter of  $\geq 2.5$  centimetres. The absence of dopplerable color flow within the echogenic fat stranding, incarcerated hernia, as well as a thickened bowel wall are indicators that must alert the clinician to the possibility of a strangulated bowel diagnosis [21]. Strangulated inguinal hernia can also be one of the presentations of acute scrotum in children [22].

#### **4-Segmental testicular infarction:**

Segmental testicular infarction is a rare, partial ischemic procedure resulting from surgery, scrotal infection, or hematologic disorders, primarily affecting men [22]. On ultrasound, segmental ischemia is identified as a geographic or wedge-shaped hypoechoic irregularity that is either avascular or hypo-vascular on colour Doppler imaging. A peripheral hyperemic rim might be detected. Normal blood flow is observed in the testicular parenchyma that isn't impacted. The superior aspect of the testis is typically affected by the ischemic region as a result of inadequate collateral vessels [18].

- **Traumatic aetiologies of the acute scrotum:** Oedema, hematoma, torsion, fracture, and rupture are potential consequences of testicular trauma. Clinical evaluation might be difficult and might not show much due to swelling and severe tenderness. This renders POCUS highly advantageous in distinguishing between these entities, thereby enabling the appropriate timely management. This is particularly true for testicular rupture, where US sensitivity may be 100% also, specificity of 93%, and for the diagnosis of other entities such as

torsion, orchitis, and hydrocele, where sensitivity and specificity range from 94% to 96% [23]

### ***1-Testicular rupture:***

Testicular rupture is the term used to describe a tear in the tunica albuginea, which causes testicular contents to be extruded. Multiple investigations have demonstrated that ultrasound has a sensitivity of one hundred percent in identifying testicular rupture. This finding offers reassurance when ultrasound results indicate the absence of ruptured muscles [24]. The primary ultrasound outcomes associated with testicular rupture are a contour abnormality, heterogeneous testicle, as well as disruption of the tunica albuginea. The testicular parenchyma's mixed echogenicity is indicative of necrosis and bleeding. Parenchyma extrusion is indicated by a disruption of the typical testicular contour. Colour Doppler imaging typically necessitates surgical debridement due to the focal or diffuse loss of vascularity [21]

When the diagnosis of testicular rupture is definitive or suspicious, surgical exploration and repair might be required. The purpose of the follow-up following surgery is to assess the relief of local symptoms and any alterations in testicular functions [21].

### ***2-Testicular fracture:***

A testicular fracture is a traumatic rupture of the testicular parenchyma that might happen independently of a disruption of the tunica albuginea. Rupture of the tunica albuginea might happen in certain cases as a result of increased intratesticular pressure that is a consequence of a haematoma [25]. A testicular fracture is distinguished from the surrounding regularly perfused testicular parenchyma by a clearly defined avascular or hypovascular fracture plane on ultrasound [25]. A testicular fracture is characterized by a distinct avascular or hypovascular fracture plane on CEUS, which is distinguishable from the surrounding regularly perfused testicular parenchyma. Vascular evaluation of testicular fractures is essential for the formulation of preoperative decisions. Most of the testis can be salvaged through debridement along the fracture line, as perfused testicular parenchyma is frequently viable [25].

### ***3-Scrotal hematoma:***

Post-traumatic hematomas may happen in several sites inside the scrotum, involving intratesticular hematomas, extra testicular hematomas, including the epididymis, scrotal wall, as well as hematomas that accumulate within the visceral as well as tunica vaginalis parietal layers (recognised as

haematocoles)[26]. Evolving blood components' chronicity determines the ultrasound characteristics. In the acute phase, focal testicular and hematoceles, scrotal wall hematomas, and epididymal are hyperechoic. As they development to subacute and chronic phases, their echogenicity decreases and their complexity rises (septa, loculations, and fluid levels). There is no internal flow in hematomas, which is responsible for their colour or power. Doppler images [9] According to these suggestions, conservative treatment may be utilized for small hematomas in the thigh, subcutaneous hematomas that don't have a small hematoceles, and hematocele as long as the tunica albuginea is still intact. However, large hematomas must be operationally investigated. The hematoma's size, which must stimulate surgical exploration, wasn't yet established [9].

- **Miscellaneous etiologies of the acute scrotum:**

#### ***1-Acute idiopathic scrotal oedema:***

Acute idiopathic scrotal oedema is a disorder that is characterised by scrotal skin erythema and oedema of acute onset, as well as dartos fascia, but does not include the testes or epididymis. This condition is considered to be benign and self-limiting [27].

Within the age range of five to eight years old, the greatest number of cases are discovered in young children, and they make up to twelve percent of any prepubertal acute scrotum presentations [27]. Characteristic outcomes of ultrasound include a normal appearance of the testes and a significant edematous thickening of the scrotal wall as well as the epididymis. A small reactive hydrocele might be detected. Color Doppler images showing hypervascular peri testicular scrotal soft tissues are a strong indicator of the diagnosis ("fountain sign") [27]

#### ***2-Referred scrotal pain:***

Renal US is suggested to check for a urinary tract obstruction (hydronephrosis or calculus) as the reason for stated pain when the symptoms aren't clear or when the first ultrasound shows the scrotum to be normal [28]. Acute scrotal pain may occur as a result of pain originating from a non-scrotal illness. Renal colic is a form of flank discomfort that is linked with obstructive urinary calculi. There is a possibility that the pain will radiate to the scrotum, and it may also occasionally manifest as localised acute scrotal pain [29]. The pain that is referred to is caused by the shared innervation of the proximal ureter, ipsilateral testicle, as well as renal pelvis, in addition to the distal ureter and the scrotum. It is possible to

identify renal colic from acute scrotal disease by using the characteristics that are frequently linked with it, such as vomiting, nausea, and dysuria, along with microscopic or gross haematuria [1].

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The authors report no conflicts of interest. The authors along are responsible for the content and writing of the paper.

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