A review of ultrasound imaging in scrotal emergencies

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Abstract Scrotal emergencies represent a small proportion of admissions to the emergency department; however, the intimate nature and potential for serious outcome often cause great anxiety. Rapid assessment is required to exclude fertility-threatening conditions and expedite surgical management. Ultrasound is an essential tool in acute scrotal assessment as it allows rapid, radiation-free, high-resolution imaging and, importantly, assessment of vascularity with colour Doppler imaging. In the presentation of the acute scrotum, the “on-call” practitioner will frequently be asked to exclude pathology requiring surgical management, in particular torsion of the spermatic cord. To provide an accurate evaluation the individual is required to have an understanding of scrotal anatomy, sonographic technique and recognition of pathology. This review article will familiarise the reader with the sonographic findings of common acute scrotal pathology.

Keywords Testis · Ultrasound · Doppler · Trauma · Infection · Torsion

Sommario Le emergenze scrotali rappresentano una piccola percentuale di accessi al pronto soccorso, ma la natura intima e la possibilità di esiti seri sono spesso causa di grande ansia. E' necessaria una valutazione rapida, al fine di escludere condizioni di pericolo per la fertilità e accelerare il trattamento chirurgico. L'ecografia è uno strumento essenziale per la valutazione dello scroto acuto

in quanto rapida, esente da radiazione, ad alta risoluzione e, soprattutto, permette la valutazione della vascolarizzazione con colour Doppler. Nello scroto acuto l'ecografista spesso verrà chiamato a escludere patologie che richiedono un trattamento chirurgico, in particolare la torsione del funicolo spermatico. Al fine di fornire una valutazione precisa è tenuto ad avere una conoscenza dell'anatomia scrotale, della tecnica ecografica e a conoscere le varie patologie. Questo articolo di revisione ha lo scopo di familiarizzare il lettore con gli aspetti ecografici della patologia scrotale acuta più frequente.

Introduction

The acute scrotum often presents as pain, swelling or a combination of sudden onset. The majority of causes may be treated conservatively; however, torsion of the spermatic cord requires immediate surgery to salvage the testis and preserve fertility. The role of ultrasound in the acute scrotum is to narrow the differential diagnosis to allow conservative management or expedite surgery. The superficial location of the testis coupled with high-frequency linear transducers allows detailed grey-scale sonographic and sensitive colour Doppler imaging. Contrast-enhanced ultrasound (CEUS) also provides further assessment of vascularity in equivocal cases and may become more important in the future [1].

Examination technique

The examination technique for a patient with scrotal pain will need to be modified to ensure patient comfort and the maintenance of a diagnostic study. The patient is positioned in the supine position, holding their penis against the

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abdomen with sufficient support by placing a towel beneath the scrotal sac. Copious ultrasound jelly is applied to the testis and a high-frequency linear transducer used. On occasion, particularly with scrotal trauma or an enlarged scrotal sac, a curvilinear transducer gives a “global” view of the anatomy, site of injury and associated abnormalities. The site of symptoms should be targeted before a complete and thorough examination; this is important if the ultrasound examination precedes urgent surgery and time is vital. Colour Doppler imaging provides an overview of vascularity but has limitations. Contrast-enhanced ultrasound (CEUS) with SonoVueTM (Bracco SpA, Milan, Italy) allows more accurate delineation of areas of non-perfused testicular tissue and should always be employed if the colour Doppler examination is equivocal [2–4].

Abnormalities presenting as an acute scrotum

Acute pathology within the testis can be assigned into one of four main categories.

Vascular

Torsion of the spermatic cord

Often given the misnomer of testicular torsion, this is the most important acute scrotal abnormality that requires immediate diagnosis to enable surgical exploration. Torsion of the spermatic cord predominantly affects children and young adults, constituting approximately 17 % of scrotal emergencies with an incidence of 1:4,000 [5]. The spermatic cord undergoes rotation of between 90° and 720°. This initially results in testicular venous outflow obstruction, subsequent engorgement, arterial obstruction and rapid irreversible testicular infarction, normally within 6 h of onset. Torsion may be either intra-vaginal or extra-vaginal. The majority of cases are intra-vaginal torsion (90 %) and associated with an anatomically absent posterior attachment of the tunica vaginalis, referred to as a “bell clapper” deformity [6]. The ectopic location of the tunica vaginalis allows mobility of the spermatic cord predisposing to twisting and subsequent torsion. Extra-vaginal torsion is rare and occurs predominantly in neonates, where the tunica vaginalis is immature and unfused, with a tendency for both the spermatic cord and tunica to rotate together and cause torsion. Extra-vaginal torsion is often detected only after testicular infarction has occurred [7].

Rapid clinical assessment is a necessity and imaging is often omitted in favour of surgery [5]. However in cases of clinical uncertainty, ultrasound is used to exclude other causes of pain, in particular epididymitis. Classically, the

patient presents with sudden onset, unilateral testicular pain with a high lying, transverse testis. In addition, there may be loss of the cremasteric reflex; lifting the testis does not abolish the pain (Prehn’s sign) [8].

On ultrasound, grey-scale images can be unremarkable, particularly immediately after onset of symptoms. With progression of symptoms, the testis may become heterogeneous or diffusely hypo-echoic, mimicking epididymo-orchitis both on imaging and clinical examination. There may be benefit in evaluation of the inguinal spermatic cord for the presence of a “whirlpool” like mass or acute change in the direction of the spermatic cord as an ancillary feature for spermatic cord torsion [9]. Additional features include scrotal wall thickening and a hydrocele (Fig. 1).

If ultrasound is performed in the assessment of torsion of the spermatic cord, colour Doppler ultrasound is essential and requires careful comparison with the adjacent normal testis [5]. Absence of intra-testicular colour Doppler signal is characteristic and expected; however both reduced and increased signal may be present depending on the stage of torsion. Colour Doppler may demonstrate hyperaemia in early stages, due to venous dilation or from rebound reperfusion following de-torsion [10]. Subsequently, colour Doppler signal does diminish and there may be increased para-testicular flow from collateralisation of epididymal vessels. Diagnostic difficulty may arise in normal pre-pubescent testis where vasculature may not be visible even with power Doppler [11]. Colour Doppler exhibits 82 % sensitivity and 100 % specificity for torsion [12]. The diagnosis may be further

Fig. 1 Grey-scale longitudinal ultrasound image of the testis in a patient with torsion of the spermatic cord. The testis is heterogeneous and enlarged (*star*) suggesting ischaemia. Lying at the upper aspect is an ill-defined circular mass representing the thickened, oedematous, tortorted spermatic cord (*arrow*). The scrotal wall is also thickened

aided with the use of spectral Doppler or CEUS; spectral Doppler may show an increased resistive index [10], whilst CEUS allows accurate direct visualisation of absence of intra-testicular enhancement clearly depicting infarction [2, 3] (Fig. 2). However, spermatic cord torsion is a clinical diagnosis; ultrasound plays a secondary role, only to exclude other cause of scrotal pain and performed only if the examination does not delay surgery. Finding an avascular testis on ultrasound is often too late for full salvage.

Torsion of the appendix testis

A number of testicular appendages exist, any of which can tort [13]. Commonly affected is the appendix testis [Hydatid of Morgagni] a pedunculated remnant of the Müllerian duct present at the superior testicular pole in 92 % of individuals [14]. The pedunculated nature of the appendix testis leaves it prone to torsion. The clinical history may be identical to torsion of the spermatic cord; however, classically the examination findings describe a superiorly located “blue spot”, an uncommon finding seen in only 23 % of cases [15]. Sonographic appearances are variable with reports suggesting an enlarged appendix testis (>5.6 mm) with an absence of colour Doppler signal characteristic [16, 17] (Fig. 3). It remains prudent to examine the testis, although signs suggestive of torsion of the appendix testis are reassuring that there is absence of spermatic cord torsion.

Fig. 2 CEUS transverse image of the testis in a patient with torsion of the spermatic cord (using a 4 MHz transducer). There is absence of vascularity within the left testicular parenchyma indicating infarction (long arrow). There is intra-testicular enhancement present in the right testis (short arrow)

Fig. 3 Grey-scale ultrasound image of a patient with acute scrotal pain showing a cystic heterogeneous pedunculated structure arising from the testis, representing an enlarged appendix testis which has undergone torsion (arrow). A small surrounding hydrocele is also present

Inflammatory or infective

Epididymitis

Epididymitis and epididymo-orchitis represent the commonest cause of acute scrotum, with a prevalence of 40 per 10,000 [18]. The underlying cause is usually bacterial; rarely a fungal infection is responsible. The pathogen is linked with age, the most prevalent age group is sexually active individuals and the commonest pathogens are *Chlamydia trachomatis* or *Neisseria gonorrhoea*. At the extremes of age, *Escherichia coli* tend to be the commonest cause and are often linked to urinary tract infections. In these patients the cause is often related to congenital malformations, repeated urinary tract infections or bladder stasis arising from obstruction. The pathogens normally ascend from static urine or sexual transmission to the vas deferens into the epididymis with resultant infection. On rare occasions, non-infective inflammatory causes have been described and include Bechet's disease, sarcoidosis, trauma or drug induced [19].

The clinical picture is pain and swelling of the affected testis. There may be systemic features of sepsis; however, these clinical features are often absent creating a clinical picture similar to spermatic cord torsion. Differentiating features, other than sepsis, may be indolent onset and the presence of urinary tract symptoms. Other clinical signs include the presence of a cremasteric reflex or Prehn's sign (relief of pain on testicular elevation). Orchitis may present without epididymitis; however, this usually occurs in the paediatric population with a history of mumps. A history of

bilateral parotid swelling is indicative of the diagnosis and patients may subsequently develop testicular atrophy [20].

Grey-scale ultrasound images may have difficulty differentiating torsion of the spermatic cord and epididymitis, with sensitivity reported at 80 % [21]. The epididymis is enlarged and hypo-echoic compared to the contralateral side, with or without focal hypo-echoic regions representing abscesses. Alternatively, haemorrhage may occur and be present as hyper-echoic foci or heterogeneity. Orchitis occurs as a consequence of local spread in 20–40 % and demonstrates focal or segmental low echogenicity [22]. A hydrocele or scrotal wall thickening may be present, but are non-specific features (Fig. 4). The characteristic finding on colour Doppler ultrasound is hyperaemia within the epididymis [21]. The important distinction is on spectral Doppler, in epididymitis there is high flow and low resistive index in comparison to high resistive flow found in torsion of the spermatic cord [21].

Ultrasound is beneficial in defining complications of the epididymitis. An uncommon complication is testicular infarction which may be segmental [3, 23] or rarely global [24], with absence of colour Doppler signal as the hallmark. Contrast-enhanced ultrasound may be useful in identifying nonviable testicular parenchyma or abscess formation [25]. Further complications include testicular abscess reported in 3–5 % which has the appearance of a complex intra-testicular fluid collection without internal vascularity, but peripheral hyper-vascularity [26].

Chronic epididymitis is most commonly the result of infection with *Mycoplasma tuberculosis*, with brucellosis

and syphilis also recognised. Clinical presentation is with indolent long-standing pain and swelling. Grey-scale ultrasound will demonstrate an enlarged epididymis of variable echogenicity with or without calcification. The testis is usually not involved as frequently as seen with acute epididymo-orchitis, but areas of focal low echogenicity, mimicking intra-testicular tumours, may be seen. As with the acute form, scrotal wall thickening, hydrocele and abscesses may occur [27].

Fournier's gangrene

Originally described in 1883, Fournier's gangrene is a rapid progressive superficial infection of the penis or scrotum, initially of unknown aetiology. However, the usual precipitating factor is superficial trauma in a patient with immunosuppression, resulting in infection which spreads between fascia planes causing tissue necrosis. *E. coli* is the commonest organisms; however, at least three different organisms are seen on microbiology assessment with the synergistic effect considered a cause for the rapid progressive symptoms. There is considerable mortality, usually from sepsis in up to 50 % [28, 29]. Urgent debridement is critical, with one study quoting a 76 % mortality if surgery is delayed by 6 days compared to just 12 % if operated upon within 24 h [30, 31].

Clinical findings are usually apparent, demonstrating a range of severity, from erythema and induration to frank gangrene and subcutaneous emphysema. The ultrasound findings are reflective of pathophysiology, with evidence of gas within the soft tissue being characteristic. On grey-

Fig. 4 A longitudinal power Doppler image of the testis demonstrating no increased Doppler signal within the testis, but hyperaemia and thickening of the epididymis. A focal avascular area within the epididymis represents an area of abscess formation (arrow)

Fig. 5 Ultrasound grey-scale image showing thickening of the scrotal wall and two focal hyper-echoic regions casting posterior acoustic shadowing (arrows), representing air; a finding seen in Fournier's gangrene

scale ultrasound images there are soft tissue hyper-echoic foci with posterior acoustic shadowing (Fig. 5). Although this finding is strongly suggestive, its absence does not exclude the diagnosis. The testis is generally unaffected secondary to blood supply derived from the testicular and deferential arteries as opposed to the pudendal artery which supplies the scrotal skin.

Traumatic

Testicular rupture

Although trauma to the scrotal sac is common, significant injury is rare, due to mobility of the testis within the scrotum. Testicular rupture occurs when there is a breach of the tunica albuginea, a thick fibrous layer surrounding the testis, with subsequent testicular extrusion; a consequence of high-impact blunt trauma. The elevated position of the right testis leaves it more prone to injury. Urgent surgical treatment is needed to preserve fertility and prevent ischaemic necrosis. Ultrasound is an accurate method of assessing for testicular rupture with 100 % sensitivity and 65 % specificity reported [32]. The tunica albuginea is seen on grey-scale ultrasound as an echogenic lining of the testis; the characteristic finding in testicular rupture is disruption of this lining with extrusion of the parenchyma. The testis may appear distorted in shape with variable echogenicity and varying degrees of haematoma, haemorrhage and ischaemia; there may be an associated haematocoele [33].

Testicular fracture

Testicular fracture is an uncommon complication of scrotal trauma, and distinct from testicular rupture, although both involve disruption of the tunica albuginea, testicular fracture indicates a parenchymal defect, which may result in haematoma or infarction. The treatment is dependent on the degree of retained testicular vascularity and can be managed conservatively or with minimal debridement of the fracture. Classically, ultrasound grey-scale images show a hypo-echoic line through the parenchyma, which may contain a haematoma of variable echogenicity within or adjacent to it, with no colour Doppler signal within the hypo-echoic fracture line (Fig. 6). However, these appearances are described in only 17 % [34]. Colour Doppler imaging guides management by determining the degree of ischaemic parenchyma which requires resection; however if parenchymal blood flow is preserved, conservative management can be undertaken [33]. CEUS may play a larger role in the future to determine the extent of viable testicular tissue and allow testis-conserving surgery [4].

Fig. 6 A longitudinal grey-scale ultrasound image in a patient following testicular blunt trauma. There is a linear hypo-echoic line traversing the testis (*arrow*) with mild heterogeneity of the surrounding parenchyma. There is also a small hydrocele and mild thickening of the scrotal wall

Haematoma and haematocoele

A haematocoele is a collection of blood between the layers of the tunica vaginalis, whereas a haematoma may occur in several locations: the epididymis, testis or scrotal wall [35]. Both haematomas and haematocoele follow a natural course of liquefaction and subsequent reabsorption. Complications can occur as both these abnormalities exert mass effect and result in compression of the testicular blood flow with subsequent ischaemia. Infection of the haematoma or haematocoele may also occur. Ultrasound appearances of haematoma and haematocoele are variable and evolve with time. Initially the appearances are echogenic and gradually over time liquefy and become anechoic, often with septations before re-absorption [33]. On colour Doppler imaging there is no signal; however, it is essential to interrogate the vascularity of the testis and expedite prompt surgery in the presence of ischaemia. CEUS is useful in this context (Fig. 7). Furthermore, a large haematoma or haematocoele may obscure the tunica vaginalis, bringing its integrity into question [36] (Fig. 8). Conservative management for scrotal haematomas less than three times the size of the contralateral testis and surgical intervention for those which are larger is generally advocated [33–36].

Miscellaneous

Acute idiopathic scrotal oedema (AISO)

Acute idiopathic scrotal oedema was originally described in 1956 and refers to swelling and oedema of the scrotal wall, occurring predominantly in the paediatric population

Fig. 7 Split screen, dual CEUS and adjacent grey-scale image demonstrating a well-defined anechoic lesion within the testis (*arrow*) which shows no vascularity on CEUS: a haematoma following blunt trauma to the scrotal sac

Fig. 8 A grey-scale longitudinal ultrasound image of the testis following blunt trauma. There is a large septated, anechoic, extra-testicular abnormality (*long arrow*), which displaces the testis in a superior direction: a haematocele. In addition there is a hypo-echoic area in the testis likely an isolated haematoma (*short arrow*)

with an average age of 6 years [37]. This phenomenon has also been described rarely in adults [38]. The pathophysiology is unclear with both infection and angio-oedema suggested as possible causes [37]. The condition is self-limiting with resolution usually within 3 days. The clinical features are unilateral pain, swelling and erythema. Clinical features are non-specific and differential diagnosis would include torsion of the spermatic cord, Fournier's gangrene and epididymitis, all entities in need of urgent treatment. Ultrasound is reliable in establishing AISO; findings are scrotal wall thickening and oedema with hyperaemia on colour Doppler imaging. A recent study suggests that

transverse imaging of the scrotal wall depicts hyper-vascularity and has been termed “fountain sign” [39]. In contradistinction to torsion of the spermatic cord and epididymo-orchitis there are normal testicular appearances.

Inguinal–scrotal Hernia

There is a male predominance for inguinal–scrotal hernias of up to 90 % [40] with an overall incidence of 4.5 % of inguinal hernias in children [41]. Often, inguinal–scrotal hernias are apparent on clinical history and examination. Most commonly, an inguinal–scrotal hernia will present as a palpable mass with indolent aching pain and less frequently as acute pain and swelling in the scrotum. Ultrasound is able to identify the presence of a hernia; grey-scale imaging relies on the presence of loops of bowel or omental fat within the scrotum. A useful sign is the presence of peristalsis, which is indicative of a hernia. However, the absence of peristalsis is an ominous sign, with a high sensitivity and specificity (90 % and 93 %, respectively [42]), for strangulation of the hernia. A further alarming sign of incarceration is hyperaemia on colour Doppler imaging of the scrotal soft tissues [43]. In addition fluid-filled bowel loops may create diagnostic difficulty and can mimic a septated hydrocele [44]. The absence of peristalsis and hyperaemia are worrying signs and should warrant urgent surgical referral.

Testicular tumour

Testicular tumours most often present as a painless, palpable lump. A described 10 % of testicular tumours present

acutely with pain, swelling or inflammation, thought due to haemorrhage or infiltration [45]. The most common tumour to present with acute symptoms is a seminoma, which infiltrates the seminiferous tubules causing obstruction [46]. Normally, ultrasound imaging findings of malignancy and inflammation are distinct, but on occasion focal orchitis may be mistaken for malignancy. While malignancy usually presents as a rounded, circumscribed mass which displaces intra-testicular vessels, focal orchitis is usually peripherally placed and crescent in shape. Secondary signs of inflammation are frequently present: scrotal wall thickening, hydrocele or orchitis. These are less likely to be present in malignancy. The overlap between malignancy and inflammation means a high level of suspicion is required, and focal testicular lesions present in inflammation should undergo repeat ultrasound to ensure resolution.

Conclusion

Although there are innumerable abnormalities of the scrotum, there are key features of the commonest and most critical disease processes. The most frequent indications for ultrasound are exclusion of torsion of the spermatic cord or epididymitis. When clinically apparent torsion of the spermatic cord is identified, ultrasound is not indicated but immediate surgical exploration should be undertaken. Only in equivocal cases should ultrasound be used to exclude other causes, with the main abnormality, epididymitis, demonstrating characteristic features on ultrasound. Epididymitis is the commonest cause of acute scrotum, with ultrasound readily able to diagnose complications such as infarction or abscess formation. The uncommon entity, Fournier's gangrene, is normally a clinical diagnosis with the catastrophic natural history making recognition a necessity; any air within the scrotal wall should warrant urgent surgical intervention. Trauma to the testis is common and the history is usually clear, ultrasound findings help to determine the integrity of the surrounding tunica albuginea and the presence complicating infarction in order to guide management. The technique of CEUS may be a useful adjuvant to ultrasound examination to ascertain the vascular status of testicular tissue in trauma. In the investigation of the acute scrotum, it is important to be aware of atypical clinical presentations. In particular, seminomas and other tumours may present acutely and mimic inflammatory conditions. It is essential to follow up cases to ensure resolution of suspected focal testicular inflammatory lesions.

Conflict of interest Gibran T Yusuf and Paul S Sidhu declare that they have no conflict of interest.

Human and animal studies The study described in this article did not include any procedure involving humans or animal.

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