INTRODUCTION

Similar to testicular abnormalities, lesions of the paratesticular space typically present with non-specific symptoms and clinical examination findings, leaving a crucial role for imaging in the diagnosis and management decision-making. Ultrasound (US) is the primary modality for evaluation of scrotal pathology, including both intra- and paratesticular abnormalities. The terms extra- and paratesticular are used interchangeably in the literature, referring to the same compartment of the scrotum. Once a scrotal lesion is detected during scrotal US, the physician needs to address the following questions: (i) is the lesion epicentre inside or outside the testicular parenchyma, thus being intra- or paratesticular; (ii) is the lesion cystic or solid, aiding proper differential diagnosis; (iii) which particular organ of the paratesticular space is affected: the epididymis, the spermatic cord or the fascial coverings. Anatomic localization of a lesion in the intra- or paratesticular space can be performed with excellent accuracy on US, reaching 100% sensitivity. Unlike intratesticular masses, the majority of paratesticular solid lesions in the adult patient are benign in nature, with only 3% prevalence of malignancy in this...
group. Cystic paratesticular lesions are typically benign. Primary paratesticular solid tumours are infrequent, with a reported prevalence of 3%-16% of all patients undergoing scrotal US. As many as 70% of paratesticular lesions are located in the spermatic cord, where lipoma is the most frequent histologic type of tumour. As a general rule, the US appearances of solid paratesticular lesions are typically non-specific and definite diagnosis is not always possible. In this review, the available literature on a wide range of paratesticular abnormalities will be presented.

2 | THE PARATESTICULAR SPACE: ANATOMY AND SCANNING TECHNIQUE

The term ‘para-testicular space’ refers to the intrascrotal compartment surrounding the testis and containing the epididymis, spermatic cord and the various fascia representing remnants of the testicular descent during foetal life. The fascial coverings of the scrotum include dartos, external spermatic fascia, cremasteric muscle, internal spermatic fascia, parietal and visceral layer of the tunica vaginalis. The paratesticular space normally contains a small quantity of fluid. As a rule, the term hydrocele should be used only when at least three aspects of the testis are surrounded by fluid. The scrotal wall should be of homogeneous thickness and echogenicity and measuring no more than 8 mm in the absence of inflammation.

There is a group of normal anatomic structures including the paratesticular appendages, which should be readily identified and not be mistaken for a paratesticular lesion. These include the following: (i) the appendix epididymis located in the superior part of the epididymis, being a remnant of mesonephric (Wolffian) duct and found in 34% of testes in postmortem studies, (ii) the appendix testis (hydatid of Morgagni), situated in the testicular surface, adjacent to the epididymal head, found in 92% of testes in postmortem studies (Figure 1), (iii) the vas aberrans or ‘organ of Haller’ is an appendage originating from the body of epididymis and (iv) the paradidymis or ‘organ of Giraldes’ connected to the vas deferens. Testicular and epididymal appendages may be solid or cystic and have a variety of shapes including rounded, ovoid or pedunculated.

The epididymis is located in the posterior aspect of the testis, formed by the efferent ductules originating from the testicular parenchyma and forming its head, body and tail. Normally the epididymis is iso- to slightly hyperechoic to the testis, with its head measuring up to 12 mm in diameter and body 4 mm, with a length normally up to 6–7 cm. The vas deferens constitutes the continuation of the epididymis tail and courses towards the inguinal canal forming the spermatic cord, along with blood vessels, lymphatic vessels, nerves and connective tissue. The arterial supply is brought by the testicular artery, branch directly from the aorta, while the venous drainage is through a venous plexus, the pampiniform plexus. The spermatic cord can be difficult to detect if normal but visualization of the testicular artery on colour Doppler can highlight this ribbon-like structure (Figure 2). Dilation of the pampiniform plexus leads to the formation of varicoceole.

An US examination of the paratesticular space employs the same basic technique as with a testicular examination. A high-frequency transducer offering adequate penetration (ideally 5–10 MHz) is used, although a curvilinear transducer may be
necessary in cases of large hydroceles or tumours. Scanning is performed with the patient in a supine position, supporting the scrotum with a towel and using warm gel, to avoid cremasteric muscle reflex. Both transverse and longitudinal views should be acquired to better assess the anatomic relationship of the various paratesticular organs and thus better localize a potential lesion. Paramedian views of the testis will better visualize the full extent of epididymis. Altering the angle of insonation may result in slight differences in epididymis echogenicity, which should not be mistaken for pathology (Figure 3).

A scanning technique to differentiate an intra-scrotal lesion is to hold the transducer steady over the lesion under investigation and push the testis downwards in real time. If the lesion closely follows the testis, this suggests it is intratesticular, whereas if it does not, it is likely a paratesticular lesion (12). Palpation of the clinical finding in real time during the US examination is always helpful to better localize the lesion on US (10).

3.1 Hydrocele

The presence of fluid inside the tunica vaginalis is termed a hydrocele and can be either congenital, resulting from incomplete closure of the processus vaginalis, or acquired, related to infection, trauma or tumour. Congenital hydroceles are typically seen in the paediatric population, as the majority of them will resolve by 18 months of age (Figure 4). Hydrocele fluid is typically anechoic although occasionally echogenic debris can be visualized. If echogenic septations and extensive echogenic debris are present, a haematocele can be suspected, representing the accumulation of blood inside the tunica vaginalis, particularly in the setting of trauma or surgery (Figure 5). In the setting of inflammatory processes of the epididymis and testes, pus can accumulate in the paratesticular space, termed pyocele (Figure 6) or abscess, with the latter being usually focal and heterogeneous in echogenicity (Figure 7). Gas bubbles may complicate the US findings, appearing as bright echoes associated with shadowing and should not be mistaken for calcifications. If a pyocele or scrotal abscess extend to the perineum, then Fournier gangrene occurs, a life-threatening inflammatory condition.20-22

3.2 Inflammatory lesions: epididymitis and abscess

Inflammation of the epididymis (termed epididymitis) may be acute or chronic, with different pathogens affecting different age groups
Epididymitis in young men is usually caused by \textit{Neisseria} gonorrhoeae and \textit{Chlamydia trachomatis}, while older men are affected by \textit{Escherichia coli}, with a retrograde direct extension of pathogens from the lower urinary system being involved. Chronic cases are typically granulomatous in terms of histology and caused by pathogens such as tuberculosis, brucellosis or other parasitic or fungal infections. Infection is usually limited in the epididymis, but 20\%-44\% of cases will present with epididymo-orchitis. US will demonstrate enlargement, echogenicity heterogeneity and hyperaemia of the epididymis, frequently coexisting with hydrocele, pyocele and oedema of the adjacent scrotal wall. Typically, an inflamed epididymis will appear hypoechoic but hyperechoic areas can be seen in case of haemorrhage. It should be kept in mind that hyperaemia can be present before greyscale abnormality of the organ and may thus be the earliest finding of epididymitis. In chronic cases, calcifications, hydrocele, scrotal wall thickening and fistula formation may occur, while indentation of the epididymis on the testicular surface can be seen, mimicking a neoplastic lesion.

The genitourinary system is a common extra-pulmonary site of tuberculosis. Tuberculous inflammation of the epididymis manifests, on US, with enlargement and a heterogeneous echogenicity caused by fibrotic component, necrosis, granulomas and calcifications (Figure 9). Sarcoïdosis of the epididymis is another cause of chronic granulomatous epididymitis, with 5\% of sarcoïdosis patients having involvement of the epididymis in an autopsy series. Sarcoïdosis can take the form of either a solitary lesion or more frequently, multiple small lesions affecting both sides.

Fibrous pseudotumour represents a reactive fibrous inflammatory condition, rather than a true neoplasia and consists of a benign fibro-inflammatory reaction of tunica vaginalis or tunica albuginea leading to formation of one or multiple nodules (Figure 10). It is considered the third most common paratesticular mass, following lipoma and adenomatoid tumour. Occasionally fibrous pseudotumour nodules can be large, reaching 8 cm in diameter, mimicking malignant lesions, but sometimes this entity may present with diffuse thickening of the testicular capsule and epididymis. There is no specific age predilection, and the condition has been associated with history of infection or trauma but is still poorly understood. US can depict the fibrous pseudotumour mass as a solid lesion of variable echogenicity, attached or located closely to the testicular surface. Calcification commonly occurs, generating acoustic shadowing. Alternatively, a fibrous pseudotumour will present as multiple hypoechoic masses,
potentially with calcifications.\textsuperscript{7,11} Doppler techniques only rarely show internal blood flow signals. Hydrocele can be seen in almost 50% of patients, while a third report a previous episode of epididymo-orchitis.

Contrast-enhanced ultrasound (CEUS) has been used to evaluate paratesticular lesions and differentiate tumoural from inflammatory entities, as a complementary technique to greyscale and colour Doppler technique.\textsuperscript{36} Both CEUS and colour Doppler US showed good agreement in the assessment of vascularity of a paratesticular lesion. Tumoural and inflammatory lesions differed in terms of echogenicity with the former being more often iso-echoic and the latter mixed in echogenicity, but a hypoechoic pattern of echogenicity was seen in both categories. The presence of vascularity on colour Doppler US yielded no significant difference between the two categories but the diagnosis of abscess was strongly associated with no vascularity on both colour Doppler US and with CEUS. With optimal contrast resolution, CEUS better delineated the absence of vascularity in the necrotic core of an abscess.\textsuperscript{36}

### 3.3 Epididymal and spermatic cord cyst

Up to 40% of asymptomatic men have an epididymal cyst, this being the commonest epididymal mass and paratesticular lesion (Figure 11). On histology, epididymal cysts can be either truly cystic, contain serous fluid lined with epithelium or represent obstructed and dilated efferent tubules, justifying the term spermatocele. If the processus vaginalis fails to obliterate in a focal point, this will lead to the formation of a cystic space representing a spermatic cord cyst (Figure 4).\textsuperscript{37,38} On US, these cysts are anechoic, well-defined and avascular and show posterior acoustic enhancement. If large in size, these cysts may have septations, resembling a chronic hydrocele, differentiated by the tendency for a large cyst to displace the testis whereas hydrocele tends to envelop the testis.\textsuperscript{39} The size of epididymal cysts ranges from <1 to 9 cm, potentially mimicking a hydrocele. If an episode of haemorrhage has previously occurred, echogenic internal debris may render the cyst echogenic, mimicking a solid lesion (Figure 12). CEUS is expected to be helpful as the absence of enhancement will confidently establish the cystic nature of the lesion. Cysts may also be located in the appendix epididymis.\textsuperscript{12}

### 3.4 Lipoma

Lipomas account for almost 50% of spermatic cord tumours, although they can originate from any part of the scrotum and considered the most frequent paratesticular space lesion.\textsuperscript{9} They may be found at any age and varying sizes have been reported.\textsuperscript{40} On US, they are typically hypoechoic but this finding is of low sensitivity and specificity as these tumours may occasionally be hypoechoic (Figure 13). This variability in echogenicity reflects the histologic composition of these...
tumours which can contain varying proportions of fibrous, myxoid, vascular tissue and interstices. Lesions with complicated appearance are difficult to differentiate from the malignant counterpart of liposarcoma and surgery is often performed.\(^3\)\(^8\),\(^4\)\(^1\) The presence of internal septa separating fat lobules may be visualized on US as hyperechoic linear interfaces. On colour Doppler US, lipomas are avascular.\(^3\)\(^5\)

### 3.5 | Adenomatoid tumour

Adenomatoid tumour is the second most frequent lesion of the epididymis and accounts for a third of all paratesticular lesions (Figure 14). It is solid, benign and usually diagnosed in men aged between 20 and 50 years.\(^4\)\(^2\)-\(^4\)\(^5\) It is a hamartomatous neoplasm, likely of mesothelial origin. US will demonstrate a rounded or ovoid, homogeneously hyperechoic lesion of well-defined border and a size of up to 7 cm.\(^4\)\(^6\) Adenomatoid tumours affect the epididymal tail four times more frequently than the head, but can be found in any aspect of the epididymis, the spermatic cord or the tunica vaginalis. Rarely, these tumours originate from the tunica albuginea and follow an intratesticular mode of expansion, mimicking a testicular neoplasm.\(^4\)\(^7\) On colour Doppler US, adenomatoid tumours typically show no increased blood flow, except for larger tumours which may demonstrate some vascularity.\(^1\)\(^1\),\(^3\)\(^6\) A CEUS examination is a more sensitive for the investigation of adenomatoid tumours, demonstrating increased enhancement similar or higher than the adjacent testis. The enhancement on CEUS correlates with the number of vessels detected on colour Doppler US.\(^3\)\(^6\) The enhancement of these lesions on CEUS, in combination with increased stiffness on elastography, has been reported in the setting of multi-parametric US.\(^4\)\(^7\) A hydrocele may accompany this type of tumour, reported in up to 20% of cases.\(^6\)

### 3.6 | Leiomyoma

Leiomyoma is a benign tumour originating from mesenchymal cells responsible for smooth muscle formation and the third most frequent neoplasm of the epididymis. On US, these lesions present as solid well-defined masses of variable echogenicity, occasionally containing punctate calcifications, an area of central necrosis or cystic spaces.\(^4\)\(^8\) The visualization of alternating linear areas of high and low echogenicity has been attributed to this type of lesion, termed ‘whirling pattern’ and stems from the histologic array of interfacing bundles of smooth muscle cells. Colour Doppler US may find some blood flow signals but this is an unreliable diagnostic criterion.\(^6\),\(^1\)\(^1\) In terms of size, leiomyomas usually range between <1 and 3 cm.\(^7\)

Angioleiomyoma is a similar histologic type of tumour, with the difference of containing small vessels and multiple ectatic vessels.\(^4\)\(^9\) This results in the visualization of avid blood flow signals on colour US.
Doppler US, within a hypoechoic solid lesion. The hyperaemia of this tumour may be mistaken for epididymitis or a malignant lesion, so it is a non-specific diagnostic feature.

3.7 | Papillary cystadenoma of the epididymis

This rare benign tumour is sporadic or associated with von Hippel-Lindau disease and is commonly solid and echogenic or may contain discrete cystic spaces rendering it more heterogeneous in echogenicity (Figure 15). Alternatively, cystadenomas may be multi-loculated cystic masses with small papillary projections and a thickened irregular wall. A minimum size criterion of 10 x 14 mm and slow growth have been suggested as diagnostic for this type of neoplasia in patients with von Hippel-Lindau disease.

3.8 | Paratesticular haemangioma

Hemangiomas may arise from the paratesticular space, namely the spermatic cord or the scrotal wall, typically affecting infants and in fewer cases older children and adolescents. Three distinct histologic types have been reported: capillary, cavernous or arteriovenous, leading to different imaging characteristics. Cavernous and arteriovenous hemangiomas are characterized by tortuous blood vessels, mimicking a varicocele. Capillary hemangiomas appear more solid and soft-tissue like, with posterior acoustic enhancement (Figure 16).

3.9 | Polyorchidism

Supernumerary testes may rarely be found, following an abnormal division of the genital ridge, usually situated inside the scrotum but sometimes in the retroperitoneum or the inguinal canal. Typically, there is only one supernumerary testis but up to five have been reported in cases of polyorchidism (Figure 17). Each supernumerary testis may share the epididymis and vas deferens with the ipsilateral testis or these may also be duplicated. There is an association with an increased prevalence of carcinoma and susceptibility to torsion, with increased mobility. On US, supernumerary testes will show an identical echogenicity to the adjacent normal testis, while colour Doppler US will demonstrate normal transmediastinal blood vessels, although in most cases supernumerary testes appear less vascular than the native testis. If a US contrast agent is administered, the supernumerary testis will demonstrate an identical enhancement pattern with the native testis.

3.10 | Splenogonadal fusion

Splenogonadal fusion may be very rarely found connected with the testis or vas deferens, a condition termed ‘splenogonadal fusion’. It typically involves the left side and can coexist with cryptorchidism, inguinal hernia or other congenital abnormalities of the heart, limbs and face. On US, a mass will be visualized attached to the testis, having similar or lower echogenicity, an appearance often misleading for polyorchidism (Figure 18). CEUS and elastography have been used to characterize this entity, concluding that splenic tissue shows increased stiffness and early arterial and prolonged contrast enhancement, features very different from those of the adjacent testicular parenchyma.

3.11 | Hernias

Inguinal hernias may clinically present as scrotal enlargement leading to US investigation. These can be classified into direct if protruding...
through the Hesselbach triangle, due to abdominal wall weakness in adult patients, or indirect if protruding through the internal inguinal ring, typically associated with patent processus vaginalis in children. The inferior epigastric artery can be used as a diagnostic landmark, being found laterally in direct hernias and medially in indirect. The US appearances of an inguinal hernia depend on its contents, with bowel loops being readily recognized as fluid-filled peristaltic structures potentially containing echogenic gas bubbles (Figure 19). Hernias containing omental fat can be subtle and difficult to differentiate from lipomas, although they are less well-defined, more elongated and can be tracked up their origin from the abdominal cavity.2

3.12 | Scrotal calculi

The term ‘scrotolith’ (also known as scrotal pearl or scrotal calculi) refers to calcified structures free-floating inside the tunica vaginalis

(Figure 20). These may either originate from previously undiagnosed torted appendices or from the deposition and aggregation of inflammatory deposits.59 US depicts a scrotolith as one or multiple mobile echogenic rounded lesions with acoustic shadowing, ranging from a few millimetres to more than a centimetre (Figure 20). A hydrocele may be associated with scrotoliths, potentially resulting from repeated trauma and rendering their visualization easier.

4 | MALIGNANT ENTITIES

As the spermatic cord consists of tissue embryologically deriving from the mesoderm, most malignant tumours are sarcomas.60 Rhabdomyosarcoma and liposarcoma are the commonest types, with the former showing a predilection for children and the latter for adults.61 Metastases from kidney, prostate, pancreas and the gastro-intestinal tract have also been reported, with past medical history being the most important for diagnosis. The suspicion that a paratesticular mass is malignant should be raised for rapidly growing masses, which can cause pain. Worrying US features include poorly defined margins, invasion of adjacent structures, disorganized internal echotexture and increased blood flow on colour Doppler US. Nevertheless, there is significant overlap between benign and malignant paratesticular lesions and thus US will often not be able to confidently make a diagnosis inevitably leading to surgical excision.5

4.1 | Rhabdomyosarcoma

This type of tumour can occur anywhere in the body with less than 10% affecting the paratesticular tissues. Rhabdomyosarcomas of the paratesticular tissues affect the paediatric age group with a peak at 5 years and a second peak at 16 years of age, accounting for 40%
of all malignant paratesticular neoplasms. These are aggressive malignant tumours with 70% of them presenting with retroperitoneal lymphadenopathy and 20% haematogeneous metastases to the lungs and bones. On US, these tumours may be homogeneous in the early stages, but are typically diagnosed as large masses of heterogeneous echogenicity with cystic or necrotic spaces (Figure 21). The size of the lesion varies greatly from 1 to 20 cm and colour Doppler US usually demonstrate increased vascularity and low resistance waveform on spectral interrogation.

### 4.2 Liposarcoma

Liposarcomas represent the malignant counterpart of lipomas with similarities in appearance but a more complicated structure. This tumour usually affects older patients than a rhabdomyosarcoma, with a mean age of 56 years. US findings are non-specific and vary from a solid hypoechoic mass to one with highly echogenic areas of adipose tissue and occasionally calcifications. The margin of these tumours can be well circumscribed or encapsulated and a distinct lobulated pattern may be visible. Doppler US demonstrate high vascularity within the lesion (Figure 22). An important role for diagnosis remains with CT and MR imaging, which is able to depict the macroscopic fat contained in these lesions. Surgical resection will be frequently curative, but a quarter of these patients will develop a local recurrence. The majority of these tumours are well-differentiated but with high-grade tumours, 10% will develop metastatic disease. Abnormal lymph nodes are present in almost 40% of cases. CEUS has also been used to assess liposarcoma of the spermatic cord, showing peripheral enhancement and central non-enhancing necrosis. A retroperitoneal concurrent liposarcoma showed a more heterogeneous enhancement with patchy, internal foci of necrosis. On quantitative analysis, the de-differentiated retroperitoneal liposarcoma showed higher peak enhancement compared with the spermatic cord well-differentiated liposarcoma. The information provided by CEUS on the enhancement pattern of liposarcoma could be used to potentially grade these tumours.

### 4.3 Leiomyosarcoma

Leiomyosarcoma constitutes the malignant counterpart of leiomyoma, originating from smooth muscle cells and typically involves the spermatic cord of men in their sixth decade of life. Histological heterogeneity of these tumours due to haemorrhage and necrosis is reflected on the US heterogeneous of these lesions, usually showing hypervascular solid components, hypo and hyperechoic parts.

### 4.4 Malignant fibrous histiocytoma

Malignant fibrous histiocytoma or undifferentiated sarcoma is another rare paratesticular sarcoma, usually affecting men in their sixth decade, similar to leiomyosarcoma. As it is the case with other sarcomas, imaging findings are non-specific and are those of a large heterogeneous solid tumour with necrotic parts and calcifications. Colour Doppler US will show increased vascularity, similar to other types of sarcomas.
4.5 | Mesothelioma

The tunica vaginalis consists of mesothelial cells which rarely give rise to mesothelioma. This tumour is related to asbestos exposure, typically affects men around 53 years old although younger ages can also be affected. On US, mesothelioma will present as simple or echogenic hydrocele in combination with multiple soft-tissue nodules or masses involving the tunica vaginalis or tunica albuginea surface. The largest nodules may be hypervascular on colour Doppler US.\(^7^0\)\(^7^2\)

4.6 | Lymphoma and leukaemia

Genital tract lymphoma is typically seen in the testis but the epididymis and the spermatic cord can also be affected in 60% and 40% of cases, respectively.\(^7^3\)\(^7^4\) Testis is usually a site of recurrence for lymphoma, although it can be rarely the primary site. The infiltration of tissue can be microscopic and thus invisible on imaging or macroscopic and present with nodules or diffuse enlargement and heterogeneity. Differential diagnosis of a diffusely enlarged and heterogeneous epididymis should also include sarcoidosis and tuberculosis. These entities rarely affect the testicular parenchyma, unlike lymphoma where testis is usually affected primarily. If focal, haematopoetic malignancy lesions are hypoechoic and infiltrative to adjacent structures. A potential characteristic feature for this type of malignancy is that blood vessels are not disrupted or distorted by the infiltrative lesion, unlike with other malignancies. This finding can be seen both in paratesticular and intratesticular foci of haematopoetic malignancies (Figure 23).

5 | CONCLUSION

The paratesticular space is affected by a wide spectrum of inflammatory and neoplastic diseases, all presenting with non-specific symptoms and clinical findings, leaving an essential role for diagnosis to US. Most of the paratesticular abnormalities have overlapping imaging appearances, with a definite diagnosis being often possible only on histology. Nevertheless, US is valuable for accurate localization of a lesion, characterization of its solid or cystic nature and represents an integral part of the diagnostic algorithm of paratesticular pathology.

CONFLICT OF INTEREST

No conflicts of interest from any author.

AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript; research design (VR, DH, PSS), acquisition, analysis and interpretation of data (VR, DH, PSS) drafting the paper (VR, PSS), critical review (VR, DH, PSS), approval of submitted and final versions (VR, DH, PSS).

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