AUDIT OF ULTRASOUND IN ADULT PATIENTS PRESENTING WITH SCROTAL PATHOLOGY AT CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in Diagnostic Radiology.

Johannesburg, 2022

Declaration

I, Nkosi Winile , declare that this research report is my own work. It is being submitted for the degree of MMed (RadD) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

DR NKOSI WINILE

On this 30th day of May 2022

To my daughters, Buhlebetfu and Siyanda for being my cheerleaders.

Publications and presentations

This work has never been published.

It has never been presented at a congress.

Abstract

INTRODUCTION: Scrotal ultrasound is one of the most frequently requested and performed radiological procedures worldwide (1-3). It is cheap, easily accessible and can significantly reduce the morbidity and mortality if prompt diagnosis and treatment are provided.

Scrotal pain accounts for 2.5-3.1 % of all annual outpatient urology visits (2, 4). The most common causes of scrotal pain are torsion of the testis or testicular appendage, infection (i.e. epididymitis/orchitis), vascular pathologies (for example varicocoele), hydrocoele, and trauma (2, 4) . Testicular malignancies account for less than 2 % of all malignant neoplasms in men but are the most frequent solid tumour in young male adults below the age of 35 (5-8).

AIM: To determine the frequencies and percentages of the most common scrotal symptoms and scrotal ultrasound findings in adult patients presenting for ultrasound imaging at Chris Hani Baragwanath Academic Hospital.

METHOD: Reports of all scrotal ultrasounds completed at Chris Hani Baragwanath Academic Hospital from the 1st of January 2020 - 31st of December 2020 were retrospectively reviewed. The indication and the findings of each ultrasound were recorded. Subjects were then categorized based on corresponding indications and ultrasound findings.

RESULTS: A total of 267 scrotal ultrasounds were performed with 141 studies meeting the inclusion criteria. The presenting symptoms were swelling in 78 of 141 (55.3%), pain in 45 (31.9%) and a mass in 31 (22.0%) (the percentages will not add up to 100% as 21 (14.9%) patients presented with more than 1 symptom) . Patients who presented with benign pathology were 131 of 141 (92.9%) ,10 (7.1%) had normal findings and no malignant findings.

Findings that are an indication for surgical intervention were demonstrated in 15 of 131 (11.5%) of the patients.

CONCLUSIONS: Routine scrotal ultrasound places a significant burden on radiology services in our clinical setting. In view of the significant percentage of benign and normal ultrasounds with only 11.5% presenting with organ-threatening pathology, the referring clinicians should reconsider which patients to send for imaging based on their clinical findings and assessment.

Acknowledgements

My supervisors Dr Jacinta Adrigwe and Dr Susan Lucas for sacrificing their time, input and for polishing the end product.

My beautiful daughters Buhlebetfu and Siyanda for being my cheerleaders and making me coffee and snacks even when I did not need it, for being less demanding and understanding while I pursued my dreams.

My sister Esther for proofreading and helping me with the statistics.

My sisters Ayanda, Anele and Fikile for their sleepless nights and helping me with the technical stuff.

My brothers Joel and Absalom for supporting me financially while I pursued my dreams.

My parents Dorica and Velaphi for their guidance, unconditional love and unwavering support.

Aubrey Chauke for helping with PACS-related issues.

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List of Abbreviations and Terminology

AFP	Alpha-fetoprotein
ADC	Apparent diffusion coefficient maps
CEUS	Contrast enhanced ultrasound
CFD	Colour flow doppler
CT	Cat scan
D/C	Discharge
DWI	Diffusion weighted imaging
ESUR	European Society of Urogenital Radiology
FoV	Field of view
F/U	Follow-up
GCT	Germ cell tumour
hCG	Human chorionic gonadotropin
HREC	Human Research Ethics Committee
LDH	Lactate dehydrogenase
MHz	Megahertz
MRI	Magnetic resonance imaging
MRN	Medical record numbers
PACS	Picture archiving and communication system
RF	Risk factors
RTE	Real-time elastography
TB	Tuberculosis
TE	Echo time
TML	Testicular microlithiasis
TNM	Tumour, nodes, metastasis
TR	Repetition time
T2 *	T2 star
T1WI	T1 weighted imaging
T1WI	T2 weighted imaging
US	Ultrasound
USB	Universal Serial Bus

1. Introduction

Scrotal ultrasound is one of the most frequently requested and performed radiological procedures worldwide (1-3). It is cheap, easily accessible and can significantly reduce morbidity and mortality if prompt diagnosis and treatment are provided.

Scrotal pain accounts for 2.5-3.1 % of all annual outpatient urology visits (2, 4). The most common causes of scrotal pain are torsion of the testis or testicular appendage, infection (i.e. epididymitis/orchitis), vascular pathologies (for example varicocoele), hydrocoele and trauma (2, 4). Testicular malignancies account for less than 2 % of all malignant neoplasms in men but are the most frequent solid tumour in young male adults below the age of 35 (5-8).

1.1 Most common scrotal pathology

Epididymitis is the most common inflammatory process although concomitant orchitis occurs in 20% (9, 10). It is more common in adults and is typically caused by urinary tract pathogens or sexually transmitted organisms (chlamydia or gonorrhoea). In children, it is due to infection with Streptococcus, Staphylococcus and E. Coli(11).

It is seen in about 31 %- 80% of patients presenting with an acute painful tender scrotum (1, 3, 12).

Isolated orchitis is rare and commonly secondary to mumps infection in prepubertal boys (13 years or younger) (3, 9, 10, 13).

In 2002 epididymitis or orchitis accounted for 1 in 144 outpatient visits (0.7 %) in men 18 to 50 years of age(1). There are approximately 600,000 cases of epididymitis per year in the United States, most of which occur in men between 18 and 35 years of age (13). In one study of U.S. Army soldiers by Mittemeyer Lennox K.W and Borski A.A, the incidence was highest in men between 20 and 29 years of age (14). In a review of 121 patients with epididymitis in the ambulatory setting, a bimodal distribution was noted with the peak incidence occurring in men 16 to 30 years of age and 51 to 70 years of age (13).

1.2 Indication for scrotal imaging and common presentations

1.2.1. Scrotal pain with or without a palpable mass

1.2.1.1 Testicular torsion

It is one of the most common causes of an acute painful tender scrotum seen in less than 25% of boys younger than 17 years (15-18). Flow restoration within the first 6 hours has a 90-100% salvage rate, however, this rate decreases to 0-20 % after 24 hrs (3, 9, 15, 18-20). If surgical detorsion cannot occur in less than 72 hours, manual detorsion should be considered.

The ultrasound findings depend on the duration of the symptoms. If clinically suspected and the US is normal or is suggestive of epididymitis or orchitis, rescanning the patient after 20-30 minutes is advised (12, 19).

Images of the twisted vessels have been described in colourful terms such as 'whirlpool' or target sign resembling a 'snail shell'.

In the acute phase (first 6 hours of torsion):

Normal duplex and colour flow doppler (CFD) in the testis itself (1).

Complete or reduced flow on a slow flow colour doppler supports the diagnosis of testicular torsion (figure 2 B). Up to 720 degrees of rotation of the spermatic cord may be required for complete torsion(19).

Duplex doppler and colour flow doppler have an accuracy of 95.5 - 97 % with a sensitivity of 85-95 % and a specificity of 96-100 % (1, 19, 21, 22).

Colour doppler has a sensitivity of 95 -100 % and specificity of 85-95 % for testicular torsion.

The evidence of a twisted spermatic cord is more sensitive than a colour doppler according to Kalfa et al (15).

Nuclear medicine: The upper pole of the involved testes may demonstrate an increased activity or appear normal

Most of the time we do the ultrasound to exclude a testicular torsion since the appendicular torsion might not be evident on sonar (1).

1.2.1.2 Epididymitis and epididymo-orchitis

It is the most common inflammatory process. In 50% of patients with epididymitis or orchitis, the urinalysis is normal (12, 19, 23).

Ultrasound findings: Ultrasound has a sensitivity of 95-100% and a specificity of 94% (3, 12). Peripheral, hypoechoic, ill-defined, amorphous or crescent-shaped testicular lesions. Enlarged and hyperaemic testis. Inhomogeneous, hyperaemic, enlarged epididymis. Hydrocoele and scrotal wall thickening are common (Figures 1A and 1B).

Contrast-enhanced ultrasound (CEUS): will reveal a lesion with intense, peripheral contrast uptake while the centre of the lesion shows no uptake (24).

Nuclear medicine: increased flow in the dynamic perfusion images and intense increased blood pool in the sequential static images in the involved side. Inflammatory changes, abscesses, haemorrhage and some tumours may result in a hyperaemic rim with a photopenic center and a significantly increased flow to the testis compared to testicular torsion.

Magnetic resonance imaging (**MRI):** will show a high signal intensity on T2WI, increased diffusion and inhomogeneous enhancement. Tuberculous (TB) orchitis will show low T2 and high T1 with strong enhancement, in the right clinical setting it should be considered in the differential diagnosis (21).
Epididymo-orchitis can be complicated by abscess or pyocele formation, ischaemia, chronic epididymitis or infertility (10, 16, 18, 20, 22). Global testicular infarction following epididymo-orchitis is extremely rare (10).

1.2.1.3 Varicocele

Varicocele represents dilated, tortuous veins within the pampiniform plexus. In 98% of cases, it occurs on the left because the testicular vein is longer and connects to the left renal vein at 90 degrees (3, 5, 18-20). It is bilateral in 70% of cases (5). It is found in 15- 25% of males and most do not have infertility issues (1, 3, 25). It may be idiopathic secondary to incompetent testicular vein(s) valves and is seen in 33.3 - 45% of infertile men (1, 5, 20). The idiopathic type is one of

the most common surgically correctable form of male infertility (18). It is more common in 15 to 25-year-old men (5). Sperm counts improve by 70-80% post-surgery (1).
Secondary varicoceles are caused by severe hydronephrosis, hepatomegaly or cirrhosis, abdominal neoplasm or compression of the left renal vein by the superior mesenteric artery, thrombosis of the inferior cava or pressure on the spermatic vein in the retroperitoneum by a mass (3, 5). It should be suspected in a patient presenting with right varicocele or newly diagnosed in a patient older than 40 years. Subclinical varicoceles can be diagnosed by an ultrasound which has a high sensitivity (>90%) (1).

Ultrasound findings: Multiple tubular cystic structures radiating from the mediastinal testis to the periphery of the testicular parenchyma. Duplex Doppler and colour flow doppler (CFD) interrogation show a low-flow venous pattern (Figure.2D). The veins increase in size with Valsalva manoeuvre and when the patient stands up. However, secondary varicocele is not affected by position (5).

1.2.1.4 Hydrocoele

Of the causes of scrotal swelling, hydrocoele is the most common one. It may be bilateral or unilateral (3).
It is demonstrated in about 19.2% of patient presenting with scrotal pain (25) .
Because of its posterior attachment to the scrotal wall and epididymis, fluid accumulates laterally and anteriorly to the testis. Hydrocoeles may be simple (serous) or complex (haematocele, pyocele).
A simple hydrocoele can be idiopathic or be secondary to continuing communication between the scrotum and peritoneal cavity via a patent processus vaginalis. It usually resolves by a year and a half of age (1).
Acquired hydrocoeles are the results of trauma, surgery, acute epididymo-orchitis and less commonly a testicular tumour.

Ultrasound findings: Simple hydrocoeles are anechoic (Figure 3E).
Complex hydrocoeles may contain lots of internal echoes with septations and loculations and when chronic, calcifications (Figures 3 A and 3 B)(2)

1.2.1.5 Scrotal trauma

Genitourinary tract injuries account for 3-10% of trauma patients (23). Injuries range from complete rupture to haematomas, haematocele or dislocation. Scrotal trauma is more prevalent in males 10-30 years of age (23). It may be caused by blunt or penetrating trauma. Blunt trauma accounts for 85% of testicular injuries. 48.5% of these cases result in testicular rupture or other serious complications (23). A retrospective evaluation of 44 patients with blunt scrotal trauma conducted by Chandra et al. found that 2 out of 3 patients with blunt scrotal trauma and clinical haematocele had testicular rupture (23). Cass and Luxemburg reported orchiectomy rates of 6% with early exploration versus 45% when surgery is delayed in cases of testicular rupture (23).

It is of paramount importance to be able to tell if the testis is intact or ruptured. Rupture of the testis as a result of trauma is a surgical emergency. If surgery takes place within 72 hours, the salvage rate is about 80-90% (1-3, 12, 20, 23) compared to only 30-45% after 72 hours (5, 23). Complications such as infertility, delayed orchiectomy, infection and testicular atrophy can be prevented if prompt surgery ensues. Trauma can predispose to testicular torsion (1, 19, 23). Due to scrotal swelling and severe pain, it is difficult to assess these patients clinically. The American Urologic Association and European Association of Urology guidelines recommend ultrasound in blunt scrotal trauma and early exploration in penetrating injuries due to the high incidence of testicular rupture.

Ultrasound findings: Irregular testicular contour is the most significant predictor of testicular rupture with a sensitivity and specificity of 90% as well as positive and negative predictive values of 82 and 94 % respectively (23).

Inhomogeneous echotexture secondary to haemorrhage and infarction (5, 20, 23).

A discrete fracture plane depicted as a linear hypoechoic line within the testis with or without disruption of the tunica albuginea is identified in less than 20% of cases (3, 11, 12, 20).

In testicular rupture, protrusion of testicular contents beyond the normal margin of the testis may be seen. The sensitivity of the diagnosis of rupture based on the disruption of the tunica alone is 50% (5).

When there is extratesticular haemorrhage, it may be hard to diagnose testicular rupture. CFD is useful in differentiating vascularised testis as opposed to avascular haematoma. Rarely, trauma may be isolated to the epididymis with an epididymal haematoma and a relatively normal appearing testis.

The presentation of a haematocele will differ depending on the age of the haematoma. Initially, the blood appears echoic with thick septations that displace the testis posteriorly. As the clot lyses, the echogenicity decreases and the septations become thinner. Chronically a haematocele can fibrose or calcify

Contrast-enhanced ultrasound (CEUS) has higher resolution and better definition of margins compared to non-contrasted grey scale ultrasound. It is valuable in patients with minor trauma or when conventional sonar is inconclusive or negative. It has a sensitivity and specificity of 95 and 100% respectively.

The testicle will be clearly hypoechoic and hypoperfused (16, 23).

Magnetic resonance imaging (MRI)

MRI has a 100% diagnostic accuracy for testicular rupture (21, 23, 26). It eliminates the need for unnecessary surgery, subsequent surgical morbidities and helps to diagnose minor tears in tunica albuginea. It takes about 15 minutes to perform and there is a significant cost saving from avoiding unnecessary surgery (23).

Disruption of the tunica albuginea appears as a distinct break in the dark signal intensity line on T2WI.

CT SCAN

This is not the modality of choice in assessing scrotal trauma because it has lower soft tissue contrast resolution and there is the risk of radiation to the gonadal tissue.

Rupture of the tunica albuginea, protrusion of the seminiferous tubules and testicular dislocation can be visualised on CT (23, 26). A Testicular dislocation occurs in < 0.5% of abdominal trauma (23).

1.2.2. Scrotal mass (incidental or palpable painless mass)

The vital thing is to determine if the mass is intra-testicular or extra-testicular.

US in most cases will limit the differential consideration, most importantly by ascertaining cysts, cyst-like lesions and other benign entities with a typical appearance.

It is important to inform the referring physician if the findings are suspicious of a malignant neoplasm. Further management of testicular masses depends on adequate histopathologic characterisation through biopsies which are impossible at times. In most cases, an orchiectomy is performed.

1.2.3. Isolated retroperitoneal lymphadenopathy

The most common causes of isolated retroperitoneal lymphadenopathy are testicular cancer, metastases, lymphoma and extragonadal germ cell tumours. Testicular US is frequently used as a screening tool in such cases. In case of testicular cancer, for which retroperitoneal nodes are the first lymphatic draining points and considered regional spread (i.e. “N”) in the TNM staging system, the spatial distribution of the retroperitoneal disease allows for some suggestions on the side of the testicular primary. Left-sided tumors typically metastasize to left periaortic and preaortic nodes, while right-sided cancers metastasize to nodes around the inferior vena cava, including inter-aortocaval nodes (17).

The following facts might be helpful while interpreting these scans:
Some types of primary testicular cancers, although widely metastatic, might be very small or involuted. On imaging, these primary tumors can be undetectable or appear as small masses or focal calcifications, a phenomenon that has been referred to as a “burned-out” primary tumour.
High levels of serum tumor markers, such as alpha-fetoprotein (AFP), human chorionic gonadotropin (hCG), and lactate dehydrogenase (LDH) are produced by some testicular cancers (17). These high levels may assist the radiologist to interpret questionable imaging findings, although of limited sensitivity and specificity.

1.2.4. Follow-up after curative treatment of testicular cancer

Patients with treated testicular cancer have a ≥10-fold increased risk for developing contralateral metachronous cancer with a 15-year cumulative incidence of 1.9% (17).
Most recurrences occur within the first 2 years after treatment. Late relapses, although less common, have been reported more than 5 years after treatment (17).
Retroperitoneal lymph nodes are the most common sites of recurrence. Follow-up studies, especially computed tomography (CT), often spare the pelvis to minimize radiation dose.
CAVEAT: In patients with any kind of surgery involving the scrotum or inguinal canal (e.g., hernia repair, orchiopexy, or others), lymphatic drainage is altered, and recurrences can occur in variable anatomic patterns, including inguinal lymph node involvement (17).

Metastases to the lung is the most common site in patients who were treated with retroperitoneal lymph node dissection (17), and CT of the chest is more sensitive and specific for their detection than radiographs.
Long-term risk for secondary malignancies (such as stomach, oesophagus, colon, urinary bladder, pancreas, lung, and malignant mesothelioma of the pleura) is increased after chemo- and/or radiotherapy (17)

1.3 Modalities used in scrotal pathology

1.3.1 Ultrasound (US)

Scrotal ultrasound is one of the most frequently requested and performed procedures worldwide. It is cheap, easily accessible, and can significantly reduce morbidity and mortality if prompt diagnosis and treatment are provided.

1.3.2 Contrast-enhanced ultrasound (CEUS)

Second generation microbubble contrast agents and very low mechanical index has been recently applied to provide information on the testicular vascularity. It allows visualisation of the testicular microvascularisation and aid in the preoperative assessment of the testicular lesions. Hypervascularization and hyperenhancement of the testicular lesion is important in the diagnosis of cancer with a positive predictive value of 97.4% (5, 11).

1.3.3 Sonoelastography

This provides information on tissue elasticity (5). Benign lesions are soft with normal or decreased tissue stiffness. Stiff or hard lesions are suspicious of malignancy (27). It has 87.5% sensitivity and 98.2% specificity in differentiating malignant from benign lesions.
Real time elastography (3) was evaluated for differentiating non-obstructive from obstructive azoospermia in a large patient cohort with promising results (5).

1.3.4 Magnetic resonance imaging (MRI)

Basics of MRI sequences

- T1 weighted imaging (T1WI) highlights differences in the T1 relaxation times. The parameters are set (short repetition time and echo time) to minimize T2 relaxation

effects. Fluid will appear dark and fat-containing tissues will appear bright on T1WI. This is good for demonstrating anatomy.

- T2 weighted imaging (T2WI) highlights differences in the T2 relaxation times. The parameters are set (long repetition time (TR) and echo time (TE)) to minimize T1 relaxation effects. Fluid will appear bright and fat-containing tissues will appear dark on T2WI. This is good for demonstrating pathology since most lesions tend to develop oedema and are associated with an increase in water content.
- T2 star (T2*) is used to detect blood products or calcium.
- Diffusion weighted imaging (DWI) assesses the ease of water molecules movement in tissues, and it gives insight into cellularity (e.g. tumours) cell swelling (e.g. ischaemia) and oedema.
- Apparent diffusion coefficient maps (ADC) are images representing the actual diffusion values of the tissues without T2 effects.
  If there is facilitated diffusion, i.e., water molecules move easily within a tissue, the tissue will be bright on both DWI /ADC. If there is restricted diffusion, i.e., water molecules move slowly within a tissue.

MRI is considered to be a second-line diagnostic tool for scrotal pathology (28). It is useful as a problem-solving tool when sonographic findings are inconclusive. The advantages of MRI include simultaneous imaging of both testes, paratesticular spaces, spermatic cords, adequate anatomic information, satisfactory tissue contrast and functional information (24, 29).

In a study done by Parenti GC, Feletti F, Brandini F et al., MRI proved to be necessary in 1.4 - 5.74% of patients suspected to have scrotal disease after sonographic evaluation. In 47.8% of these cases, correct diagnosis was reached and in 37% focal lesions where excluded (26, 30). In another study done by Mohrs OK, Thoms H, Egner T et al. which was conducted in 165 scrotums, MRI had 100% sensitivity, specificity, positive predictive value and negative predictive value for precise localization of scrotal focal lesions.
It has a sensitivity of 100%, specificity of 87.5% with an overall accuracy of 96.4% in differentiating benign from malignant lesions (26).
Dynamic contrast enhanced MRI provides information regarding the characteristics of microvasculature of testicular carcinomas and assess tumour angiogenesis. In a trauma setting

it can confidently differentiate between a haematoma and neoplastic mass. It can also demonstrate an associated tunica albuginea tear.
T2 and T2*WI have 100% accuracy in the detection of testicular necrosis (26, 30).
It is a useful tool for local staging of testicular neoplasms, testis-sparing surgery planning and for differentiation between fibrosis and local recurrence after nodulectomy.
ADC may be used for early testicular torsion diagnosis without the use of contrast media.
DWI/ADC is useful in differentiating between normal, benign and malignant lesions with an accuracy of 100 % in the characterisation of scrotal lesions (30).

1.4 Sonographic technique of examination

A high-frequency 7-12 MHz linear transducer with a short focal zone is used to examine the scrotum and its contents (29).The scrotum is firmly supported by placing a towel laid across the patient's closed upper thighs. The patient should hold the penis out of the scanning field before applying a liberal amount of gel to the scrotum.
Each testis and epididymis should be examined separately and documented on longitudinal and transverse scans. The echogenicity of the two testes should be compared on several transverse images in which both testicles are imaged side to side ("buddy shot" or "sunglasses view"). The examiner should manually palpate all clinically described masses that cannot be visualised. A finger of the non-scanning hand should be placed underneath the lesion while scanning directly over it (29).
A varicocele should be evaluated with the patient performing the Valsalva manoeuvre or standing upright (2).
For patients with suspected testicular torsion Duplex and colour flow doppler are necessary. Use a 10MHz linear transducer. Always start with the examination of the normal side and optimize settings for low flow, low resistance and low velocity. The background 'noise' should just be visible in the asymptomatic testis. Once you have a good image of the normal side, 'don't touch any of the settings' and go to the symptomatic side (1-3, 5, 9, 11, 12, 15, 19, 20, 31, 32).

1.5. Imaging features of other testicular or scrotal pathologies

For testicular and scrotal pathologies, ultrasound is the initial imaging modality of choice.
In selected cases, MRI may be used as a diagnostic adjuvant. Localization of the mass is the main task of imaging, whether it is intra-testicular or extra-testicular. Intratesticular masses

have a higher likelihood of malignancy than those occurring in extra-testicular sites, including the epididymis although there are some exceptions.

1.5.1. Testicular pathology

1.5.1.1. Testicular malignancies

Are usually discovered by clinical palpation. They account for less than 2 % of all malignant neoplasms in men but are the most frequent solid tumour in young male adults under the age of 35 (5-8). Mortality is lower than 10% and the cure rate has reached 95% (5, 6).

On the US they are usually inhomogeneously hypoechoic compared to normal testicular tissue. They are well-defined, often lobulated lesions with internal blood flow detectable on Doppler US.

The intralesional vascularity depends more upon the size than the tumour type. Duplex and colour flow doppler will demonstrate blood flow in testicular tumours 1.5 cm or greater (1). Greyscale US is nearly 100% sensitive for detection of testicular tumours (5).

The next step for most of these patients is usually orchiectomy since it is impossible to characterize the histologic subtypes based on imaging.

Imaging features are not specific to testicular cancer and might also be seen in benign or non-neoplastic tumour mimics.

A few factors should be considered before contemplating these diagnoses:

The age distribution overlaps with most scrotal and testicular malignancies, and asymptomatic neoplasms can be incidentally identified on imaging.

About one-third of scrotal/testicular malignancies can present with scrotal pain (17).

In the right clinical setting and absence of internal vascularity, focal infarction, haematoma, or infection might be an appropriate differential diagnosis and avoid futile surgery. However, these cases need to be followed up closely to document involution and exclude malignancy.

Risk factors for testicular cancer (5, 17, 33, 34)

- Personal or family (1st degree relative) history of germ cell tumor
- Testicular atrophy <12 mL
- Orchiopexy
- History of abnormal descent
- Patients with cryptochidism, 2.5 -8 x risk

- Klinefelter syndrome
- Testicular dysgenesis syndrome

1.5.1.2. Testicular Microlithiasis (TML)

Is defined as the presence of five or more echogenic, non-shadowing foci <3 mm per testis or field of view (3, 5, 18, 33, 34) (Figures 3E and 3F). It is seen in 6 -18.8% of patients (3, 5, 33, 34). It is a frequently encountered entity and can be associated with infertility and testicular cancer. However, in the absence of risk factors, follow-up of isolated microlithiasis is not recommended as advised by the European Society of Urogenital Radiology (ESUR) (5, 8, 17, 20, 26, 33-36). Annual US surveillance along with periodic self-examination, though not scientifically-proven necessary, would probably be reasonable for the 1st year after the diagnosis. Routine use of serum tumor markers and CT/ MRI are not justified for the majority of patients with testicular microlithiasis (TML) (8, 16, 36).

TML ratios were determined as 25% in cryptorchidism, 6.5% in varicocele, 23% in hydrocoele, 10% in epididymal cyst and 50% in atrophic testes (35). TML has been associated with testicular neoplasms in 18-75% of cases (3, 34-36).
The ESUR released guidelines on the imaging and follow-up of TML. This is summarised in Tables 1.1 and 1.2 (33).

Table 1. 1 Summary of ESUR guidelines on imaging and follow up in testicular microlithiasis.

US findings	< 5ML per FoV	>5ML per FoV	Diffuse [a]	<5 ML per FoV but>-5 total [b]
Normal testis, no risk factor	Discharge	Discharge	Annual US	Discharge with open access
Normal testes but prior GCT[c], maldescent, orchidopexy or atrophic testis	GCT under oncology surveillance	F/U annual US	F/U annual US	GCT under oncology surveillance
	Maldescent, orchidopexy or atrophy: D/C with advice			Maldescent, orchidopexy, atrophy: D/C with advice
Genetic disease (Klinefelter)	F/U ultrasound at 6 & 12 months looking for nodule >3mm, D/C if none detected F/U U/S at 6 & 12 months looking for a nodule >3mm, discharge if none detected	F/U at 6 & 12 months looking for nodule >3mm, D/C home if none detected	Refer to specialist	D/C
Focal lesion	Refer to specialist centre (for urology +- oncology input) Consider close follow up (4-6 weekly), MRI with contrast biopsy or orchidectomy NOTE: Clustering of microliths adjacent to a focal non-cystic lesion is highly suggestive of GCT			
Macrocalcification	As for focal lesions above			

RF (risk factors) which include previous malignancy, maldescent, small testis, orchidopexy, TML (testicular microlithiasis), 5 or more microcalcifications per field of view, FoV (field of view), D/C (discharge) from follow up with advice about self-examination. F/U (follow-up), MRI scrotal MRI with gadolinium sequences, CEUS (contrast enhanced (microbubble) ultrasound), US (scrotal ultrasound), GCT (germ cell tumour), ML (microliths)

a Often associated with atrophy and infertility

b Very unlikely in reality to have > 10 ml in total, as would then be >_ 5 in a FoV

c Men with prior history of GCT will be under surgical / oncological review.

The ESUR also states that if TML is found on US, the risk of the patient developing GCT should be determined. Table 1.2 reflects these risk factors.

Table 1.2 Checklist to be completed in men discovered to have TML

If TML is identified during ultrasound scanning, risk factors for developing CT should be ascertained.

Risk factors	Normal	Yes >= 5 ML per FoV	Yes Diffuse	No TML i.e. no FoV contains 5 or more microliths
Maldescent	Ask patient for relevant history	Annual US	Annual US	
Orchidopexy	Ask patient for relevant history	Annual US	Annual US	Discharge
Previous GCT	Likely to have orchidectomy so this should be easy to ascertain. If there is any doubt, ask the patient	Annual US	Annual US	Discharge
Genetic disease	Ask patient for relevant history	Repeat US at 6 and 12 months, D/C if no nodule > 3mm	Refer	Discharge
Family history of GCT	Ask patient for relevant history	Encourage self-examination and offer open access	Encourage self-examination and offer open access	Discharge
Atrophic testis	Should be noted during the ultrasound			Discharge

1.5.1.3 Cystic testicular lesions

More than 95% of intratesticular lesions are malignant (32), however, most intratesticular cystic lesions are benign (5).

They are well-defined, thin-walled, homogeneously hypoechoic/ anechoic lesions with posterior acoustic enhancement with no internal vascularity (1, 17). They can measure from a few mm up to 20 mm and are usually found adjacent to the mediastinum testis in the upper half of the testis. They are not palpable and may be bilateral. They may be associated with epididymal cysts. Complex cysts have some degree of internal echogenicity.

Ectasia of the rete testis appears as a cluster of multiple small cysts and tubules along the testicular mediastinum and is typically seen in men older than 55 years. It is frequently bilateral and often asymmetric (12, 18, 20). Tubular ectasia is often seen with epidydimal obstruction as a result of previous inflammation or trauma (1).

In the appropriate clinical setting, differential diagnoses are testicular haematomas and abscesses with large cystic components. Close follow-up is always needed to exclude purely cystic testicular tumours (exceedingly rare) or testicular tumours with cystic changes.

MRI not routinely recommended. A simple cyst follows a fluid signal on all pulse sequences, with no solid components or enhancement. Tubular ectasia will be seen as multiple, tubular cystic structures in the mediastinum testis of fluid signal with no enhancement (21).

1.5.1.3.1 Epidermoid cysts

This is a rare non-malignant tumour of germ cell origin with no malignant potential. It accounts for 1-2% of intratesticular tumours (3, 5, 20, 30). In most cases, it has typical sonographic features . It is well defined with multiple concentric layers of keratinous debris giving it a more solid appearance of a round hypoechoic lesion with multiple concentric hyperintense internal layers resembling an “onion skin” and lacking internal blood flow (1, 5, 15, 17, 18, 20, 27). The echogenic wall may calcify. Ultrasound cannot always differentiate them from a malignant tumour, therefore they are usually resected (1, 17).

MRI findings demonstrate the alternating zones of high and low signal intensity on T2WI giving the onion ring or target appearance. The absence of contrast enhancement confirms the benignity of the lesion (21).

1.5.1.4 Focal infections, haematomas, and infarcts

In the appropriate clinical setting such as local or systemic signs of infection and recent history of inguinal or scrotal surgery/trauma, torsion or abnormal states of coagulation for

haematoma and infarction; these entities should be considered as differential diagnoses. All these entities are avascular on Doppler US. They must be monitored to document involution and exclude malignancy.

1.5.1.5 Testicular abscess

Usually associated with acute scrotal infection such as epididymo-orchitis but may be secondary to testicular torsion, testicular haemorrhage, trauma or superinfection of a necrotic tumour. It is also associated with systemic infections such as mumps, smallpox, typhoid, scarlet fever and TB (1, 18).

Ultrasound findings will be an enlarged testis with a complex fluid collection (Figures 1C and 2A).

CEUS may be used in equivocal cases (37).

1.5.1.6 Fournier's gangrene

Is a polymicrobial infection of the scrotum that typically originates from the skin, rectum or urethra and prostate. It is a clinical diagnosis with very high morbidity and mortality. Because of the rapid spread of infection, it is a surgical emergency requiring intravenous antibiotics and rapid debridement (9). Immunocompromised patients, diabetics and alcoholics are at higher risk. About 50% have diabetes (9). When performing the scrotal ultrasound, look for evidence of perineum infections.

Ultrasound findings: gas in the scrotal wall indicated as a hyperechoic 'dirty' shadowing. Scrotal wall oedema ("cobblestoning") with normal testes and epididymis (3, 11, 17, 30). Increased flow in the scrotal or peripheral vessels in response to inflammation (19).

CT: is the imaging modality of choice. It can accurately depict the presence of gas at any anatomic site, show the presence of fluid collections and abscesses, show the spreading of the disease process out of the perineal region, thus guiding surgical debridement of infected tissues (37, 38).

MRI accurately depicts the fascial spread of the inflammatory process and necrotic component.

1.5.1.7 Testicular adrenal rest

These non-malignant masses are encountered in patients with congenital adrenal hyperplasia. They can also be found in patients with Addison disease, Cushing's syndrome and adrenogenital syndrome. The key to the diagnosis other than the clinical history is its bilaterality although unilateral appearance has been reported (17, 20). Their imaging features are otherwise similar to testicular cancer.

In the appropriate clinical setting, there is no need for further workup however they need to be differentiated from Leydig cell tumours as 10% of these are malignant (1).

Adrenal rests secrete cortisol and regress with the administration of prednisone.

MRI is recommended in candidates for partial orchiectomy. The adrenal rest tumours will appear as multiple bilateral eccentrically located lesions, low T2 signal and contrast enhancement (21, 28).

1.5.2 Epididymal masses

They are seen in about 23.1 % of patients presenting for scrotal sonar (25). They are frequently encountered as incidental findings on scrotal ultrasound. They are mostly benign and do not require specific treatment.

Epididymal cysts are the most common epididymal masses, seen in 20-40% (18). They are well-defined, homogeneously hypoechoic / anechoic lesions of varying size, most frequently located in the epididymal head. Spermatocele usually appears as a cystic lesion with multiple small low-level echoes in a patient with prior vasectomy or other inguinal/scrotal surgery (17). The most common solid neoplasms of the epididymis are adenomatoid tumours and leiomyomas. Both entities are well-defined and show variable size, echogenicity, and vascular flow (17).

1.5.3 Extra-testicular masses

Most extra-testicular neoplasms are benign, most commonly lipomas and fibrous pseudotumors. Calcified tumor-like masses known as scrotoliths may be seen in any part of the scrotum. It is more common in young patients under the age of 35 years. The rare exceptions are paratesticular rhabdomyosarcomas in children and adolescents, as well as sarcomas, metastases and locally advanced scrotal skin cancer in adults. These malignant lesions only occur in about 3 % of extratesticular solid lesions (5).

1.5.3.1 Malignant paratesticular tumours

The patient's age and a Doppler US demonstrating a hypoechoic extra-testicular mass that is highly vascular are a key in diagnosing a rhabdomyosarcoma. Rhabdomyosarcoma is more common in young patients. A study done by Kumar reported a median age of 16.5 years (39). Paratesticular sarcomas are heterogeneous, markedly hypervascular tumours of adult men; liposarcomas can contain macroscopic fat. The diagnosis of metastases and locally advanced skin cancer can be made in an adequate clinical context.

1.5.3.2 Fat-containing paratesticular lesions

These are best assessed on MRI. They will demonstrate fat signal intensity with no enhancement post contrast (21). Lipoma is the most common fat-containing paratesticular neoplasm. In an adult patient, a large highly vascular fat-containing mass is suspicious for liposarcoma. Fat necrosis after trauma or surgery and inguinal hernia are other differential diagnoses of a fat-containing tumour.

1.5.3.3 Scrotal hernia

Ultrasound can help identify the contents of the hernia sac however scrotal hernia is usually a clinical diagnosis. About 80 % of all groin hernias are of the indirect type.The bowel may be identified if haustra or valvulae conniventes are seen or peristalsis is present. Omental fat appears echogenic.

Four sonographic signs of hernia incarceration are: free fluid in the hernia sac, free fluid within the hernia bowel loop, thickening of the incarcerated bowel and dilated loops in the abdomen. The testis and epididymis will appear normal. In hernias containing bowel loops, a combination of 2 or more of the 4 identified signs allowed the detection of incarceration with a sensitivity of 100 % and sensitivity of 100% (19).

Identification of an akinetic dilated loop of bowel in the US has a 90 % sensitivity and a 93 % specificity for bowel strangulation (12, 38).

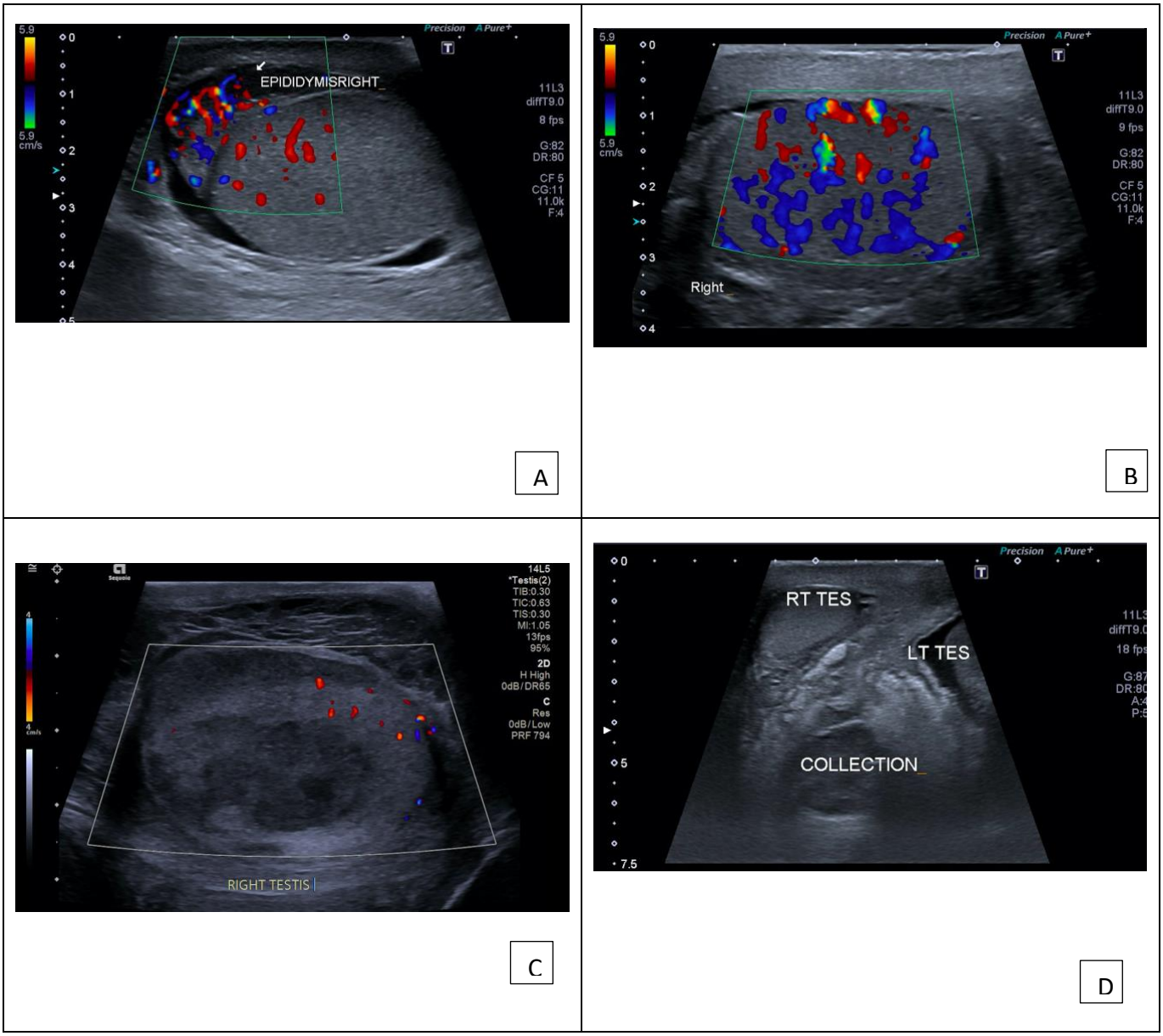

Figure 1 Examples of scrotal infections. (A) Epididymo-orchitis in a 54-year-old male. Colour Doppler - Inhomogeneous, hyperaemic, enlarged epididymis and testis associated reactive hydrocoele (B) Orchitis in a 30-year-old male demonstrating an enlarged and hyperaemic testis.

(C). Testicular abscess in a 40-year-old male demonstrating a focal central inhomogeneous, avascular lesion with associated hypereamia and reactive hydrocoele. (D)Grey scale ultrasound demonstrating an extratesticular focal inhomogeneous lesion with associated scrotal skin thickening in keeping with a scrotal abscess

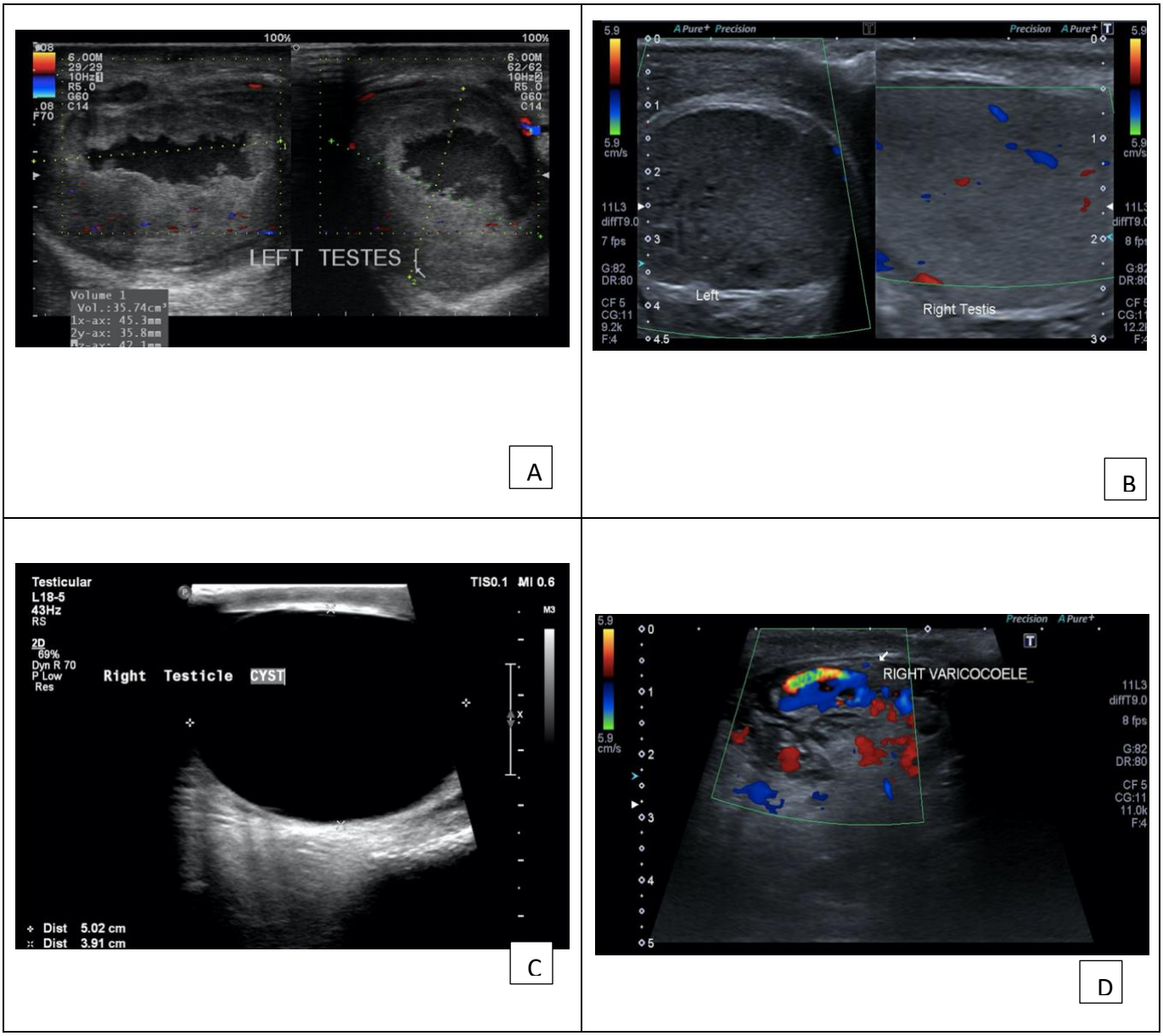

Figure 2 Examples of testicular pathology and varicocoele. (A) Left testicular abscess in a 30-year-old patient. Colour doppler demonstrating a focal region of altered echogenicity, avascular and skin thickening (B) Testicular torsion in a 19-year-old male. Colour doppler demonstrates avascular, inhomogeneous right testis and skin thickening. (C)Right testicular cyst in a 57-year-old male. Grey scale US demonstrating a well-defined, thin walled, homogeneously anechoic lesions with posterior acoustic enhancement (D)Colour doppler demonstrates dilated and tortuous vein (in the pampiniform plexus) around the epididymis in a 30-year-old male.

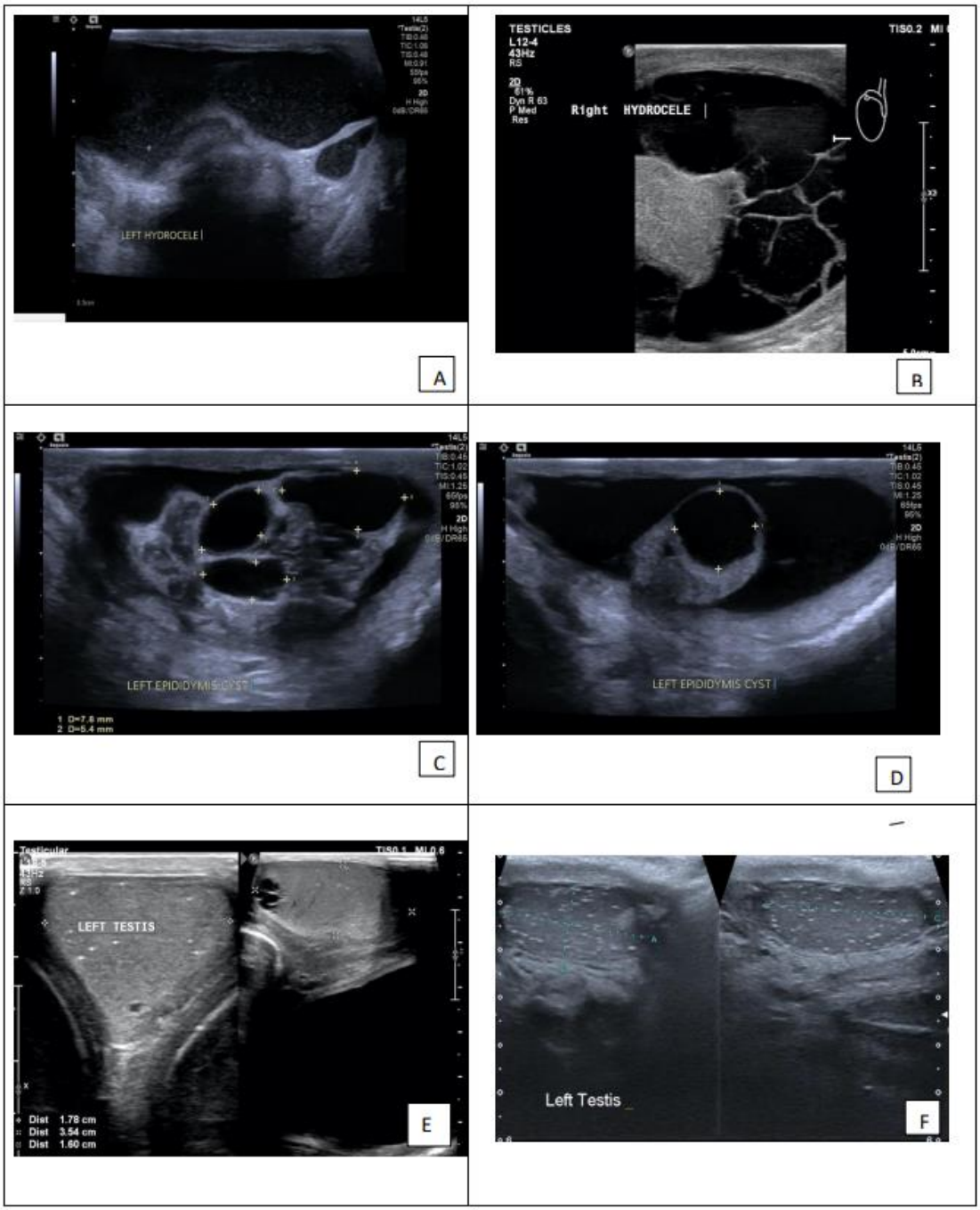

Figure 3 Examples of common scrotal pathologies. Complex hydrocoeles (A) & (B) .A Demonstrates multiple internal echoes and B also demonstrates lots of internal echoes with septations.(C) Multiple well defined , anechoic , thin walled epididymal head lesions in keeping with simple epididymal cysts. (D) Simple solitary epididymal cyst and simple hydrocoele. (E) & (F)Testicular microlithiasis in different patients .US demonstrates diffuse echogenic, non-shadowing foci <3 mm per testis.(E) also demonstrates simple testicular cyst and simple hydrocoele.

1.6. Aim

This study aims to determine the frequencies and percentages of the most common scrotal symptoms and ultrasound findings in adult patients presenting for ultrasound imaging at Chris Hani Baragwanath Academic Hospital.

1.7. Study Objectives

To document and report the scrotal ultrasound pathology and the most common scrotal symptoms in our setting.

2.Materials and Methods

2.1 Research paradigm

This was a retrospective record review of scrotal pathology diagnosed on ultrasound in adult male patients who ended up being referred to radiology sonar department at Chris Hani Baragwanath Academic Hospital (CHBAH)

2.2. Sample

The study population included all adult male patients who presented to the ultrasound department with scrotal symptoms from the 1st of January 2020 – 31st of December 2020. Examinations were performed on an average of 20 patients per month.

2.2.1 Inclusion criteria

It included all adult male patients with scrotal symptoms who ended up being referred to the ultrasound department from the 1st of January 2020 – 31st of December 2020.

2.2.2 Exclusion criteria

Patients with no clinical data included in their ultrasound reports.

Inadequate ultrasound reports.

2.3. Material and methods

The Picture archiving and communication system (PACS) at CHBAH was searched for the time period as defined. A new file was created under worklist, clicked 'add criteria 'and the following parameters were selected:

- Modality: ultrasound (40)
- Study description: testes, scrotum, scrotal
- Date: 1 January 2020 – 31 December 2020
- Institution: CHBAH

The sonographic images were obtained using high frequency linear probes of the following makes and Models: TOSHIBA APLIO 500, TOSHIBA XARIO FLAT, SIEMENS SEQUIOIA, ALOKA SSD ALPHA 10, GE LOGIQ F8 and PHILIPS HD7 XE.

2.4. Data collection

Data was collected anonymously by allocating a random number code (the key to this code was only available to the primary investigator and supervisors.) to each patient using the tick sheet (Appendix B). It was entered into an Excel spread sheet and analysed using The jamovi project (2021). jamovi (Version 1.6) [Computer Software]. Retrieved from https://www.jamovi.org. Sydney, Australia.

Results were reported as frequencies and percentages.

Descriptive statistics for tabulation of data.

Measurements of average were done using mean with standard deviation and median with interquartile range where applicable.

2.5. Reliability and validity

The ultrasounds were performed by an array of personnel with different levels of experience but if a junior experienced difficulties there was always a senior available to review the findings.

2.6. Bias

The study was performed at CHBAH which is the largest referral hospital in the southern hemisphere and the third largest hospital in the world.

My research was solely based on their static imaging and reports.

CHBAH being one of the largest tertiary hospitals with a myriad of subspecialist, some of the emergency ultrasounds are done by the urologist in casualty unit and that would have interfered with the number of cases presenting to the radiology department.

2.7. Data analysis and statistics

The findings were analysed using Excel and reported as frequencies and percentages.

Descriptive statistics for tabulation of data was used.

Measurements of average was done using mean with standard deviation and median with interquartile range.

2.8. Ethics

The study was approved by the Human Research Ethics Committee of the University of the Witwatersrand, approval number M210143. This certificate is attached as Appendix A.

3. Results

3.1 Study population

There were a total of 267 scrotal ultrasounds performed with 141 studies meeting the inclusion criteria. Of the 267, 126 were excluded because there was either no indication documented or they had inadequate ultrasound reports.

The patients had ages ranging from 18-85 years (mean age 48.5 years, median 46 years with a standard deviation of 16.7 years).

Only 18 of the 141 (12.8%) patients had the duration of symptoms specified on the reports. The mean duration in days was 666 with a median of 135 and a standard deviation of 1687 days. Of these patients, the range was between 4 to 7300 days.

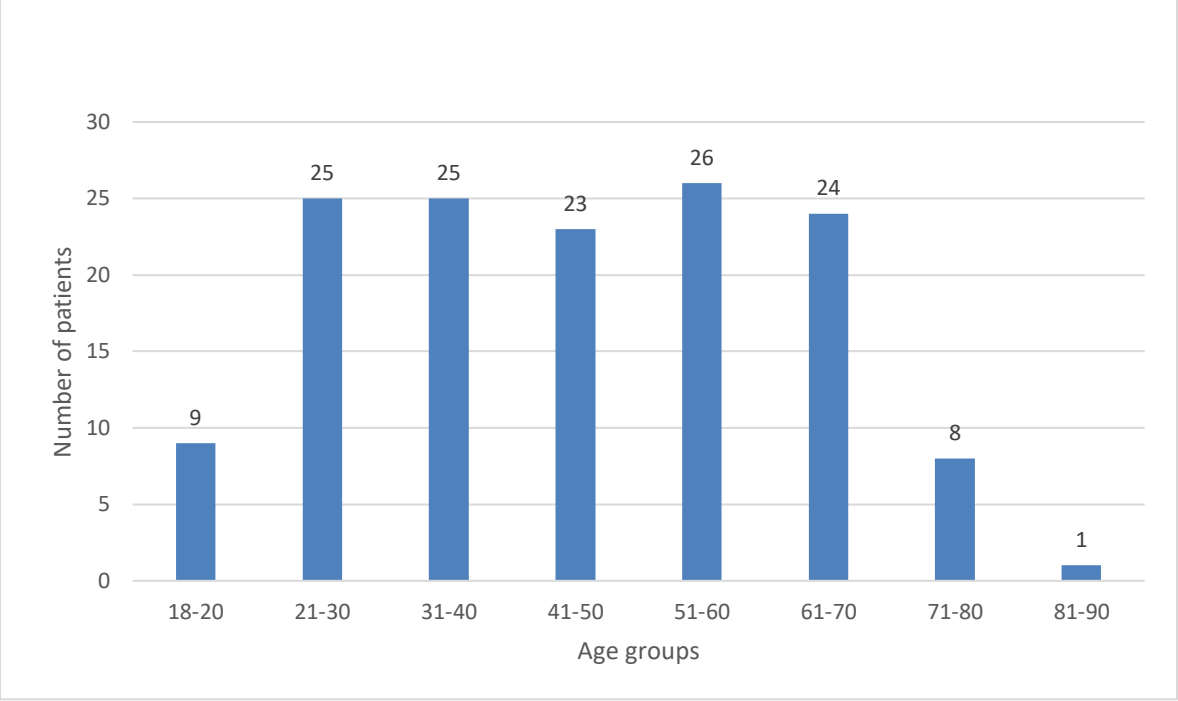

Figure 4 Bar graph demonstrating the age at presentation.

3.2 Frequencies of the presenting symptoms

Table 3.1 Frequencies and percentages of scrotal symptoms.

Presenting symptoms	Frequency (N) (N=141)	Percentage (%)
Swelling	78	55.3%
Pain	45	31.9%
Mass	31	22.0%
Other	3	2.1%
More than 1 symptom	21	14.9%

Note: Percentages do not add up to 100%, as some patients (14.9%) had more than 1 symptom and 3 of 141 (2.13%) had different indications for the ultrasound as entailed below.

The presenting symptoms were swelling in 78 of 141 (55.3%), pain in 45 (31.9%) and a mass in 31 (22.0%). As 21 (14.9%) patients presented with more than 1 symptom, the percentages will not add up to 100%.

Of the 141 ultrasounds,3 (2.13%) had different indications for the ultrasound, namely an undescended testis in 2 of the patients and 1 had a previous testicular infection, however, the nature of the infection was not stated.

3.3. Frequencies of ultrasound findings

Patients who presented with benign pathology were noted to be 131 of the 141 (92.9%) and 10 (7.1%) had normal findings. There were no malignant or suspicious findings (0%).

Patients who presented with benign pathology were further divided into infective, vascular, non-infective/ non-vascular and other findings.
Of these, the largest category was the non-infective/non-vascular category. This constituted 84 (64.1%) patients with hydrocoele, 15 (11.5%) with an epidermal cyst,15 (11.5%) with inguinal hernia,13 (9.9%) with varicocele,12 (9.2%) with testicular microlithiasis, 3 (2.3%) with a testicular cyst, 1(0.8%) with rete testis ectasia and 1(0.8%) with scrotal haematoma (however it was not stated whether it was spontaneous or post-traumatic and no history of trauma was mentioned on the form).

Non-abscess infections were demonstrated in 29 (22.2%) patients of which epididymo-orchitis accounted for 14 (10.7%) of the findings, epididymitis 11 (8.4%) and orchitis 4 (3.1%).
Findings that are an indication for surgical intervention were demonstrated in 15 (11.5%) of the patients which are subdivided into 3 (2.3%) testicular torsion,6 (4.6%) testicular abscesses, 5 (3.8%) scrotal abscesses/collection and 1 (0.8%) low flow priapism.

Other findings were demonstrated in 13 (9.9%) of the ultrasounds, namely, undescended testis 5(3.8%), inguinal necrotic nodes 3 (2.3%), complex scrotal lesion 1(0.8%), paratesticular mass 1 (0.8%), scrotal thickening 1 (0.8%), testicular atrophy 1(0.8%) and calcification in the epididymis 1 (0.8%).
Of note is that individual percentages do not add up to 100 % as 53 of 131 (40.5%) presented with more than 1 finding.

Table 3.2 The frequencies and percentages of the ultrasound findings

Ultrasound findings		Total number of the patients who presented for ultrasound N (%) N=141	Patients who presented with pain N (%) N=45	Patients who presented with Mass N (%) N=31
Normal		10 (7.1%)	4 (8.9%)	2 (6.5%)
Benign		131 (92.9%)	41 (91.1%)	29 (93.5%)
Non-vascular/ non-infectious benign				
	Hydrocoele	84 (64.1%)	20 (48.8%)	14 (48.3%)
	Epidermal cyst	15 (11.5%)	3 (7.3%)	6 (20.7%)
	Inguinal hernia	15 (11.5%)	1 (2.4%)	8 (27.6%)
	Varicocele	13 (9.9%)	7 (17.1%)	2 (6.9%)
	Testicular microlithiasis (TML)	12 (9.2%)	4 (9.8%)	3 (10.3%)
	Testicular cyst	3 (2.3%)	1 (2.4%)	-
	Scrotal haematoma	1 (0.8%)	1 (2.4%)	-
	Rete testis ectasia	1 (0.8%)	1 (2.4%)	-
Infection	Epididymo-orchitis	14 (10.7%)	7 (17.1%)	1 (3.4%)
	Epididymitis	11 (8.4%)	7 (17.1%)	1 (3.4%)
	Orchitis	4 (3.1%)	2 (4.9%)	2 (6.9%)
	Testicular abscess*	6 (4.6%)	4 (9.8%)	-

	Scrotal abscess/collection*	5 (3.8%)	3 (7.3%)	-
Vascular	Testicular torsion*	3 (2.3%)	2 (4.9%)	-
	Low flow priapism*	1 (0.8%)	1 (2.4%)	-
Other		13 (9.9%)	-	6 (20.7%)
	Scrotal thickening	1 (0.8%)	-	-
	Inguinal necrotic nodes/lymphadenitis	3 (2.3%)	1 (2.4%)	2 (6.9%)
	Testicular atrophy	1 (0.8%)	-	-
	Undescended testis	5 (3.8%)	-	2 (6.9%)
	Paratesticular mass	1 (0.8%)	-	1 (3.4%)
	Complex scrotal lesion	1 (0.8%)	-	-
	Calcification in the epididymis	1 (0.8%)	-	1 (3.4%)

Note: **Percentages do not add up to 100%, as some patients had more than 1 finding**

* Findings that are an indication for surgical intervention

3.4. Frequencies of ultrasound findings in patients who presented with pain.

In the literature the most common presenting symptom is pain. In our study, pain was the presenting symptom in 45 of the 141 patients. Of these patients, 4 (8.9%) had normal findings and 41 (91.1%) had benign findings.

The most common findings were hydrocoele in 20 (48.8 %) followed by non-abscess infections. The non-abscess infections were demonstrated in 16 (39 %) ultrasound of which epididymo-orchitis accounted for 7 of 41 (17.1 %) of the findings, 7 of 41 (17.1 %) had epididymitis and 2 of 41 (4.9 %) had orchitis.

The rest of the findings are summarised in table 3.2 above.

Individual percentages do not add up to 100 % as other patients presented with more than 1 finding.

3.5. Frequencies of ultrasound findings in patients who presented with a mass.

Patients who presented with a mass were 31 of the 141 patients. Of the 31 patients, 29 (93.5 %) presented with benign findings and 6.5 % revealed normal findings.

The most common findings were hydrocoele in 14 (48.3 %), inguinal hernia in 8 (27.6 %), epidermal cyst in 6 (20.7 %) and testicular microlithiasis in 3 (10.3%) of the patients

The rest of the findings are summarised in table 3.2 above.

Individual percentages do not add up to 100 % as other patients presented with more than 1 finding.

4. Discussion

In the setting of scrotal symptoms, healthcare professionals refer patients for scrotal ultrasound to evaluate for scrotal pathology. Our study represents one of the largest data sets to date addressing not only scrotal ultrasound performed for pain, but all the most common indications including swelling and masses. To our knowledge, it is also one of the few studies performed in Africa.

In contrast to other studies (40-42), pain was the second (after swelling) common indication for requesting a scrotal ultrasound.

In our hospital, an average of 22 scrotal ultrasounds were performed per month for the evaluation of scrotal symptoms. The age at presentation was more or less the same across the different age groups.

In our study, of all the patients referred to us for scrotal ultrasound, only 7.1 % had normal findings similar to a study by Thinyu who reported 6.4 % (41). However, it is contrary to studies by Van Haarst who reported 69.4 %(43), London 28.4 % (42)and Kashanian 33.9 %(25). These low numbers in our setting may have been due to prior antibiotic treatment from the referring health care facilities before the ultrasound study or patients were seen and discharged from the facilities and never represented to our facility for imaging.

The other 92.9% of patients demonstrated benign findings, the most common being hydrocoele (64.1%) followed by inguinal hernia (11.5%) epididymal cysts (11.5%), epididymo-orchitis (10.7%) varicocele (9.9%) and TML (9.2%). These findings are comparable to studies by Suzer (99%), D'Andrea (95.9%) and Thinyu (90.9%). These studies on average demonstrated about 95.2% of benign findings. No malignancies were identified in our study.

Of this 92.9% who presented with benign findings ,22.2 % presented with non-abscess infection (epididymo-orchitis 10.7%, epididymitis 8.4% and orchitis 3.1%), almost similar to a study by London and Kashanian which reported 20.8% and 25.9% respectively. This is however contrary to studies by Suzer (76.5 %), D'Andrea (61%), Thinyu (50%) and Van Haarst (46.6%). This could be due to the successful treatment of most patients at our

referral hospitals and primary clinics before the ultrasound study or they may have not been referred for imaging.

Findings that are an indication for surgical intervention were demonstrated in 11.5% (testicular torsion 2.3%, testicular abscess 4.6%, scrotal abscesses/collection 3.8% and low flow priapism 0.8%) which is comparable to most of the studies below which on average had a percentage of 11.7%. The range was between 3.7%-20.8%.

Table 4.1 Comparison of previously published studies examining the findings of scrotal ultrasound to our study

Ultrasound findings		London N (%) N=109	Thinyu N (%) N=110	Our study N (%) N=141
Normal		31 (28.4%)	7 (6.4%)	10 (7.1%)
Benign		72 (66.1%)	100 (90.9%)	131 (92.6%)
Non-vascular/ non-infectious benign	Hydrocoele	18 (25%)	12 (12%)	84 (64.1%)
	Epididymal cyst	26 (36.1%)	5 (5%)	15 (11.5%)
	Inguinal hernia	1 (1.4%)	1 (1%)	15 (11.5%)
	Varicocele	4 (5.6%)	13 (13%)	13 (9.9%)
	Testicular microlithiasis (TML)			12 (9.2%)
	Testicular cyst	1 (1.4%)		3 (2.3%)
	Scrotal haematoma/Haematocoele		2 (2%)	1 (0.8%)
	Rete testis ectasia			1 (0.8%)
Infection	Epididymo-orchitis	5 (6.9%)	30 (30%)	14 (10.7%)
	Epididymitis	9 (12,5%)	19 (19%)	11 (8.4%)
	Orchitis	1 (1.4%)		4 (3.1%)
	Testicular abscess*	2 (2.8%)		6 (4.6%)
	Scrotal abscess/ collection*	1 (1.4%)	3 (3%)	5 (3.8%)
	Scrotal cellulitis		1 (1%)	
Vascular	Testicular torsion*		4 (4%)	3 (2.3%)
	Low flow priapism*			1 (0.8%)
	Spermatic vein thrombosis			
Other				13 (9.9%)
	Scrotal thickening			1 (0.8%)
	Inguinal necrotic nodes/lymphadenitis			3 (2.3%)

	Testicular atrophy			1 (0.8%)
	Undescended testis		4 (4%)	5 (3.8%)
	Paratesticular mass			1 (0.8%)
	Complex scrotal lesion			1 (0.8%)
	Calcification in the epididymis			1 (0.8%)
	Testicular neoplasm/ malignancy	6 (5.5%)	3 (3%)	
	Testicular rupture	2 (2.8%)	4 (4%)	
	Other	2 (2.8%) [a]	2 (2%) [b]	

a. Sperm granuloma

b. Seroma in scrotal sac

Table 4. 1 above demonstrates previously published studies examining the findings of scrotal ultrasound. Thinyu (41) and London (42) looked at all patients who presented for scrotal ultrasound. Percentage of their findings calculated in relation to the total number of patients presented for scrotal ultrasound and specifically for pain (see table 4.2 below).

Table 4.2 Comparison of studies with scrotal ultrasound (US) performed for pain including our study

Ultrasound findings		Van Haarst N (%) N=111	Suzer N (%) N=102	London N (%) N=47	Kashanian N (%) N=7668	Thinyu N (%) N=84	D'Andrea[a] N (%) N=125	Our study N (%) N=45
Normal		77 (69.4%)		19 (40.4%)	2600 (33.9%)	6 (7.1%)	2 (0.1 %)	4 (8.9%)
Benign		34 (30.6%)	101 (99.0%)	28 (59.6%)	4946 (64.5%)	77 (91.7%)	118 (95.9%)	41 (91.1%)
Non-vascular/ non-infectious benign	Hydrocoele	15 (44.1%)			1469 (29.7%)	4 (5,2%)	20 (16.9%)	20 (48.8%)
	Epididymal cyst	12 (35.3%)		6 (21.4%)	1768 (35.7%)	1 (1.2%)		3 (7.3%)
	Inguinal hernia	3 (8.8%)	1 (1%)					1 (2.4%)
	Varicocele	3 (8.8%)		4 (14.3%)	1301 (26.5%)	10 (13%)	18 (15.3%)	7 (17.1%)
	Testicular microlithiasis (TML)				286 (5.8%)			4 (9.8%)
	Testicular cyst				106 (2.1%)			1 (2.4%)
	Scrotal haematoma/Haematocoele		2 (2%)		37 (0.7%)	2 (2.6%)	7 (5.9%)	1 (2.4%)
	Rete testis ectasia							1 (2.4%)
Infection	Epididymo-orchitis		78 (77.2%)	4 (14.3%)	1248 (25.2	29 (37.7 %)	72 (61.0%)	7 (17.1%)
	Epididymitis	5 (14.7%)		9 (32.1%)		19(24.7%)		7 (17.1%)
	Orchitis	1 (2.9%)		1 (3.5%)				2 (4.9%)
	Testicular abscess*	1 (2.9%)	2 (2%)	2 (7.1%)	54 (1.1%)			4 (9.8%)
	Scrotal abscess/ collection*			1 (3.5 %)		3 (3.9%)		3 (7.3%)
	Scrotal cellulitis				33 (0.7%)	1 (1.2%)		
Vascular	Testicular torsion*	2 (5.9%)	18 (17.8%)		45 (0.9%)	4 (5.2%)	10 (8.5%)	2 (4.9%)
	Low flow priapism*							1 (2.4%)
	Spermatic vein thrombosis				34 (0.7%)			
Other								

	Scrotal thickening							
	Inguinal necrotic nodes/lymphadenitis							1 (2.4%)
	Testicular atrophy							
	Undescended testis						5 (4.2%)	
	Paratesticular mass				40 (0.8%)			
	Complex scrotal lesion							
	Calcification in the epididymis							
	Testicular neoplasm/ malignancy		1 (1%)		72 (0.9%)	1 (1.2%)	5 (4.0 %)	
	Testicular rupture					4 (5.2%)	1 (0.8%)	
	Other	4 (11.8%) [b]		1 (3.5%) [c]	50 (0.7%) [d]			

Suzer (44), Van Haarst (43) and Kashanian (25) in table 4.2 only included patients presenting with scrotal pain.

a. D'Andrea (40) also assessed patients who presented for scrotal ultrasound, however they only analysed in details patients who presented with scrotal pain (125 out of 164) (However their numbers as far as the scrotal swelling / mass is concerned ,do not make sense)
b. Thickening of epididymis in 3 patients and 1 had hypoechoic testicular lesion with negative tumour markers
c. Sperm granuloma
d. Testicular lesion too small to characterize

4.1 Review of the patients who presented with pain.

Of the 45 patients who presented with pain, 4 out of 45 had normal findings and 41 had benign findings. The most common finding was non-abscess infection accounting for 39.1 % of the findings. This is lower than the findings by Kashanian which reported 25.9% and higher than the findings by Suzer (76.5 %), Thinyu (63.6%), D'Andrea (61%), London (49.9%) and Van Haarst (46.6%). Probably most patients were successfully treated at our referral hospitals and clinics before the ultrasound study or they were never referred for imaging.
An indication for surgical intervention was demonstrated in 24.4 % of the patients of which 4 of 41 (9.8 %) had a testicular abscess, 3 of 41 (7.3 %) had scrotal abscesses/collection, 2 of 41 (4.9%) had testicular torsion and 1 of 41 (2.4%) had low flow priapism.
These findings are comparable to a study by Suzer (44) who reported 20.8 % and higher than the other studies tabulated in table 4.1 which ranges from 3.7-15.5 %. Again this could be attributed to the fact that we are a referral hospital.

4.2 Review of the patients who presented with a mass.

Of all the 31 patients who presented with a mass, there was no testicular tumour or any indication for surgical intervention reported during the study period. This may have been because our study was conducted during the COVID-19 pandemic (i.e. patients not presenting to the hospital due to the restrictions at hand or out of fear of contracting the virus from the hospital)

4.3. Limitations of the current study

CHBAH is the largest hospital in Africa and the third largest hospital in the world. Most of the patients seen at CHBAH are referrals from local clinics and regional hospitals and that potentially influenced our results (especially the low rate of normal findings and infection compared to other studies). There is also a myriad of subspecialists at CHBAH. Some of the emergency scrotal ultrasounds were done by the urologist in casualty and that would have interfered with the number of cases presenting to the radiology department for an ultrasound.

Our study design was retrospective and therefore based on static images and reports provided. It is known that ultrasound is operator-dependent and a real-time form of imaging, we cannot therefore, re-examine the patients and confirm the accuracy of these findings.

Even though there was always a senior registrar or consultant available to ask for an opinion if a junior experienced challenge with the interpretation of the ultrasound images, we can never be able to assess if indeed juniors consulted when faced with difficulties or felt embarrassed, inadequate, and uncomfortable to frequently ask for opinions.

4.4. Future applications

In view of many patients excluded because of the lack of clinical history, there is room for improvement in including the clinical history in each ultrasound request we approve. This will help narrow down our differential diagnosis, help with the planning of management of the scrotal disorders and avoid unnecessary exploration.

Going forward we will encourage our personnel to include the clinical history and referring clinicians to provide the duration of symptoms if given by the patients. The inclusion of the duration of symptoms will help us triage the patient and give them appropriate booking dates for their ultrasound.

We should consider introducing the latest modalities such as contrast-enhanced ultrasound and elastography to diagnose testicular cancer .
There are currently no guidelines on how to manage testicular microlithiasis (TML) in our department. Of the 9.2 % of the patient who presented with TML, whether the patient had risk factors or not, there was no follow-up suggested. In future we will put a chart in our sonar department on how to manage/follow-up these patients with testicular microlithiasis including the risk factors to look out for (based on the ESUR Guidelines).

A prospective similar study focusing not only on adult patients, but all patients referred for scrotal sonar will be considered in the future. We will ensure that proper indication, duration of the symptoms and clinical diagnosis is provided by the clinicians before accepting the scan requests.

5. Conclusion

Routine scrotal ultrasound places a significant burden on radiology services. Given the significant percentage of benign and normal ultrasounds with only 11.5 % presenting with organ-threatening pathology, the referring clinicians/Urologists need to be confident in their ability to make a clinical diagnosis based on physical exam alone and only order adjunct testing when the diagnosis is in question.

They should also assess patients at risk of testicular malignancy and refer for imaging, especially since no testicular cancer or metastasis was diagnosed in this study population.

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Appendix A: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Dr Winile Nkosi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M210143

NAME: (Principal Investigator)	Dr Winile Nkosi
DEPARTMENT:	Radiation Sciences Chris Hani Baragwanath Academic Hospital(CHBAH)
PROJECT TITLE:	Audit of ultrasound in adult patients presenting with scrotal pathology at Chris Hani Baragwanath Academic Hospital
DATE CONSIDERED:	29/01/2021
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Dr J. Adrigwe and Dr S. Lucas
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	08/03/2021

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. I **agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **January** and will therefore be due in the month of **January** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B. Tick sheet

STUDY NO	AGE

SYMPTOMS														
DURATION		PAIN	YES	NO	SWELLING	YES	NO	MASS	YES	NO	OTHER	YES	NO	

ULTRASOUND FINDINGS																	
Epididymitis		Orchitis		Epididymo-orchitis		Epididymal cyst		Spermatocele		Epididymal mass		Testicular torsion		Testicular abscess		TML	
YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Testicular cysts		Testicular tumour		Hydrocoele		Varicocele		Scrotal haematoma		Inguinal hernia		Normal		Other		Other finding	
YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO		

Appendix C: Turn it in

Appendix D: Note on referencing style

Please note that the referencing in this thesis is a modification of the Vancouver Referencing style, done according to the Faculty of Health Sciences Style Guide as set out by the Wits Health Sciences Library.

The information on this WHSL Vancouver Citation Style Guide for Theses, Dissertations and Research Reports is available from http://libguides.wits.ac.za/whsl-vancouver updated on 8 August 2017.