"HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER STUDY IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS"

By

Dr. VARUN S.

DISSERTATION SUBMITTED TO SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, KOLAR, KARNATAKA

In partial fulfilment of the requirements for the degree of

DOCTOR OF MEDICINE

IN

RADIODIAGNOSIS

Under the Guidance of

Dr. ANIL KUMAR SAKALECHA, M.D.,
PROFESSOR OF RADIODIAGNOSIS

DEPARTMENT OF RADIODIAGNOSIS,
SRI DEVARAJ URS MEDICAL COLLEGE,
TAMAKA, KOLAR – 563 101.

MAY 2017

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER STUDY IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. ANIL KUMAR SAKALECHA**, Professor, Department of Radiodiagnosis, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award "**M.D. DEGREE IN RADIODIAGNOSIS**", the examination to be held in May 2017 by SDUAHER. This has not been submitted by me previously for the award of any degree or diploma from the university or any other university.

Dr. VARUN S.
Postgraduate in Radiodiagnosis,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

Place: Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER STUDY IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS"** is a bonafide research work done by **Dr. VARUN S.,** under my direct guidance and supervision at Sri Devaraj Urs Medical College, Kolar**,** in partial fulfilment of the requirement for the degree of "**M.D. IN RADIODIAGNOSIS"**.

Dr. ANIL KUMAR SAKALECHA, M.D.
Professor,
Department Of Radiodiagnosis,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

Place: Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH TAMAKA, KOLAR, KARNATAKA

CERTIFICATE BY THE HEAD OF DEPARTMENT

This is to certify that the dissertation entitled "**HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER STUDY IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS"** is a bonafide research work done by **Dr. VARUN S.,** under direct guidance and supervision of **Dr. ANIL KUMAR SAKALECHA**, Professor, Department of Radiodiagnosis at Sri Devaraj Urs Medical College, Kolar**,** in partial fulfilment of the requirement for the degree of "**M.D. IN RADIODIAGNOSIS"**.

Dr. PURNIMA HEGDE, M.D.
Professor & HOD
Department of Radiodiagnosis
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:

Place: Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH TAMAKA, KOLAR, KARNATAKA

ENDORSEMENT BY THE HEAD OF THE DEPARTMENT AND PRINCIPAL

This is to certify that the dissertation entitled **"HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER STUDY IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS"** is a bonafide research work done by **Dr. VARUN S.** under the direct guidance and supervision of **Dr. ANIL KUMAR SAKALECHA,** Professor, Department of Radiodiagnosis, Sri Devaraj Urs Medical College, Kolar, in partial fulfilment of University regulation for the award "**M.D. DEGREE IN RADIODIAGNOSIS**"**.**

Dr. PURNIMA HEGDE,
Professor & HOD
Department Of Radiodiagnosis,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:
Place: Kolar.

Dr. M. L. HARENDRA KUMAR,
Principal,
Sri Devaraj Urs Medical College,
Tamaka, Kolar.

Date:
Place: Kolar.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION

AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

ETHICAL COMMITTEE CERTIFICATE

This is to certify that the Ethical committee of Sri Devaraj Urs Medical College, Tamaka, and Kolar has unanimously approved

Dr. VARUN S.

Post-Graduate student in the subject of

RADIODIAGNOSIS at Sri Devaraj Urs Medical College, Kolar

to take up the Dissertation work entitled

"HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER STUDY IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS"

to be submitted to the

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION

AND RESEARCH, TAMAKA, KOLAR, KARNATAKA,

Member Secretary,

Sri Devaraj Urs Medical College,

Kolar – 563 101.

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION

AND RESEARCH, TAMAKA, KOLAR, KARNATAKA

COPY RIGHT

I hereby declare that the Sri Devaraj Urs Academy of Higher Education and Research, Kolar, Karnataka shall have the rights to preserve, use and disseminate this dissertation/thesis in print or electronic format for academic/research purpose.

Dr. VARUN S.

Date:

Place: Kolar.

ACKNOWLEDGEMENT

I owe my debt and gratitude to my parents ***Shri Dr. V. SURESH KUMAR*** *and* ***Smt. KALPALATHA,*** *along with my sister* ***Dr. SAHANA S.*** *for their moral support and constant encouragement during the course of the study.*

With humble gratitude and great respect, I would like to thank my teacher, mentor and guide, ***Dr. ANIL KUMAR SAKALECHA****, Professor, Department of Radiodiagnosis, Sri Devaraj Urs Medical College and Research Institute, Kolar, for his able guidance, constant encouragement, immense help and valuable advices which went a long way in moulding and enabling me to complete this work successfully.*

I have great pleasure in expressing my deep sense of gratitude to ***Dr. PURNIMA HEGDE,*** *Professor and Head, Department of Radiodiagnosis, Sri Devaraj Urs Medical College and Research Institute, Kolar. Without her initiative and constant encouragement this study would not have been possible. Her vast experience, knowledge, able supervision and valuable advices have served as a constant source of inspiration during the entire course of my study.*

I would like to express my sincere thanks to ***Dr. PATTABHIRAMAN V.****, Professor, Department of Radiodiagnosis, Sri Devaraj Urs Medical College for his valuable support, guidance and encouragement throughout the study.*

*I would like to thank **Dr. RACHEGOWDA N., Dr. A. NABAKUMAR SINGH** and **Dr. ASHWATHNARAYANASWAMY**, Professors, Department of Radiodiagnosis, Sri Devaraj Urs Medical College and Research Institute, Kolar, for their constant guidance and encouragement during the study period.*

*I also would like thank **Dr. NAVEEN G. NAIK, Dr. JAGADISH B., Dr. VINAY K. K.** and **Dr. KUKU MARIAM SURESH**, Assistant professors, Department of Radiodiagnosis, Sri Devaraj Urs Medical College, Kolar for their support.*

*I am thankful to my fellow **postgraduates, especially Dr. Sujata** and **Dr. Shivaprasad Gangadhar Savagave**, for having rendered all their co-operation and help to me during my study.*

*I am also thankful to staff nurse **Mrs. Radha,** helper **Mrs. Munivekatamma** and other **technicians** of Department of Radiodiagnosis, R.L Jalappa Hospital & Research Centre, Tamaka, Kolar for their help. My sincere thanks to **Mrs. Veena** along with rest of the computer operators.*

My sincere thanks to all the patients and their families who formed the backbone of this dissertation.

*Last but not least I would be failing in my duty if I do not express my gratefulness to the **Almighty,** who helped me to successfully complete this study.*

Dr. VARUN S.

LIST OF ABBREVIATIONS

2D	Two dimensions
AFP	α-fetoprotein
AMH	Anti Mullerian hormone
ATT	Antitubercular therapy
C	Celsius
CDI	Color Doppler Imaging
cm	Centimeter
CT	Computed Tomography
DWI	Diffusion weighted imaging
GCT	Germ cell tumor
HCG	Human chorionic gonadotropin
HF	High frequency
HPE	Histopathology
ISE	Idiopathic scrotal edema
LDH	Lactate dehydrogenase
M/c	Most common
MHz	Mega Hertz
MIS	Mullerian inhibiting substance
mm	Millimeter
MRI	Magnetic Resonance Imaging
NHL	Non-Hodgkin's lymphoma

LIST OF ABBREVIATIONS

NSGCT	Non-seminomatous germ cell tumor
RI	Resistivity Index
SDI	Spectral Doppler imaging
SMA	Superior mesenteric artery
SWF	Spectral waveforms
T	Thoracic
Tb	Tuberculosis
TGC	Time gain compensation
THI	Tissue harmonic imaging
USG / US	Ultrasonography
WHO	World Health Organization

ABSTRACT

Introduction:

Under normal circumstances the testis and its appendages are accessible for clinical examination. But in acute setting, there is limited accessibility for clinical assessment due to swelling, pain and distortion of morphology. Some conditions may present with overlapping clinical features, restricting the clinicians to arrive at appropriate diagnosis. High frequency ultrasonography and color Doppler study is considered primary imaging modality

Aims and objectives:

1. The purpose of the study is to describe high frequency ultrasonographic characteristics in patients with non-traumatic scrotal swellings.
2. To correlate high frequency ultrasonography and color Doppler study findings with histopathology or follow-up.

Materials and methods:

This prospective observational study includes 196 patients who presented with scrotal swellings of non-traumatic etiology over a period of 18 months and were referred to department of Radio-Diagnosis for scrotal ultrasonography at Sri Devaraj Urs Medical College.

Results:

Scrotal swellings were most commonly seen in age groups of 21 to 60 years. Most of the patients had more than one inguinoscrotal abnormality on ultrasound.

Most common scrotal disease was hydrocele (n=78), followed by varicocele (n=71), epididymitis (n=68), epididymal cysts (n=46), epididymo-orchitis (n=45), inguinoscrotal hernia (n=19), scrotal wall thickening/edema (n=19), pyocele (n=7) testicular abscess (n=6), testicular tumors (n=3), extra-testicular tumor (n=1) and torsion testis (n=1). Seven patients with scrotal swellings also complained of infertility. Six had varicocele and one patient diagnosed to have inguinoscrotal hernia, intraoperative findings revealed uterus as content of the sac. One patient with testicular tumor was incorrectly diagnosed as acute epididymo-orchitis however MRI was performed and revealed malignant tumor, and on histopathology it was diagnosed as yolk sac tumor.

Conclusion:

High frequency ultrasonography with color Doppler study serves as an excellent diagnostic imaging modality in evaluation of scrotal swellings. It is the investigation of choice as it is highly sensitivity, easy to perform, widely available, repeatable and involves no risk of ionizing radiation radiosensitive parts like testis. It helps to arrive at accurate diagnosis in majority of patients with scrotal swellings, thus guiding for further management. When USG findings are inconclusive MRI may be useful. Periodic follow-up USG studies are recommended for all patients with inflammatory scrotal lesions for monitoring response to treatment or to reveal development of complications.

TABLE OF CONTENTS

Serial No.	TOPIC	Page No.
1	INTRODUCTION	1
2	AIMS AND OBJECTIVES	3
3	REVIEW OF LITERATURE	4
4	MATERIALS AND METHODS	52
5	RESULTS	54
6	DISCUSSION	81
7	CONCLUSION	90
8	SUMMARY	91
9	BIBLIOGRAPHY	95
10	ANNEXURES	103

LIST OF TABLES

Table No.	TABLES	Page No.
1	Normal resistivity indices of intratesticular artery in different age groups	19
2	Scrotal swellings of non-traumatic etiology	22
3	Mode of spread of infection	23
4	Complications of cryptorchidism	29
5	Causes of primary idiopathic varicocele	33
6	Terminations of right & left gonadal veins	33
7	Intra-abdominal causes of secondary varicocele	33
8	Sonographic grading of varicocele	35
9	Evaluation of a complete hernia	40
10	Classification of testicular tumors	42
11	Classification of extra-testicular tumors	50
12	Age distribution	54
13	USG diagnosis of various scrotal swelling	56
14	Total lesions on ultrasonography	57
15	Symptoms associated with scrotal swellings	58
16	Location of epididymal cysts	59
17	Location of epididymitis	60
18	Location of epididymo-orchitis	61
19	Location of testicular abscess	62

Table No.	TABLES	Page No.
20	Location of pyocele	63
21	Location of hydrocele	64
22	Location of varicocele	65
23	Location of inguino-scrotal hernia	66
24	Scrotal wall thickening	67
25	Scrotal tumors	69
26	USG diagnosis versus final diagnosis	72

LIST OF FIGURES

Figure No.	FIGURES	Page No.
1	Schematic diagram of male reproductive system	10
2	Processus vaginalis	11
3	Layers of scrotal wall	12
4	Arrangement of the ducts in testis	15
5	Normal testis on ultrasonography	20
6	Normal rete testis and epididymis on ultrasonography	20
7	Normal testicular vascularity	21
8	Normal intratesticular artery and spectral waveform	21
9	Age distribution	54
10	USG diagnosis of various causes of scrotal swelling	55
11	Total lesions on each side	57
12	Location of epididymal cysts	59
13	Location of epididymitis	60
14	Location of epididymo-orchitis	61
15	Location of testicular abscess	62
16	Location of pyocele	63
17	Location of hydrocele	64
18	Location of varicocele	65
19	Location of inguino-scrotal hernia	66
20	Cause of scrotal wall thickening	67
21	Scrotal tumors	68
22	Hydrocele	73
23	Acute epididymo orchitis	73
24	Acute epididymitis	74

Figure No.	FIGURES	Page No.
25	Acute epididymitis with abscess formation	74
26	Acute epididymo-orchitis	75
27	Complex hydrocele in tubercular infection.	75
28	Varicocele	76
29	Varicocele with reversal of flow during Valsalva's manoeuvre	76
30	Large epididymal cyst	77
31	Filariasis	77
32	Inguinoscrotal hernia	78
33	Seminoma	78
34	Yolk sac tumor	79
35	Liposarcoma of right spermatic cord	80

INTRODUCTION

The testes, epididymes and their appendages are enclosed in a cutaneous musculofascial sac known as the scrotum. Normally they are easily accessible for clinical examination. Most of the diseases affecting the scrotum present with limited accessibility for clinical assessment to differentiate intra-testicular from extra-testicular lesions and benign from malignant lesions due to swelling and tenderness. Some patients present with overlapping features of different diseases such as acute epididymo-orchitis, testicular abscess and torsion testis, thereby necessitating prompt and accurate diagnosis for further management[1].

High frequency ultrasonography of scrotum provides excellent anatomical details of testes, epididymes, their appendages and scrotal wall. Addition of color Doppler imaging (CDI) helps in visualization of vascularity and viability of testes there by providing vital information for diagnosis of various diseases[2].

Ultrasonography (USG) in evaluation of scrotal diseases has several advantages as follows- it is a non-invasive, rapid and easily reproducible technique with real-time evaluation capability. Also it is economical, widely available and free of ionizing radiation. The higher imaging modalities like computed tomography (CT) for scrotal swellings is not preferred over US as they are relatively expensive, requires contrast media enhanced studies and has risk of ionizing radiation to the gonads. Though magnetic resonance imaging (MRI) provides better cross section details, it is expensive and not easily

accessible, thereby making USG as the first choice of investigation for the evaluation of diseases of the scrotum[3].

The current study was planned for evaluation of non-traumatic scrotal swellings by high frequency US and color Doppler study as there are very few studies involving the rural population.

This dissertation titled “High frequency ultrasonography and color Doppler study in evaluation of non-traumatic scrotal swellings” was performed from January 2015 to June 2016.

AIMS AND OBJECTIVES

The aims of the study are:

1. To describe high frequency ultrasonographic characteristics in patients with non-traumatic scrotal swellings.
2. To correlate high frequency ultrasonography and color Doppler study findings with histopathology or follow-up.

REVIEW OF LITERATURE

HISTORICAL BACKGROUND

B–mode sonography of the testes was first performed by Miskin and Bain using a static scanner with 2.5 MHz transducer[4]. The details of B-mode and gray scale images obtained using a high frequency (5 MHz) transducer was presented by Murray Miskin, Martin Buckspan and Jerald Bain for normal appearances of testes, sonographic appearances of testicular neoplasm, abscess, trauma, hydrocele, varicocele, spermatocele and epididymitis[5].

A large series of patients with scrotal masses were evaluated using a 5.0 MHz, 7-mm diameter transducer, which enabled differentiation of intra and extra testicular mass. Majority of the patients with testicular masses presented with areas of reduced echogenicity[6].

High-resolution real-time ultrasonographic scanner was developed at the Stanford research institute. It employed a single 13 mm, 10 MHz water bath transducer, focused at approximately 1.5 cm beneath the skin surface which made recognition of epididymis and physiological amounts of extra testicular fluid[7].

Subramanyam BR et al performed Inguino-scrotal USG in 65 patients for primary scrotal mass. They concluded that scrotal and inguinal sonography was effective in

evaluation of primary scrotal masses to differentiate inguinoscrotal hernia, extratesticular masses or testicular masses[8].

Real-time sonography of the scrotum was conducted in a group of patients with clinical suspicion of varicocele. They were examined using a high-resolution real-time scanner with a mid-range frequency of 8 MHz transducer. They were able to visualize the blood flow within the dilated veins and acceleration of flow in the veins during Valsalva's manoeuvre[9].

Horstman WG et al in 1991 performed Color Doppler evaluation of scrotum using a 7.5 MHz transducer in patients with clinical diagnosis of infective / inflammatory conditions. Along with gray scale findings they demonstrated hypervascular status in the scrotum which increased the diagnostic confidence[10].

Farriol VG et al, described the gray-scale and power Doppler sonographic appearances in inflammatory scrotal diseases and concluded that power Doppler imaging is an easy and fast imaging modality for evaluating inflammatory conditions of the scrotum like epididymitis, epididymo-orchitis and abscess[11].

Ultrasonography is the most preferred imaging modality in acute scrotum as it provides good anatomic details and helps in characterization of lesions. With color Doppler imaging it provides vascular information of the organs[2].

Localizing the lesion correctly as intratesticular or extratesticular is crucial because most intratesticular lesions are malignant, unlike extratesticular, which are usually benign. Assessing the vascularity of the lesion is valuable in acute settings such as infection, trauma and torsion. Absence of vascularity is observed in hematoma and testicular infarction. However in patients where clinical and ultrasound findings are inconclusive, MR imaging will be useful[12].

Studies have shown that US with color Doppler is very accurate and sensitive for diagnosis of torsion in the setting of acute scrotum. USG has high sensitivity (100%), specificity (97.9%), and diagnostic accuracy (98.1%) in testicular torsion. False-positive rate for torsion testis was 2.6% and there were no false-negative cases[13]. The most common cause of scrotal pain is infection. USG plays an important role in the diagnosis of scrotal diseases and in planning the appropriate treatment[14,15].

Currently high-resolution ultrasound scan with Color Doppler imaging is the modality of choice in investigating scrotal lesions. It has rendered other modalities like testicular scintigraphy, venography and thermography as obsolete.

ANATOMY OF SCROTUM

EMBRYOLOGY

In human embryo, the primordial germ cells are initially found in the wall of yolk sac adjacent to allantois. By 6th week of gestation, they migrate to the genital ridges on either side of midline at level of T6 - T12 of embryonic segments. Three sources contribute for development of testis (Figure 1)[16] -

- Mesothelium - forms tunica vaginalis (lines the posterior abdominal wall)
- Mesenchyme - supporting stromal cells (embryonic connective tissue) of the testicular interstitium, including endothelial cells and vascular smooth muscle cells
- Primordial germ cells – earliest undifferentiated sex cells (gives rise to most testicular tumors).

The development of the dense tunica albuginea is the characteristic feature of testicular development. Gradually, the enlarging testis separates from the degenerating mesonephros and is suspended by the mesorchium. The seminiferous cords develop into the seminiferous tubules, tubuli recti (straight tubules), and rete testis. The seminiferous tubules are separated by mesenchyme that gives rise to the interstitial cells (Leydig cells). By the 8th week, these cells begin to secrete androgenic hormones, testosterone and androstenedione, which induce masculine differentiation of the mesonephric ducts and external genitalia[16].

Testosterone production is stimulated by human chorionic gonadotropin, which reaches peak during the 8th to 12th week period. In addition to testosterone, the fetal testis

produces a glycoprotein, AMH or Mullerian-inhibiting substance (MIS). AMH is produced by the sustentacular cells (Sertoli cells); and its production continues until puberty, after which the levels of the hormone decreases. AMH suppresses development of the paramesonephric ducts. The seminiferous tubules (Figure 4) have no lumen until puberty. The walls of the seminiferous tubules are composed of 2 types of cells: 1) Sertoli cells- derived from the surface epithelium of the testis which support spermiogenesis, 2) Spermatogonia- primordial sperm cells, are derived from primordial germ cells[16]

Sertoli cells constitute most of the seminiferous epithelium in the fetal testis. During development, the surface epithelium of the testis flattens to form mesothelium (a layer of cells) on the external surface of the testis. The rete testis becomes continuous with 15 to 20 mesonephric tubules that become efferent ductules. These ductules are connected with the mesonephric duct, which becomes the duct of the epididymis (Figure 1)[16].

The seminal vesicles arise on either side, as a diverticulum from the lower end of the mesonephric duct. The ejaculatory ducts are formed partly from mesonephric duct between its openings into the prostatic urethra. The mesonephric ducts (Wolffian ducts) develops in to the male reproductive system. The fetal testes produce testosterone and MIS Sertoli cells produce MIS by 6^{th} to 7^{th} week. The interstitial cells begin producing testosterone in the 8^{th} week. Testosterone stimulates the mesonephric ducts to form male genital ducts, whereas AMH regresses the paramesonephric ducts[16]

Under the influence of testosterone produced by the fetal testes during 8th week, the proximal part of each mesonephric duct becomes highly convoluted to form the epididymis. As the mesonephros degenerates, some mesonephric tubules persist and are transformed into efferent ductules. These ductules open into the duct of epididymis. Distal to the epididymis, the mesonephric duct acquires a thick investment of smooth muscle and becomes the ductus deferens[16].

Testicular descent occurs due to: 1) Enlargement of the testes and atrophy of the mesonephroi, allowing caudal movement of the testis along the posterior abdominal wall. 2) Atrophy of the paramesonephric ducts induced by MIS, enables the testis to move transabdominally to the deep inguinal ring. 3) Enlargement of the processus vaginalis guides the testis through the inguinal canal into the scrotum[16].

The gubernaculum forms a path through the anterior abdominal wall for the processus vaginalis to follow during formation of the inguinal canal. It anchors the testis to the scrotum and guides its descent into the scrotum. Growth of the abdominal viscera increases the intra-abdominal pressure, which facilitates testicular descent. Descent of the testes through the inguinal canals into the scrotum usually begins during the 26th week, and in some fetuses, it takes 2 or 3 days (Figure 2). By 32 weeks, both testes are present in the scrotum. During its descent, its arteries, veins, lymphatics and sympathetic nerves accompany it. Once the testis is in scrotum, the inguinal canal contracts around the spermatic cord. More than 97% of full-term neonates have both testes in the scrotum. In few neonates the undescended testis descends into scrotum during the first 3 months[16].

The mesenchymal cells, surrounding the developing testis, form a dense layer of fibrous tissue called as tunica albugenia. The testes are invaginated by tunical sac from posterior, leading to deficiency posteriorly. Soon after birth, the processes vaginalis from the level of deep inguinal ring to upper pole of testis, obliterates into fibrous cord. Persistence or non-obliteration of processes vaginalis leads to congenital or infantile, and encysted hydroceles (Figure 2) [16].

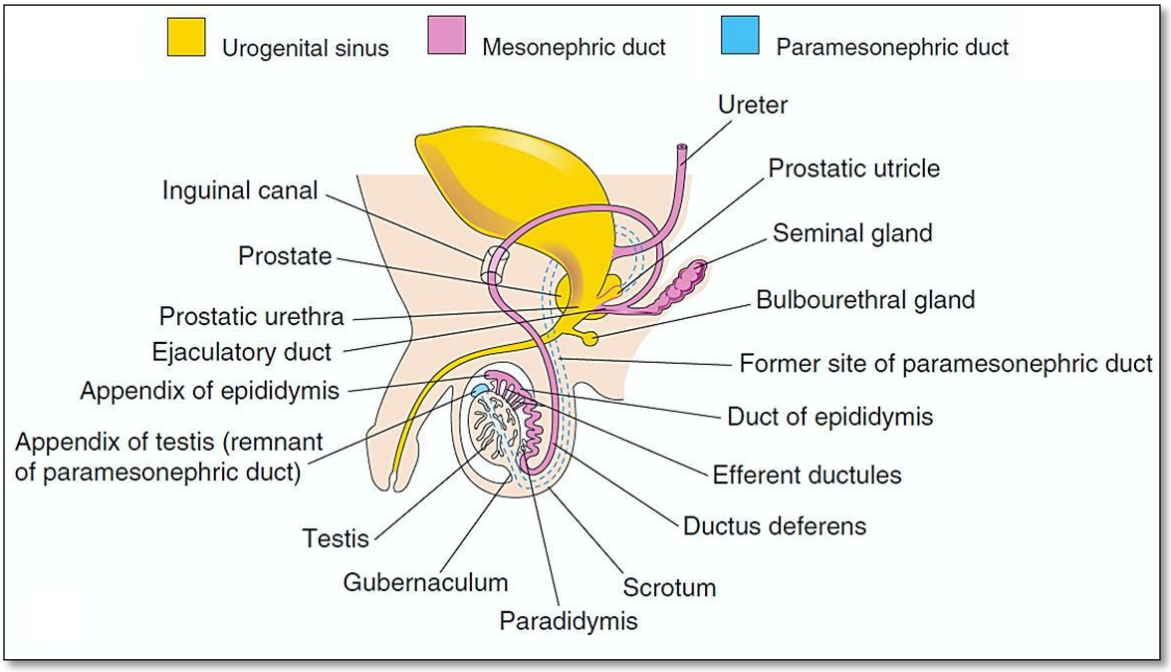

Figure 1. Schematic diagram illustrating reproductive system in a male neonate

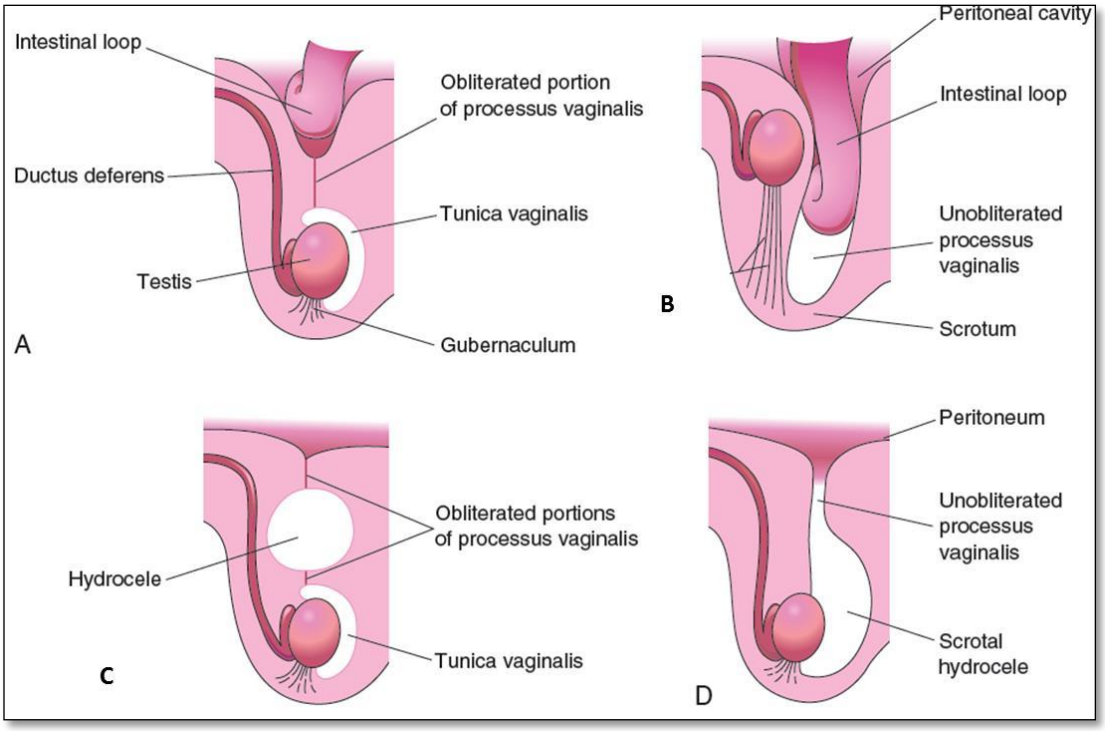

Figure 2. Diagrams of sagittal sections illustrating conditions resulting from failure of closure of the processus vaginalis.

A, Incomplete congenital inguinal hernia resulting from persistence of the proximal part of the processus vaginalis.

B, Complete congenital inguinal hernia into the scrotum resulting from persistence of the processus vaginalis. Cryptorchidism, a commonly associated defect, is also illustrated.

C, Large hydrocele that resulted from an unobliterated portion of the processus vaginalis.

D, Hydrocele of the testis and spermatic cord resulting from peritoneal fluid passing into an unobliterated processus vaginalis.

NORMAL ANATOMY OF SCROTUM AND TESTIS

The scrotum is a cutaneous fibromuscular sac, which contains the testis, epididymis and lower spermatic cords bilaterally, lying dependent below the pubic symphysis, anteromedial to the upper thigh. It is divided in to right & left hemi scrotum by a median raphe, which continues vertically to ventral surface of penis and dorsally along midline of perineum, to the anus[16].

The normal scrotal wall measures 2-8 mm in thickness. From superficial to deep the scrotal wall is composed of the multiple layers (Figure 3): a) skin, b) dartos muscle, c) superficial perineal fascia, d) external spermatic fascia, e) cremasteric muscle and fascia, f) internal spermatic fascia, g) parietal and visceral layers of tunica vaginalis[16].

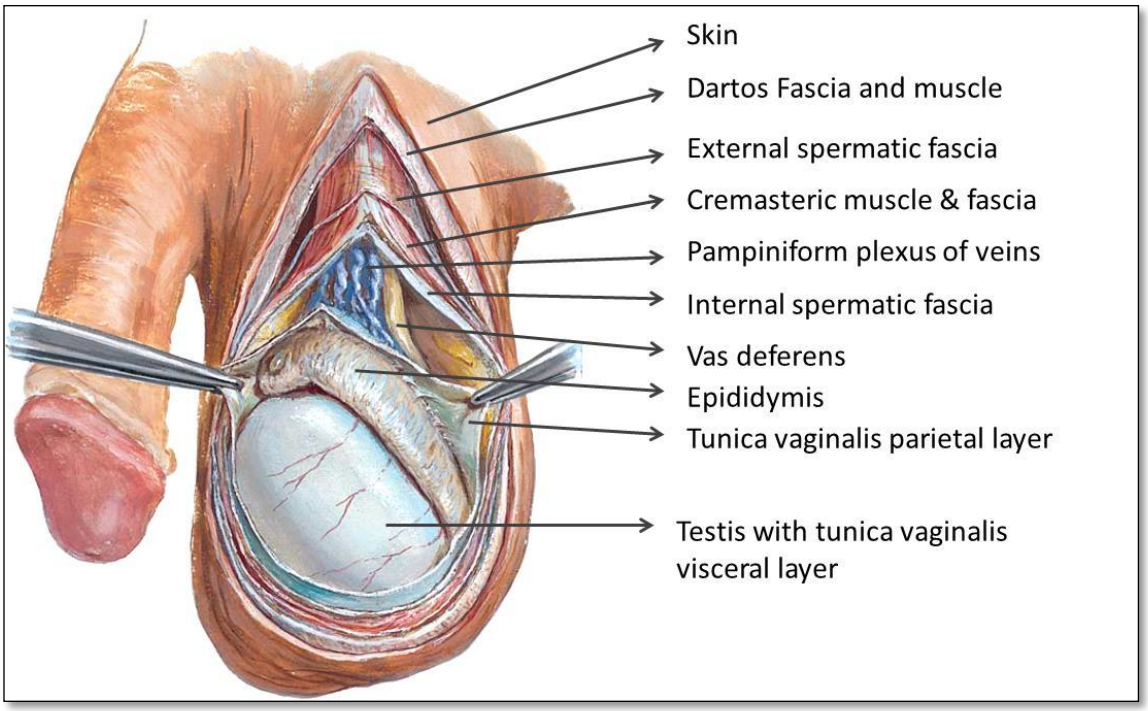

Figure 3. Layers of scrotal wall

The cremasteric muscle is derived from the internal oblique muscle. The spermatic fascia is a thin layer derived from the transversalis fascia, loosely attached to the parietal layer of the tunica vaginalis[16].

TESTIS

Testis is the male gonad suspended in the scrotum by the spermatic cord. The left testis is situated at a lower level (approx 1 cm) than the right. They measure about 4 to 5 cm in length, 2 to 3 cm in transverse and anteroposterior dimensions. An average adult testis weighs about 10 to 15 gm. Both testes are approximately equal in size/volume. Normal post-pubertal testicular volume is 15 to 20 ml. The epididymis is located posterolaterally to the testis[16].

Beneath tunica vaginalis the testis is enclosed by a fibrous capsule known as tunica albuginea (Figure 4). In the posterior aspect of testis, the tunica albuginea invests inside and forms an incomplete septum called the mediastinum testis, which serves as a hilum for ducts, blood vessels and nerves. The tunica albuginea has contractile properties and propagates spermatozoa from the seminiferous tubules to epididymis. Each testis is divided into lobules by fibrous septa; each lobule contains seminiferous tubules, the site of spermatogenesis and the principal functioning unit of the testes. Tunica albugenia is surrounded by the tunica vaginalis, a 2-layered fascia consisting of an inner visceral layer and an outer parietal layer, which lines the inner scrotal wall[16].

The seminiferous tubules converge to form ducts known as the tubuli recti, which open into the rete testis (Figure 4). They converge to form efferent ductules and exit through the mediastinum testis to form the head of the epididymis[16].

EPIDIDYMIS

It is a tortuous canal, folded and tightly packed into a longitudinal mass attached posterolaterally to the upper pole of testis. It has a triangular head, a central body and a tail. The head is connected to the upper pole of testis by the efferent ducts and the tail to the lower pole by loose areolar tissue and the reflected tunica vaginalis. The head of epididymis is made up 15 to 20 enlarged ducts, which are continuation of efferent ductules which forms an epididymal lobule. The lobular ducts open in to a single duct of epididymis, which coils to form body and tail of epididymis. The coils when unwinded measures approximately 6 meters in length and its thickness increases as it approaches the tail where it is continuous with the ductus deferens (Vas deferens) [16].

Vas Deferens- It is very tortuous tube, but becomes straighter, & ascends along the posterior aspect of testis, medial to the epididymis (Figure 4). From the superior pole of the testis, it ascends posteriorly as spermatic cord to traverse the inguinal canal[16].

Spermatic Cord- It extends from the deep inguinal ring to the level of posterior aspect of upper pole of testis. It traverses the inguinal canal. In the canal, it acquires covering from layers of abdominal wall, which merges on to the scrotal wall as the external

spermatic, cremasteric and internal spermatic fascia. It contains vas deferens, testicular vessels, pampiniform venous plexus, and nerves[16].

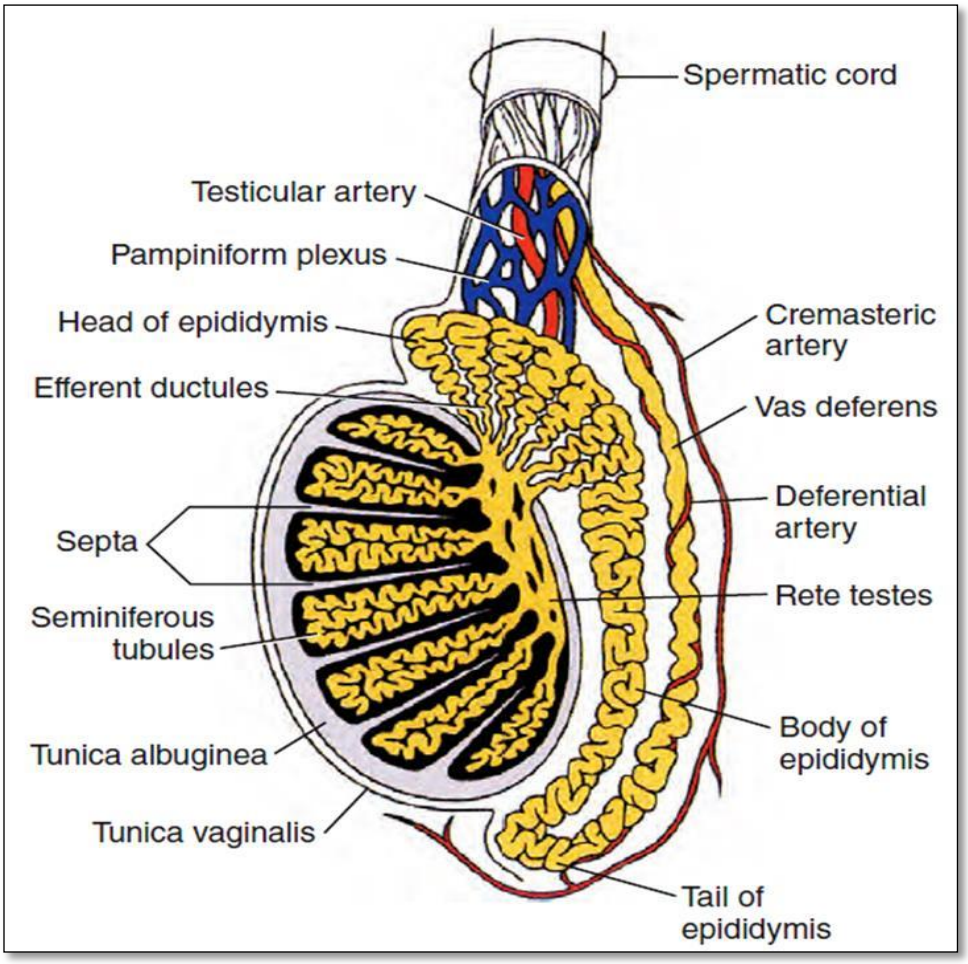

Figure 4. Vertical section through the testicle showing arrangement of the ducts and formation of epididymis and vas deferens.

Blood Supply of Scrotum

Arteries supplying the scrotum are: 1) superficial and deep branches of external pudendal artery (branch of femoral artery), 2) Scrotal branch of internal pudendal artery, 3) Cremasteric branch of inferior epigastric artery[16].

Venous drainage of scrotum follows the corresponding arteries. The subcutaneous tissue is richly vascularized, which facilitates effective heat loss from the gonads[16].

Arterial supply of testes is derived from: 1) Testicular artery – a branch of lower abdominal aorta, 2) Differential artery – a branch of inferior vesical artery, 3) Cremasteric artery – a branch of inferior epigastric artery[16].

Venous drainage of testis occurs through a venous plexus accompanying the lower most part of spermatic cord— pampiniform plexus (resembling a cluster) of veins. The pampiniform plexus condenses to 4 testicular veins at the superficial inguinal ring and 2 at the level of deep inguinal ring. Eventually, they form a single vein– the testicular vein. The left testicular vein drains into left renal vein. The right testicular vein drains directly into inferior vena cava[16].

The scrotum and testes have dual lymphatic drainage. The scrotal lymphatics drain to inguinal lymph nodes. The testicular lymphatics ascend along with testicular veins and drain into the pre and paraaortic group (sentinel node) of lymph nodes at the level of L2 vertebral body[16].

Nerve supplying the testes and scrotum are: a) Genital branch of genitofemoral nerve, b) Testicular sympathetic plexus around the testicular artery, c) Cremasteric nerve, d) Two posterior branches of perineal nerve, e) Perineal branch of posterior femoral cutaneous nerve[16].

IMAGING TECHNIQUE

Ultrasonographic evaluation of scrotum is performed with a 5 to 10 MHz linear transducer as it provides higher resolution images of the scrotal contents. A direct-contact scan is performed using acoustic coupling agent (gel)[17].

Patients are usually examined in the supine position and the testes are imaged in the sagittal and transverse planes. Less often if greater penetration is needed because of scrotal thickening, a 6 MHz or lower frequency transducer may be used[17].

A midline transverse image, including a portion of each testis, is essential for comparison of echotexture and vascular flow. Scanning a patient in the upright position or during a Valsalva manoeuvre augments the detection rates of varicocele[17].

It is advisable to perform a transverse scan using a larger-footprint transducer, or extended field of view demonstrating both testes in a single window for comparison[17].

SONOGRAPHIC APPEARANCE OF NORMAL SCROTUM

Sonographically the normal testis has a homogeneous echotexture with uniformly distributed medium level echoes (Figure 5). The septula testis may be seen as linear echogenic or hypoechoic structures. The mediastinum testis is seen as a linear echogenic band extending craniocaudally within the testis. Its appearance varies according to the amount of fibrous and fatty tissue present and is best visualized after 15 years (Figure 6)[18].

The epididymis is normally isoechogenic or slightly hyperechogenic to testis, and its echotexture may be coarser. It is best evaluated in the sagittal plane (Figure 6). The narrow body of the epididymis measures 2 to 4 mm. The tail may be seen as a curved 2 to 5 mm structure at the inferior pole of testis where it becomes the proximal vas deferens[18].

Intratesticular vascular flow can reliably be demonstrated with color Doppler and spectral Doppler waveforms (Figure 8). The spectral waveforms of the intratesticular arteries, as well as the waveforms within the epididymis, typically have a low resistance pattern, i.e. monophasic waveform with continuous diastolic forward flow (Figure 8)[19]. Normal spermatic cord lies just beneath the skin and is difficult to distinguish from the adjacent soft tissues of the inguinal canal[20].

The layers of scrotal wall are normally indistinguishable even by high frequency sonography and are seen as a (2.5 mm thick) single echogenic stripe. If any fluid is present

in the scrotal wall, the tunica vaginalis may be identified as a separate thin echogenic curvilinear structure[12,17].

The velocity waveforms of the normal capsular and intratesticular arteries reveal continuous diastolic forward flow throughout the cardiac cycle, suggesting low resistance pattern. However there are two types of waveforms for the supratesticular arterial system:[17,19]

a. Low-resistance wave form in the capsular and intratesticular arteries (Table 1).
b. Relatively higher pulsatility and higher resistance waveform with sharp, narrow systolic peaks and little or no diastolic forward flow.

This high-resistance waveform reflects the vascular resistance offered by the extratesticular tissues.

Table 1. Normal resistivity indices of intratesticular artery in different age groups[19]

Age group	Resistivity index (RI)	Mean (RI)
Adults	0.46 to 0.78	0.64
Post-pubescent	0.48 to 0.75	0.62

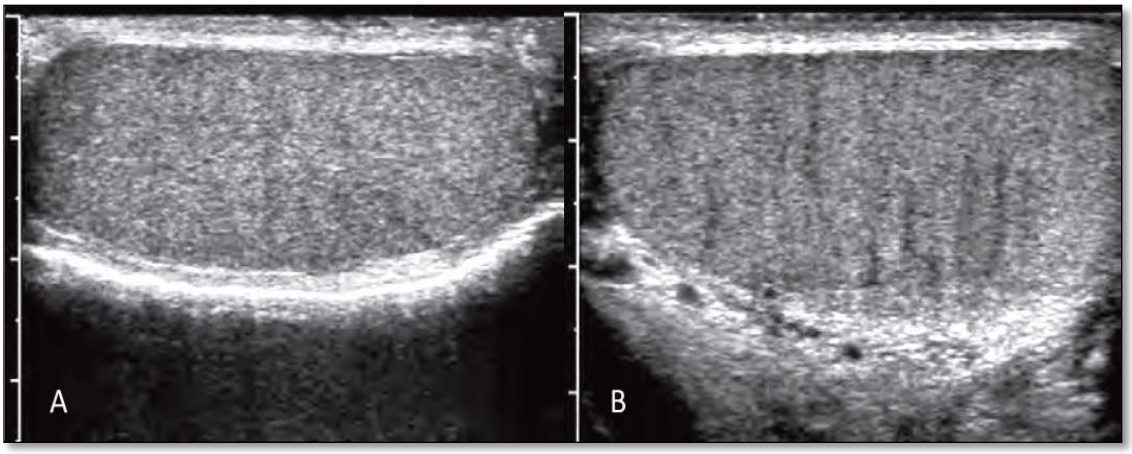

Figure 5. A. Longitudinal USG scan showing normal homogeneous echotexture of the testis. B. Longitudinal scan showing normal striated appearance of the septula testis.

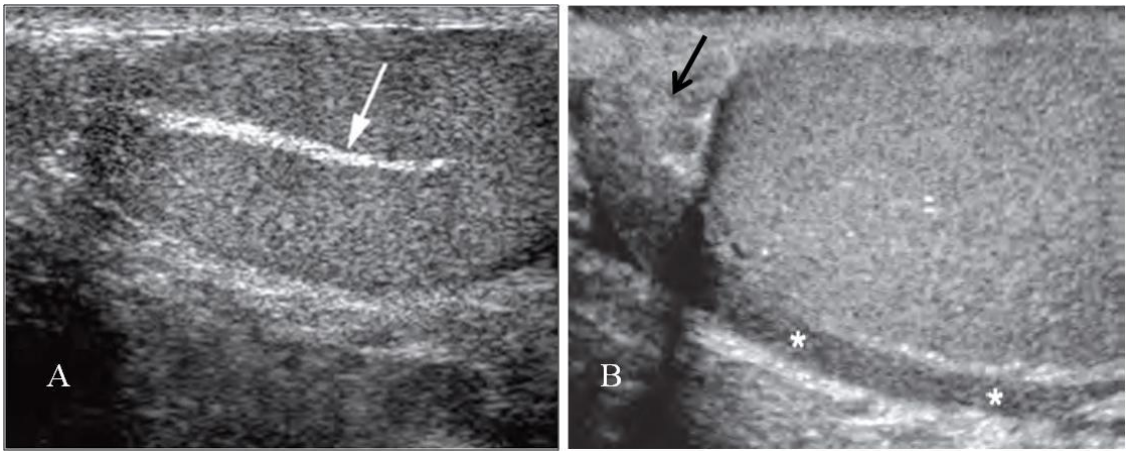

Figure 6. (A) Longitudinal USG scan of testis showing normal rete testis (white arrow) as a linear echogenic band of fibro-fatty tissue. (B) Longitudinal scan in a different patient showing normal appearance of epididymal head (black arrow) and body (white *).

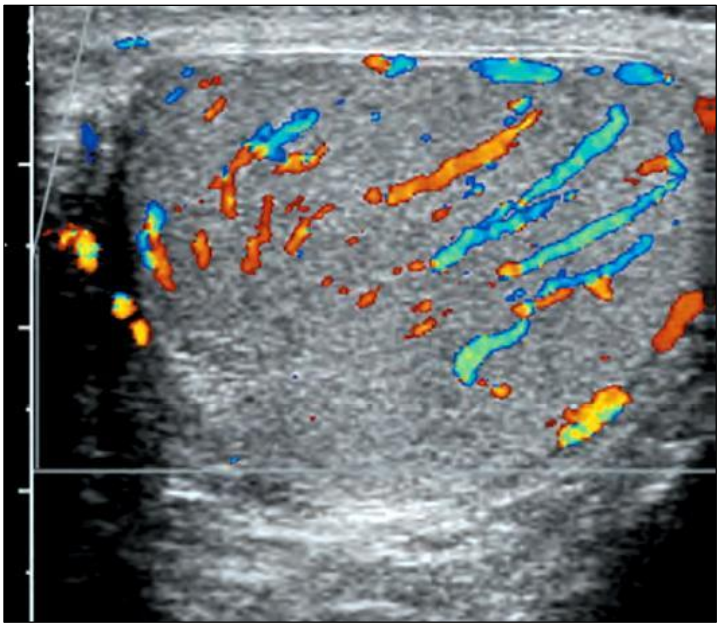

Figure 7. Transverse USG scan with color Doppler showing normal testicular vascularity.

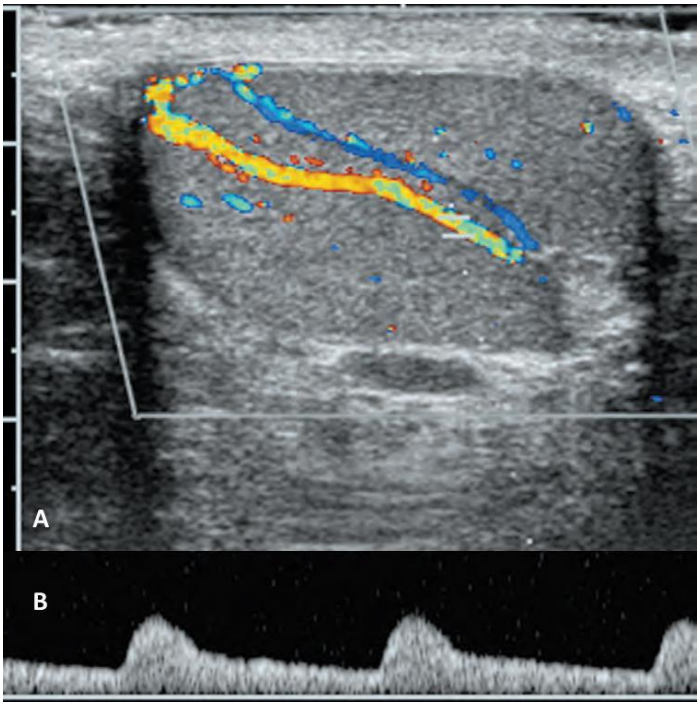

Figure 8. A. Color Doppler of normal intratesticular artery. B. Spectral Doppler waveform of normal intratesticular artery reveals low-impedance pattern with continuous diastolic forward flow.

CLINICAL FEATURES, ETIOLOGY AND SONOLOGICAL FEATURES OF SCROTAL SWELLINGS

CLASSIFICATION

The following table shows the classification of commonly encountered scrotal and testicular swellings of non-traumatic etiology (Table 2).

Table 2. Commonly occurring scrotal swellings of non-traumatic etiology.

Inflammation	Testis and Epididymis	Acute epididymitis, epididymo-orchitis and orchitis, Chronic epididymitis epididymo-orchitis and orchitis, Abscess
	Scrotal wall	Fournier's gangrene, idiopathic scrotal edema, cellulitis, abscess
Congenital	Scrotal Sac	Congenital hydrocele- encysted hydrocele of the cord, due to persistent processus vaginalis, hernia
Vascular	Arterial	Torsion, infarct
	Venous	Intra and extra-testicular varicocele
Non-neoplastic	Testicular, Epididymal, Spermatic cord	Hydrocele, epididymal cyst, sperm granuloma, lymphocele, spermatocele, testicular cyst
	Anterior abdominal wall defect	Inguinoscrotal (complete) hernia
Neoplastic	Benign	Tunica albuginea cyst, tubular ectasia of rete testis, epidermoid cysts
	Primary malignant testicular	Seminomatous germ cell tumors, Non-seminomatous germ cell tumors
	Metastases to testis	Lymphoma, leukemia & nonlymphomatous
	Extratesticular	Benign = Adenomatoid tumor, lipoma
		Malignant = Lipo/fibrosarcoma, metastasis

INFLAMMATION OF SCROTUM, TESTIS & EPIDIDYMIS

Acute epididymitis and epididymo-orchitis

Acute epididymitis and acute epididymo-orchitis represent a continuation of scrotal inflammatory process where there is primary inflammation of epididymis followed by secondary inflammation of testicle (Table 3). Direct extension of epididymal inflammation to the testicle is referred as epididymo-orchitis. It occur in up to 20% of patients with acute epididymitis. Isolated orchitis may also occur. Patients may present with variable degree of swelling, pain, tenderness and fever. In prepubertal boys and in men over 35 years of age, the disease is most frequently caused by *E* coli and *Proteus* mirabilis[17].

Table 3. Mode of spread of infection[18].

Mode of infection	Infective focus from	Part first involved
Retrograde (ascending infection)	Urethra, prostate, seminal vesicles-	Tail of epididymis
Hematogenous	Globus major	Head of epididymis

On USG, acute epididymitis may appear as: a) heterogeneous hypoechogenicity of epididymis, b) thickening and enlargement of epididymis, c) reactive hydrocele formation, d) thickening of overlying scrotal wall, e) may involve epididymal body, and tail also[11,17].

Usually epididymis measures 7 mm to 14 mm at head, and 4 mm at the body[18].Color Doppler Imaging reveals hyperemic flow in the epididymis and testis, as compared with the asymptomatic side. Spectral Doppler waveforms show increased diastolic forward flow in uncomplicated cases[17,21].

The most frequent cause of orchitis is direct extension of infection from adjacent inflamed epididymis. Testicular involvement may be focal or diffuse. Focal orchitis causes a heterogeneously hypoechoic area adjacent to enlarged portion of epididymis. On USG, acute orchitis appears as poorly defined, focal, peripherally situated hypoechoic intratesticular lesions[17,22]. The testis will be diffusely enlarged and probe tenderness may be present. CDI shows increased color flow signal in and around the hypoechoic area of the testis; increased flow in the tunica vasculosa may be visible as lines of color signal radiating from rete testis. These lines of color correspond to accentuation that is visible as hypoechoic bands on gray-scale USG. Arterial spectral Doppler waveform shows increased diastolic forward flow (monophasic pattern, low impedence) and usually resistivity index (RI) of <0.5 in uncomplicated orchitis[23].

In complicated orchitis, the entire testicle may be diffusely hypoechogenic due to edema. This results in venous congestion leading to infarction and hemorrhage which initially appears hyperechoic and with time it shows hypoechoic echotexture on USG[12,17]. Ischemia and infarction of testis may occur due to venous occlusion in the epididymis and cord. In severe cases there may be complete testicular infarction. On USG, these conditions may be difficult to differentiate from torsion testis. CDI may demonstrate focal reactive hyperemia adjacent to infarcted areas in the testis in patients with severe complicated epididymo-orchitis. Reversal of diastolic flow in arterial spectral waveform of testis is suggestive of testicular infarction in severe epididymo-orchitis [24]. Other complications of acute epididymo-orchitis are: a) abscess formation in testis/epididymis, b) pyocele, c) scrotal wall abscess, d) funiculitis e) reactive hydrocele[17].

Epididymal abscess- On USG it appears as focal fluid collection with low-level echoes. Small abscess may show resolution on follow-up scans after treatment. The testicular and epididymal abscesses can rupture into the tunical sac leading to pyocele formation[17].

Pyocele- Rupture of a testicular or epididymal abscess into the tunical sac leads to pyocele formation. On USG it appears as a multiloculated fluid collection with mobile low level echoes, or fluid-fluid and fluid-debris levels. The presence of gas in the tunical sac may be identified as a strong reflector with posterior comet tail artifacts. No vascular color flow signal is seen on CDI[17,25].

Scrotal wall abscess- This may be present de novo, or may arise secondary to acute epididymal and testicular inflammation. On USG they are seen as focal hypoechoic lesion with intralesional low level echoes. CDI may show hyperemic color signal[17].

Funiculitis- On USG the cord appears diffusely thickened and heterogeneously hypoechoic. Cord thickening may be either due to torsion or complication from acute epididymitis. The two cannot be readily distinguished. CDI reveals localized hyperemic color flow signal[17,26,27].

Chronic epididymitis and epididymo-orchitis

As compared to acute epididymitis and epididymo-orchitis, chronic epididymitis and epididymo-orchitis represent a spectrum of inflammatory injury of testis arising

secondary to epididymal inflammation. However, testicular involvement may occur many years after epididymal disease. There are two types-

i. Chronic tubercular epididymitis / epididymo-orchitis = 90% of cases.
ii. Chronic non-tubercular epididymitis / epididymo-orchitis = 10% of cases

Tubercular epididymitis is frequently associated with lung and urinary tract tuberculosis. It may be unilateral or bilateral disease. It either follows an acute attack or has a chronic insidious onset. Following vasectomy/chronic low-grade inflammation in the epididymis, sperm granulomata formation may be seen. On high frequency USG, may show diffusely bulky and heterogeneously hypoechoic lesions. Tuberculous orchitis demonstrates similar features as in tubercular epididymitis like: a) diffuse or focal enlargement of testis with heterogeneously hypoechoic echotexture, b) associated sinus tract, c) extratesticular calcifications[28,29].

High frequency USG features of non-tubercular epididymis are diffuse enlargement with uniform decrease in echogenicity. On CDI, tubercular epididymitis may show focal linear or spotty color flow signals at the periphery of the epididymis[28].

Chronic non-tubercular epididymitis & epididymo-orchitis

Chronic infection of epididymis and testis may be seen in incompletely resolved inflammation. Swelling of the epididymis may persist and appear as a heterogeneous mass on USG. The testis may reveal striated appearance of septae due to fibrosis. This striated

appearance of the testicle is nonspecific as it is also noted after ischemia from torsion, following hernia repair procedure, and in elderly patients due to atrophy and sclerosis of semeniferous tubules[24,30].

Non-tubercular epididymitis usually shows increased color flow signals within the affected epididymis. Infarcted areas in testis appear as a wedge or cone shaped hypoechoic areas or may appear as hyperechoic scars on USG. If complete infarction of the testis has occurred due to epididymo-orchitis, overtime the testis may become atrophic, with a hypoechoic and heterogeneous echotexture[24,30].

Inflammatory disease of scrotal wall

Normal scrotal wall thickness is about 2 mm to 8 mm. Scrotal wall edema occurs secondary to acute epididymitis and epididymo-orchitis; however, it also occurs primarily in various conditions like: a) cellulitis of scrotal wall, b) Fournier's gangrene, c) idiopathic scrotal edema.

Cellulitis of scrotal wall- High frequency USG demonstrates thickening and loss of uniform hyperechogenicity of scrotal wall. The testis and epididymis appear normal. CDI reveals increased low velocity color flow signal[31].

Fournier's gangrene- It is necrotizing fasciitis of the scrotum and perineum, most frequently seen in patients of 50 to 70 years. Individuals with diabetes mellitus and/or physical debilitation are commonly susceptible to this condition[31]. Polymicrobial

involvement is noted including *Klebsiella*, *Proteus*, *Streptococcus*, *Staphylococcus*, *Peptostreptococcus*, *Escherichia* coli, and *Clostridium* species. Surgical debridement of non-viable tissue is usually required. The morbidity and mortality are high (33 to 35%) without prompt treatment. Ultrasound may be helpful in diagnosis by showing scrotal wall thickening containing gas and loss of normal hyperechogenicity of the scrotal wall (loss of homogeneous band-like appearance of wall). The fluid accumulation occurs in the connective tissue layer between the dartos and cremasteric fascia and this layer appears hypoechoic on ultrasound[32].

Idiopathic scrotal edema- It manifests as mild scrotal pain and swelling in young boys less than 10 years of age. USG features are similar to cellulitis of scrotal wall. However, ultrasonographic tenderness is very mild[33].

CONGENITAL LESIONS

Cryptorchidism- Refers to testes which are usually within the abdominal cavity and not palpable on examination. Testes lying in the course of normal descent in inguinal canal or root of scrotum are palpable and are termed incompletely descended testes. Usually seen in low birth weight, prematurity, small for date neonates and twin neonates. Undescended testis is a common genitourinary anomaly in infants. Its prevalence is about 3.5% at birth; and by age of 1 year it reduces to 0.8 %. This is due to spontaneous descent of testis in many children[34].

USG may disclose a mass in the expected position whose echogenicity is less than that of the surrounding fat. However to justify that a mass is testis, a bright echogenic band- mediastinum testis has to be identified, as an enlarged lymph node can simulate an undescended testis[34]. Usual sites of arrest are at inguinal canal, deep and superficial inguinal rings. It is associated with congenital indirect inguinal hernia and congenital hydroceles due to patency of processes vaginalis. Incidence of incomplete descent is about 50% on right side, 30% on left side alone and 10 to 33% bilaterally[37]. The incompletely descended testis are relatively smaller and shows a homogenously hypoechoic parenchyma as compared to normal testis. Table 4 lists the complications of cryptorchidism.

Table 4. Complications of cryptorchidism[34,35]

Sterility	If present on both sides
Trauma	In case of incomplete descent
Indirect inguinal hernia	
Torsion	
Epididymo-orchitis	Intra-abdominal testis may mimic acute appendicitis
Malignant transformation	Incidence of malignancy in undescended testicle is 20 times higher than that in normal testicle, most common being seminoma.

Congenital hydrocele- Patency of processes vaginalis leads to communication with the peritoneal cavity beyond 18 months of age. Usually the communicating orifice is very narrow for development of hernia. When the patient is in supine posture, the fluid in tunical pouch disappears into the general abdominal cavity, and returns to the scrotum, when erect posture is resumed[36].

VASCULAR CAUSES OF SCROTAL SWELLINGS

Testicular Torsion

Testicular torsion is a surgical emergency because occlusion of the testicular artery causes necrosis of the testis in approximately 6 hours. Torsion most frequently is seen in children and adolescents than in older patients. There are two types of torsion:[37]

a. **Intravaginal testicular torsion-** Occurs more frequently during pubertal age. Here the tunica vaginalis insertion is abnormally high on the spermatic cord (bell-clapper deformity), causing excessive mobility, predisposing to torsion testis.
b. **Extravaginal testicular torsion-** Occurs in neonates and infants, in whom the spermatic cord and testis may be loosely attached to the surrounding structures.

In both types of testicular torsion the veins are occluded much before the arteries, resulting in early vascular engorgement and edema of testis.

High frequency gray-scale USG during acute phase (1 to 5 hours) demonstrates several features such as: a) change in longitudinal axis of testis, b) enlargement of testis with normal echogenicity later it becomes heterogeneous and hypoechoic compared to normal testis, c) spermatic cord cranial to the testis and epididymis appears twisted, causing characteristic “whirlpool pattern”, d) epididymis maybe bulky and heterogeneous due to hemorrhage- this epididymis-cord complex may mimic epididymitis, e) reactive hydrocele, f) scrotal wall thickening[37,38,39,40].

On CDI, there will be complete absence of flow on the affected side. Rarely flow may be present, but significantly diminished. CDI is a rapid and a useful technique to arrive at diagnosis of testicular torsion and to distinguish torsion from epididymo-orchitis. In torsion, blood flow is absent in the affected testis or significantly lower than in the contralateral normal testis. Careful scanning of the testis with use of low-flow Doppler detection settings [low pulse repetition frequency (PRF), low wall filter, high Doppler gain] is important because testicular vessels are small and have low flow velocities, especially in prepubertal boys. CDI is more sensitive in demonstrating reduced testicular vascular flow in setting of incomplete torsion than nuclear scintigraphy study[41].

Pitfalls of USG in diagnosis of torsion testis are partial torsion, torsion-detorsion, and ischemia from orchitis. Torsion of at least 540 degrees is necessary for complete arterial occlusion to occur. In partial torsion of 360 degrees or less, arterial flow may still occur, where as venous outflow is often obstructed, causing diminished forward diastolic arterial flow on spectral waveform[42]. If spontaneous detorsion occurs, flow within the affected testis may be normal, or it may be increased and mimic orchitis[43]. There may be segmental infarction in case of spontaneous detorsion. It is difficult to demonstrate testicular vascularity in paediatric patients[44].

In subacute or chronic torsion, color Doppler shows no flow in the testis and increased flow in the paratesticular tissues, including the epididymis-cord complex and dartos fascia[44].

Segmental testicular infarction- It is commonly seen after torsion, trauma, bacterial endocarditis, vasculitis, leukemia, and hypercoagulable states. Spontaneous infarction of the testis is rare[45]. USG features depend on the age of the infarction. Initially, a segmental infarct is seen as a wedge-shaped or round hypoechoic area[46]. It is difficult to differentiate infarction from neoplasm based only on 2D-grayscale findings. These lesions demonstrate reduced/absent color flow signal, depending on the age of infarction. With time, the infarcted area or the entire testis often atrophies and shows hyperechogenicity due to fibrosis or dystrophic calcification. The early USG appearance may be difficult to distinguish from a testicular neoplasm, but on follow-up studies infarcted testis decreases in size, whereas tumors usually enlarge[47].

Varicocele

It is defined as an abnormal tortuous, elongation and dilatation of pampiniform venous plexus[48]. It occurs in 15 to 20 % of general population, and in 21 to 39 % of men attending infertility clinics[49]. Varicocele is the most common correctable cause of male infertility when a patient presents early[50]. It may be classified etiologically as-

- Primary- idiopathic, most commonly due to incompetent valves (Table 5)
- Secondary.

Idiopathic varicoceles occur on the left side in 98% of cases and are most common in age group of 15 to 25 years. Left side predominance is due to difference in venous drainage of gonadal veins (Table 6).

Table 5. Causes of primary idiopathic varicocele

Incompetence valves in internal spermatic veins leads to retrograde flow/reflux of blood through the spermatic cord into the pampiniform plexus of veins
Collaterals which are by-passing competent valves
Absence of valves

Table 6. Differences in terminations of right & left gonadal veins

	Right	Left
Venous drainage	Inferior vena cava	Left renal vein at approximately right angle
Length	Shorter course	Relatively longer course

Idiopathic varicoceles distend when the patient is in upright posture or on performing Valsalva manoeuvre. It may decompress when the patient is in supine position. Primary varicoceles may be seen bilateral in up to 70 % of cases. Intra-abdominal lesions (Table 7) causing increased pressure on the spermatic vein or its tributaries leads to secondary varicoceles[51].

Table 7. Intra-abdominal causes of secondary varicocele[51,52,53]

Marked hydroureteronephrosis
Hepatomegaly
Abdominal (retroperitoneal) neoplasm
Tumor thrombus in gonadal vein
Feces loaded colon in chronic constipation
Nutcracker syndrome (nutcracker phenomenon)- Superior mesenteric artery (SMA) compresses the left renal vein.

A thorough search for neoplastic obstruction of gonadal venous return must be done in cases of non-compressible or new onset, isolated right sided varicocele in a patient older than 40 years, because these cases are rarely idiopathic. The appearance of secondary varicoceles is not affected by patient positioning[51].

In infertile men, USG aids in diagnosis of clinically palpable and subclinical varicoceles. It is also of value in assessing testicle size before and after treatment, as varicocele may be associated with a decreased testicular volume, however there is poor correlation between the size of the varicocele and the degree of testicular tissue damage leading to infertility[54].

On USG, the varicocele consists of multiple, serpentine, anechoic tubular structures of more than 2 mm in diameter, creating a tortuous, multi-cystic appearance located adjacent to/proximal to the upper pole of the testis and head of the epididymis. Low-flow Doppler settings should be used to optimize detection of slow-flow in varices. In few patients, slowly moving red blood cells may be visualized with high-frequency transducers, when flow is too slow to be detected by CDI. Reflux of blood flow is best demonstrated by CDI and Doppler spectral waveform. Augmentation of venous flow can be achieved by positioning the patient in upright posture or by performing Valsalva's manoeuvre. Varicoceles follow the course of the spermatic cord into the inguinal canal and are easily compressed with gentle pressure through the transducer[55].

Varicoceles may be extra-testicular or intra-testicular (subcapsular or around the mediastinum testis). The relationship between varicocele and male subfertility is known. Semen analysis of patients with varicocele and infertility may reveal: a) decreased sperm count, b) decreased sperm motility, c) Increased abnormal morphology of sperm.

Spermatogenesis requires testicular temperature to be at 2 to 5 degree Celsius lower than rectal temperature. Varicoceles disrupt this normal temperature gradient to 0 to 1 degree Celsius. The subclinical varicocele is responsible for a significant percentage of male infertility cases. So these cases are undetectable by clinical examination and are diagnosed when the patient undergoes USG examination. Varicocele is diagnosed by gray-scale evaluation alone if 2 or more dilated veins are present, with at least one vein having diameter of 2 mm or more. Detection of retrograde flow in the pampiniform plexus spontaneously and/or during Valsalva manoeuvre by CDI confirms presence of varicocele. In normal beings, this increase in diameter is of the order of 0.5 mm or less. Varicoceles can be graded sonographically, based on diameter of the main spermatic vein (Table 8)[56]. USG with CDI is useful in management of varicocele for establishing the diagnosis and in assessment of treatment results[56].

Table 8. Sonographic grading of varicocele[56]

Grade	Mean diameter (standing posture)	Diameter on Valsalva manoeuvre
Small	3 to 4 mm	Increases by 1 mm
Moderate	4 to 5 mm	Increases by 1.2 to 1.5 mm
Large	>5 mm	Increases by 1.5 mm

Intra-testicular varicocele- It is a rare type of varicocele where there are both dilated extra-testicular and intratesticular veins. These vessels are distinguished from transmediastinal vessels by their tortuous course within the testis. They are situated near the mediastinum testis like transmediastinal vessels. On performing Valsalva manoeuvre, these vascular structures become more prominent. Intra-testicular varicocele closely mimics tubular ectasia of rete testes. CDI helps to differentiate the two conditions[56].

NON-NEOPLASTIC SCROTAL SWELLINGS

It includes hydrocele, sperm granuloma, fibrous pseudotumor, lymphocele, spermatocele, epididymal cyst, testicular cyst and inguino-scrotal hernia.

Hydrocele- It is collection of serous fluid in the scrotal sac between the visceral and parietal layers of the tunica vaginalis. It is the most common cause of painless scrotal swelling. It may be congenital or acquired (primary / idiopathic and secondary)[48,57].

Causes of secondary hydroceles are as follows: 1) Acute epididymitis and epididymo-orchitis, 2) Testicular neoplasms, 3) Filariasis, 4) Post-operative status, 5) Post-irradiation status for testicular malignancy, 5) Acute septic peritonitis in children with patent processes vaginalis[58].

On USG, a hydrocele is seen as an anechoic fluid collection in the tunical sac. At high gain settings, low-level echoes may be seen. These internal echoes are thought to be due to

cholesterol crystals. Scrotal calculi and parietal wall calcification may be visualized. Other less commonly seen hydrocele are-

A. **Infantile hydrocele**: Here the tunica vaginalis and unobliterated processes vaginalis are distended up to the deep inguinal ring, but communication with peritoneal cavity is not present. Despite the term this condition is not restricted to infants.
B. **Lymphocele**: Occurs in the post-renal transplant patients. Lymphocele of scrotal sac is believed to occur due to obstruction of scrotal lymphatics or due to dissection of peritransplant lymphatics. On high frequency USG, the lymphocele appear as an anechoic fluid collection with multiple septations.

Spermatocele- It is a retention cyst arising from sperm conducting tubules of the epididymis. It is usually situated in the head and hence is cranial and posterior in relation to the testicle. They tend to be large and multiloculated[59]. Large spermatoceles tend to displace the testis anteriorly and may show multiple internal septations. They contain spermatozoa and sediment[55].

Epididymal cyst- They occur in approximately 20 to 40 % of the general population. They are typically small, unilocular, multiple in number and asymptomatic. However large cysts (>3 cm in maximum diameter) may cause mild discomfort. Most of them arise in the epididymal head, although they can occur in the body and tail. Epididymal cysts may be observed in association with tubular ectasia of the rete testis[59].

Both spermatocele and epididymal cyst appear anechoic. It is difficult to distinguish cysts and spermatocele on USG.

Tunica albugenia cyst- These lesions are incidentally noted on USG in 5 to 10 % of general population. They are located within the tunica, the covering of testis: are well-defined and vary in size from 2 to 30 mm. Usually solitary and unilocular but may be multiple or multilocular. The mean age at presentation is 4th decade. The cysts may be asymptomatic, but patients frequently present with cysts that are clinically palpable resembling firm scrotal nodules. Complex cysts may mimic a testicular neoplasm[60].

Intratesticular Cysts- They are simple cysts filled with clear serous fluid. They vary in size from 2 to 18 mm. Most commonly located near the mediastinum testis, and are thought to originate from rete testis, secondary to post-traumatic or post-inflammatory stricture formation. On USG they appear as well-defined, anechoic lesions with thin, smooth walls and posterior acoustic enhancement[61].

Tubular ectasia of rete testis- It is associated with epididymal obstruction caused by inflammation or trauma. It can be mistaken for testicular neoplasm. They are variable sized cystic lesions in mediastinum testis with no associated soft tissue abnormality. CDI reveals no color flow signal which differentiates it from malignancy. Most of them are bilateral, asymmetrical and usually associated spermatocele[62].

Sperm Granuloma- Occurs due to necrotizing granulomatous response from extravasation of spermatozoa into the soft tissues surrounding the epididymis. They may be asymptomatic or painful. They are frequently seen in post-vasectomy patients. USG findings are a solid, hypoechoic mass, often located in epididymis; however may mimic an intratesticular lesion. Chronic sperm granuloma may rarely contain calcification[63].

Epidermoid cyst- They are benign, generally well-circumscribed germ cell tumors, representing ~ 1% of all testicular tumors. These tumors may occur at any age but are most common during the 2nd to 4th decades. The tumors are discovered incidentally on physical examination. Diffuse, painless testicular enlargement occurs in 10% of patients. The tumor wall is thought to be derived from epithelial rests or inclusions and have no malignant potential. They may represent monomorphic or mono-dermal development of a teratoma along the line of ectodermal cell differentiation. It can be differentiated from premalignant teratoma only by histopathologic examination[64].

On USG, they are usually of variable size, well-defined, avascular masses and may be multiple or bilateral. They demonstrate characteristic "whorled appearance", like layers of onion peel, due to alternating layers of compacted keratin and desquamated squamous cells. This whorled appearance is not-specific for epidermoid cyst as it is seen in few teratomas also[64]. Avascularity is the clue to diagnosis of epidermoid cyst. When the USG appearance is characteristic, confirmation by histopathology is still obtained by a conservative testicle sparing approach with local excision (enucleation)[65].

Inguino-scrotal Hernia

Inguino-scrotal hernia is common paratesticular soft tissue mass. A complete hernia extends up to the inferior aspect of scrotal sac. Sonography is useful in the evaluation of atypical cases. The hernia may contain small bowel or colon, with omentum. Bowel loop within the hernia may be confirmed by demonstration of valvulae conniventes or haustrations and detection of peristalsis by USG (Table 9). If these features are not visualized, it is difficult to differentiate a hernia from other extra-testicular multicystic lesions like hematocele and pyocele.

Omentum and lipoma appear as highly echogenic areas within the scrotum. Hernias occur anteromedial to the spermatic cord, whereas lipomas are lateral or inferior to the cord. One can also demonstrate the characteristic expansile cough impulse sign on USG by performing a dynamic 2D-grayscale imaging and instruct the patient to perform Valsalva manoeuvre. Once the patient relaxes, there will be partial reduction of the hernial sac[66].

Table 9. Checklist in evaluation of a complete hernia[66]

Identification of bowel loops within the scrotum
Exclusion of testicular pathology by demonstrating normal testicular elements
Demonstration of hernial sac in the inguinal region with bowel and / or omentum.

NEOPLASTIC CAUSES OF SCROTAL SWELLINGS

Recent advances in chemotherapy regimen have led to success in management of testicular cancer because it is curable. In young men, approximately 95% of testicular cancers are germ cell tumors, and 5% are sex cord–stromal tumors. Approximately 50% of germ cell tumors are seminomas, and approximately 50% are non-seminomatous germ cell tumors, predominantly occurring in age group of 15 to 35 years[51].

In elderly age group of more than 60 years, lymphoma is most common testicular malignancy (non-Hodgkin's lymphoma). It carries a poor prognosis. Other less common testicular tumors include leukemia, sarcoma, leiomyoma, vascular tumors, fibroma, and neurofibroma[67].

Metastases to the testes are rare. The tumors that most commonly metastasize to testis are primaries from prostate, lung, kidney and colon. Others include melanoma and leukemia. Metastases are bilateral in 8 % to 15 % of cases. Risk factors for testicular cancer are: a) undescended testis, b) family history, c) previous history of testicular cancer, d) infertility, and e) testicular microlithiasis[67,68].

Undescended testes are usually surgically moved into the scrotum as it reduces the risk of malignancy and also allows physical surveillance[51,67]. Testicular tumors (Table 10) are broadly classified into: a) Germ cell tumors, b) Sex-cord stromal tumors and c) Miscellaneous tumors (including metastasis)[67].

Table 10.Classification of testicular tumors[67]

Germ cell tumors (M/c)	Sex-cord stromal tumors	Miscellaneous tumors
Seminoma	Leydig cell tumor	Lymphoma
Mixed germ cell tumor	Sertoli cell tumor	Leukemia
Embryonal carcinoma	Granulosa cell tumor	Sarcoma
Yolk sac tumor	Thecoma-fibroma	Leiomyoma
Choriocarcinoma		Vascular tumors
Teratoma		Fibroma
		Neurofibroma

Note: M/c = Most common.

Embryonal carcinoma, yolk sac tumor, choriocarcinoma, teratoma and mixed germ cell tumor are collectively grouped as non-seminomatous germ cell tumors (NSGCT). Ninety-five percent of primary testicular neoplasms are of germ cell origin. The incidence of testicular germ cell neoplasm is 2 per 100000. These are seminoma (40 to 50%), embryonal carcinoma (15 to 20%), teratoma (5 to 10%) and choriocarcinoma (rare) [67,68].

Remaining 5% neoplasms arise from Sertoli cells, Leydig cells, or mesenchymal tissues which may be benign / malignant tumors. The testicular tumours have a trimodal age distribution with peak during infancy, late adolescence to early adulthood and after 60 years. Clinical features include- gradual testicular enlargement, mild dragging pain, acute painful scrotum (10%), gynecomastia (2 to10%), and metastasis (25%)[67,68].

Secondary neoplasms include lymphoma, leukemia and metastases. Metastases may arise from a variety of primary cancers like carcinoma of lung, gastrointestinal system & prostate, kidney, melanoma, sarcoma. On USG, a solid intratesticular hypoechoic lesion

with internal vascularity is suggestive of testicular tumor; however hemorrhage, calcifications, or fatty changes can show hyperechoic areas within the tumors[67,68].

Primary Malignant Tumors of Testis

Germ Cell Tumors

Seminoma- is the most common single-cell type of testicular tumor in adults, accounting for 40% to 50% of all germ cell tumors. They occur in older patients of fourth and fifth decades as compared to other testicular neoplasms. However may occur at older or younger ages, rarely occur before puberty. They are usually slow growing tumors and are confined within the tunica albuginea at presentation. Only 25% of patients have metastases at time of diagnosis[67,68,69].

Seminomas and its metastases are highly radio and chemo sensitive; therefore they have the most favorable prognosis of all malignant testicular tumors. Seminoma is the most common tumor type in cryptorchid testes; 8% to 30% of patients with seminoma have a history of undescended testicle[67,68].

Undescended testis, even after orchiopexy are at higher risk of developing seminoma. Also there is an increased risk of malignancy for the contralateral normally descended testis. Sonography is used as a screening technique for occult tumors in both testes after orchiopexy. Patients with a normally located, but atrophic testis have an increased risk of seminoma. On high frequency USG seminomas have predominantly

uniform, hypoechoic texture without calcification. In few instances they may show a more heterogeneous echotexture. Rarely, seminomas become necrotic and appear partly cystic on sonography[67,68].

Non-Seminomatous Germ Cell Tumors (NSGCT)-

1. **Mixed Germ Cell Tumors**

Mixed germ cell tumors are the commonest among NSGCTs. They are the second most common primary testicular malignancy after seminomas, constituting up to 40% of all germ cell tumors. They contain non-seminomatous germ cell elements in various combinations including seminomatous elements without significant change in prognosis. They are uncommon before puberty and after age 50 years. They are more aggressive than seminomas and frequently invade the tunica albuginea, resulting in distortion of the testicular contour. They are known to cause visceral metastases[55, 67,68,69].

USG appearance of NSGCTs depend on the histologic features. These tumors are heterogeneous, may have both solid (hypoechoic to background normal testis) and cystic (anechoic) components. Coarse calcifications are common. The identification of subtype NSGCTs is by histopathologic examination[67,68].

2. Embryonal Carcinoma

Pure embryonal cell carcinoma accounts for only about 2% to 3% of testicular germ cell neoplasms. It is usually seen with other neoplastic germ cell elements, like yolk sac tumor and teratoma. They occur in much younger patients compared to seminomas. It has a peak incidence during second and third decades[67,68,70].

The infantile form of embryonal carcinoma is known as endodermal sinus tumor/yolk sac tumor. It accounts for approximately 60% of germ cell testicular tumor in pediatric age group younger than 2 years of age. It is associated with elevated levels of α-fetoprotein (AFP) in 95% of cases. They are locally aggressive tumors invading the tunica vaginalis and infiltrate epididymis. Both the embryonal cell carcinoma and yolk sac tumor are relatively radio and chemoresistant as compared to seminomas[70].

On USG, about 30 % of pure embryonal cell carcinomas demonstrate cystic areas and up to 40% of cases show echogenic foci, with or without distal acoustic shadowing[67,68,70].

3. Teratoma

Teratomas comprise about 5% to 10% of primary testicular neoplasms. World Health Organization (WHO) classification is done based on presence of derivatives of the

different germinal layers (endoderm, mesoderm, and ectoderm). WHO categories of teratoma are– a) mature, b) immature and c) teratoma with malignant transformation[70].

Metastasis by lymphatic route is seen in up to one third of teratomas, within 5 years. Incidence is bimodal with first peak in infancy to early childhood, and second peak in third decade of life. In infants and young children, the well differentiated mature variant teratomas are the second most common testicular tumor. Occasional they may contain immature elements. During post puberty stages, teratomas contain immature and mature elements along with other germ cell types. In adults they are usually malignant. Cases with elevated levels of AFP or human chorionic gonadotropin may be present, suggesting malignancy. On high frequency USG they appear as fairly well-defined, markedly heterogeneous mass with cystic and solid areas of varying sizes. Focal calcifications appear as dense echogenic foci causing distal acoustic shadowing due to presence of cartilage, immature bone, fibrosis, and noncalcific scar and hair[51,55].

4. Choriocarcinoma

It is the rarest germ cell tumor, comprising less than 0.5% of malignant primary testicular tumors. Approximately 23% of mixed germ cell tumors contain a choriocarcinoma component. The peak incidence is seen during 2nd and 3rd decades. These tumors are highly malignant and metastasize early by hematogenous and lymphatic routes. Metastases may be symptomatic causing hemoptysis, hematemesis, and neurologic deficits. Gynecomastia is common because of the high levels of circulating chorionic gonadotropins

produced by tumor cells. Metastases may be present with occult primary in testis. On USG, hemorrhage, focal necrosis of tumor and calcification are typical features, similar to the other NSGCTs. Due to its aggressive nature, the primary tumor may out grow its blood supply and regress in the presence of widespread metastases. This phenomenon is known as "burned out tumor". The regressed tumor may appear as a calcified or echogenic fibrous scar[67,70].

Sex Cord (Gonadal) Stromal Tumors

They account for 3% to 6% of all testicular neoplasms. Approximately 20% of these tumors occur in pediatric age group. Gonadal stroma refers to Leydig, Sertoli, thecal, granulosa, or lutein cells and fibroblasts in various degrees of differentiation. Tumors containing any of the aforesaid components are known as sex-cord stromal tumors. These tumors may contain single or multiple cell types due to totipotentiality of the gonadal stroma. Gonadal stromal tumors and germ cell tumors together are called gonadoblastomas. Majority of gonadoblastomas in males occur with cryptorchidism, hypospadias[67,70].

Non germ cell tumours are generally benign, but they produce hormones such as estrogens and androgens leading to endocrine syndromes. The leydig cell tumor is associated with excess androgen production which may cause sexual precocity and extreme muscularity (infant Hercules). The Sertoli cell tumours cause excessive estrogen secretion leading to gynecomastia and loss of libido. About 10 % of these stromal tumours may undergo malignant transformation[67,70].

On USG these lesions appear as small, hypoechoic masses. Occasionally, hemorrhage or necrosis may occur occasionally in larger lesions, giving a heterogeneous appearance on sonography. CDI shows mainly peripheral flow[67,69,70].

Testicular Metastases

Malignant lymphoma is the most common cause of testicular metastasis. It is also the most common testicular tumor in men older than 60 years. Testicular involvement occurs in only 0.3% of patients with lymphoma. The peak age at diagnosis is around 60 to 70 years. Malignant lymphoma is commonly seen to involve bilateral testes (50% of bilateral testicular neoplasms are lymphomas). Most malignant lymphomas of the testicle are of the non-Hodgkin's type. Hodgkin's lymphoma of the testis is rare[68,69,70].

Testicular lymphoma is seen with disseminated disease or as an initial sign of occult nodal disease. Favorable prognosis is largely dependent on lymph node involvement. Most patients with malignant lymphoma of testis have painless testicular mass or diffuse testicular enlargement. Approximately 25% of patients have fever, weakness, anorexia, weight loss, night sweats. At the time of diagnosis they are often large. Involvement of scrotal wall is very rare[68,69,70].

USG appearance of lymphoma is nonspecific and similar to seminomas. Most malignant lymphomas are homogeneously hypoechoic and they diffusely replace the testis; however, focal hypoechoic lesions can occur. Hemorrhage and necrosis are rare. Color

Doppler imaging shows increased internal vascularity resembling diffuse inflammation but they are usually painless, and the testes are not tender to probe pressure[68,69,70].

Leukemia is the second most common cause of testicular metastasis. Primary testicular leukemia is rare, but leukemic infiltration of the testicle during bone marrow remission is common in pediatric age group. The testis acts as a harbor site for leukemic cells during chemotherapy due to inhibition of concentration of chemotherapeutic agents in testicle by the blood-testis barrier[68,69,70].

Testicular involvement is commonly found in patients with acute leukemia (64%). About 25% of patients with chronic leukemia have testicular involvement. Majority of cases occur within 1 year after discontinuation of long-term remission maintenance chemotherapy. Due to diffuse infiltration they appear diffusely enlarged and hypoechoic on USG similar to lymphoma[68,69,70].

Non-lymphomatous metastases to the testes are very rare and therefore all patients with testicular metastases may have wide spread dissemination. The most common primary malignancies are from the lung and prostate. Other common primary malignancies with tendency for testicular metastatsis are melanoma, kidney, colon, stomach, and pancreas. In majority of cases they are clinically silent and incidentally discovered after orchidectomy for prostatic carcinoma or at autopsy. They are usually multiple and are bilateral in up to 15% of cases. Routes of tumor spread to testis are: a) retrograde venous route, b) hematogenous route, c) retrograde lymphatic route and, d) direct tumor invasion[68,69,70].

USG features of non-lymphomatous testicular metastases is non-specific. They often appear hypoechoic but may be echogenic or complex.

EXTRATESTICULAR NEOPLASMS

Primary extratesticular neoplasms are rare. Majority (up to 70 %) of them arise from spermatic cord and are benign. The most common epididymal tumors are (Table 11) adenomatoid tumors (mesothelioma), mesenchymal neoplasms, epididymal cystadenoma and metastasis[71,72].

Table 11. Classification of extra-testicular tumors[72]

Benign	Malignant
Adenomatoid tumor	Liposarcoma
Lipoma	Fibrosarcoma
Fibroma	Rhabdosarcoma
Leiomyoma	Histiocytoma
Neurofibroma	Lymphoma
Cholesterol granuloma	Metastases
Adrenal rest	
Papillary cystadenoma	

Epididymal tumors: Adenomatoid tumors are rare, slowly growing benign neoplasm, predominantly from epididymis and account for 30 % of all extra-testicular tumors. They are usually seen after 20 years, unilateral and associated with hydroceles in 15 to 20 % of cases. Clinically they are usually asymptomatic, but up to 30 % of them may present with pain. Histologically these tumours are derived from mesothelial origin, hence

they are also known by the term mesothelioma[71,72]. Other neoplasms involving the epididymis are leiomyoma and papillary cystadenoma. Epididymal cystadenoma are rare and often part of Von-Hippel-Lindau syndrome and have a cystic component. They are bilateral in up to 33% of cases. On USG they appear homogeneously hyperechoic and well circumscribed[71,72].

Spermatic cord neoplasms

Includes lipoma, leiomyoma, neurofibroma, embryonal rhabdomyosarcoma and others. Lipoma of the cord is the most common benign tumor. Primary malignant extra-testicular tumors usually liposarcoma, fibrosarcoma, lymphoma in adults and rhabdomyosarcoma in pediatric age group. Metastasis to extra-testicular sites are very rare, however the commonest causes include lymphoma and primary malignancy of testis, stomach, kidney, prostate, colon, and rarely pancreas[71,72].

On USG the lipoma appear as a well-circumscribed lesion with medium to high intensity echoes, confined to the cord and discrete from both testes and epididymis. Large masses (>1.5 cm) with prominent color flow signal without symptoms of inflammation are more likely to be malignant[71,72].

When the tumors are very large or when there is gross thickening of scrotal wall, limiting the sonographic assessment of lesion cross sectional imaging, preferably, MRI is valuable[12,71,72].

MATERIALS AND METHODS

Source of Data

This descriptive observational study was carried out over a period of 18 months from January 2015 to June 2016 in 196 patients with complaints of scrotal swelling and underwent high frequency ultrasonography and color Doppler imaging at Department of Radiodiagnosis, R. L. Jalappa Hospital & Research Centre, affiliated to Sri Devaraj Urs Medical College, Kolar. Consecutive patients with scrotal swellings who met the inclusion criteria were included in the study.

INCLUSION CRITERIA:

All patients with non-traumatic scrotal swellings.

EXCLUSION CRITERIA:

None.

Method of collection of data:

The study was conducted on patients who underwent USG for evaluation of non-traumatic scrotal swelling and had agreed to participate in the study. An informed consent was obtained from the patient before including them in the study.

All the referred patients were examined using "SIEMENS ACUSON X300 PREMIUM" ultrasound system with high frequency (5 to 10 MHz range) linear transducer including color Doppler imaging.

Baseline demographic data was recorded, which included the patient's age, symptoms and clinical diagnosis. The USG findings were analyzed with regard to location and extent of abnormality, which included- hydrocele, varicocele, testicular abscess, extratesticular abscess, epididymal cyst, epididymitis, orchitis, testicular torsion and testicular tumor, scrotal wall thickening/edema, inguino-scrotal hernia and calcifications if any. Among the patients who underwent surgery, USG findings were correlated with surgical and histopathological findings. Patients who were diagnosed to have infective disease were followed-up after a minimum of 3 to 45 days by USG study for post-therapeutic changes.

Descriptive statistics was used for data analysis. An open-source statistical software (OpenEpi®) was been used for data analysis.

RESULTS

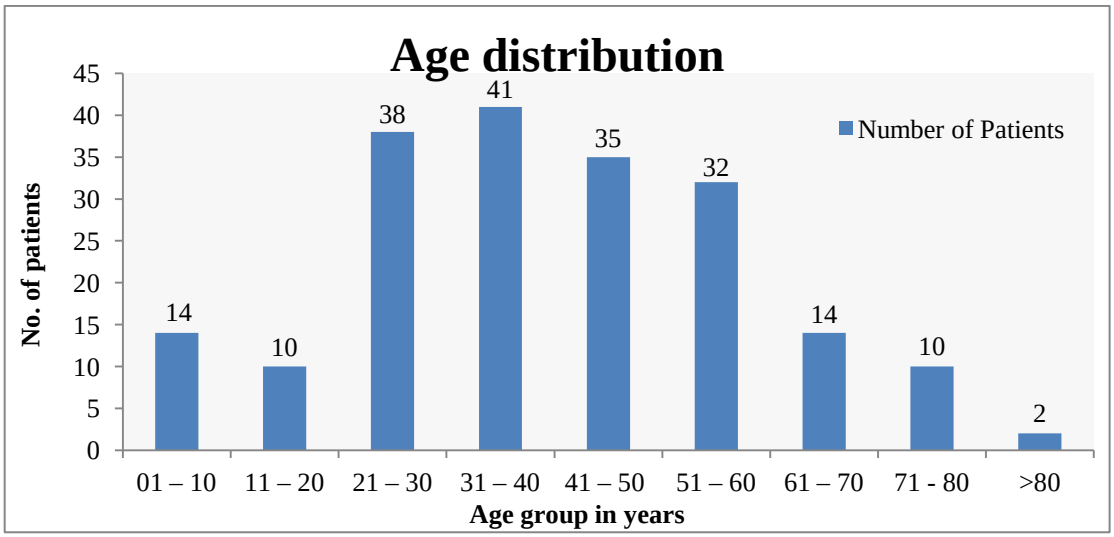

Figure 9. Distribution of patients based on age group.

The study included a total of 196 patients (Table 12). The most commonly involved were patients belonging to age group of 31 to 40 years (n = 41; 20.9%) followed by 21 to 30 years (n = 38; 19.4%) and 41 to 50 years (n = 35; 17.9%). Least number of patients belonged to age group of >80 years (n = 2; 1%). The age group from 21 to 60 years constituted more than 70% of the patients.

Table 12. Distribution of patients based on age group.

Age (in years)	No. of patients	%
0-10	14	7.1
11-20	10	5.1
21-30	38	19.4
31-40	41	20.9
41-50	35	17.9
51-60	32	16.3
61-70	14	7.1
71-80	10	5.1
>80	2	1.0
Total	**196**	**100**

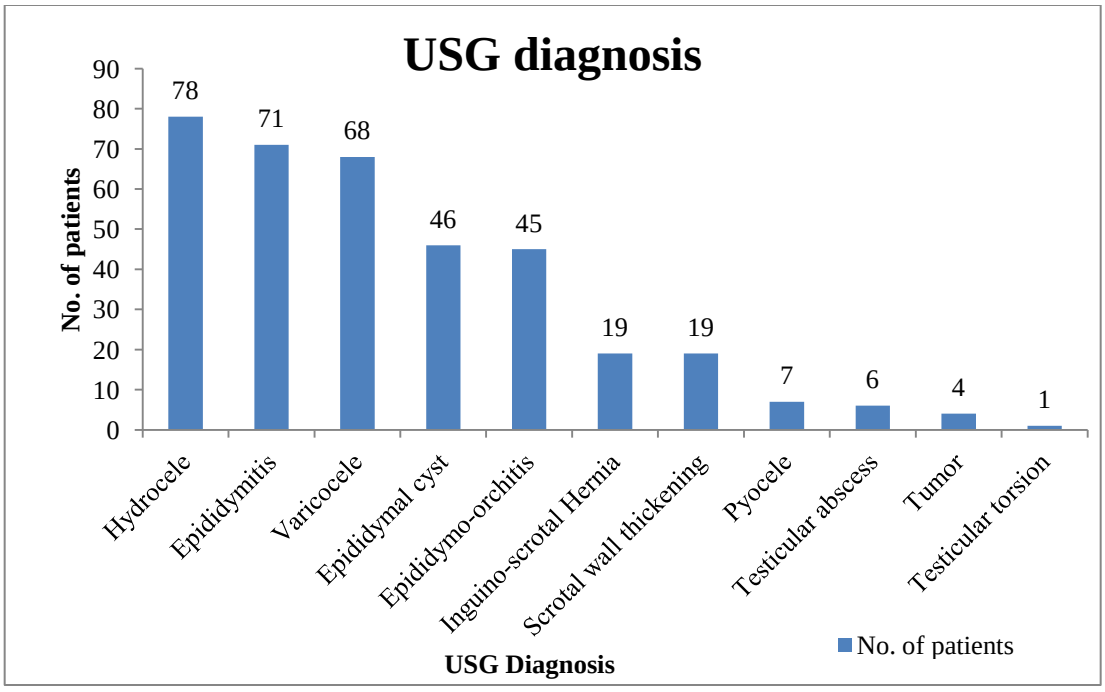

Figure 10. USG diagnosis of various causes of scrotal swelling

On USG, the commonest cause (Figure 10) for scrotal swelling was hydrocele, seen in 21.5% of patients (n = 78; 21.4%) followed by epididymitis (n = 71; 19.5%), varicocele (n = 68; 18.7%), epididymal cyst (n = 46;12.6%), epididymo-orchitis (n = 45; 12.4%), inguino-scrotal hernia (n = 19; 5.2%), scrotal wall thickening (n = 19; 5.2%), pyocele (n = 7; 1.9%), testicular abscess (n = 6; 1.6%), tumor (n = 4; 1.1%) and testicular torsion (n = 1; 0.3%) (Table 13).

Table 13. USG diagnosis of various causes of scrotal swelling

Condition	No. of lesions	%
Hydrocele	78	21.4
Epididymitis	71	19.5
Varicocele	68	18.7
Epididymal cyst	46	12.6
Epididymo-orchitis	45	12.4
Inguino-scrotal hernia	19	5.2
Scrotal wall thickening	19	5.2
Pyocele	7	1.9
Testicular abscess	6	1.6
Tumor	4	1.1
Testicular torsion	1	0.3

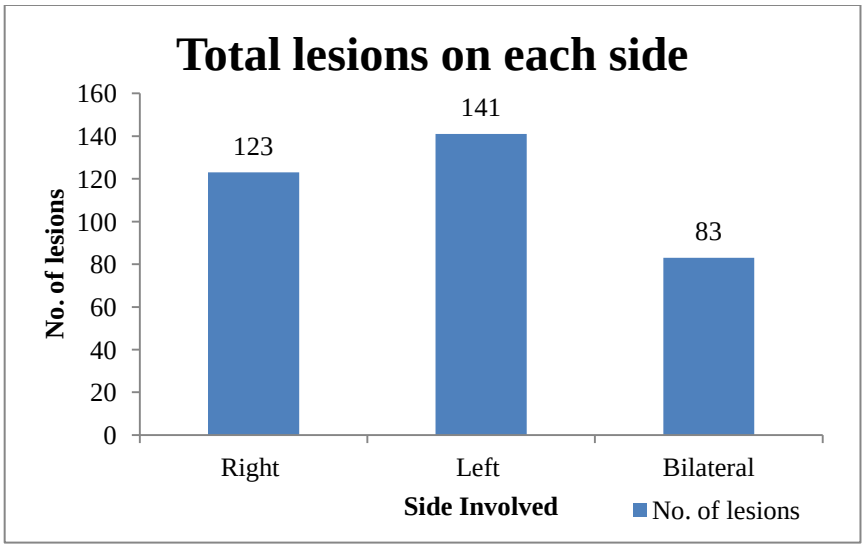

Figure 11. Total lesions on each side

The scrotal lesions were most commonly seen on left side in our study (n = 141, 40.6%) followed by right side (n = 123, 35.4%) and bilateral (n = 83, 23.9%) (Figure 11, Table 14). Majority of patients (n = 111; 56.6%) had more than one lesion in one or both sides.

Table 14. Total number of lesions on each side

Side Involved	No. of lesions	%
Right	123	35.4
Left	141	40.6
Bilateral	83	23.9
Note: Scrotal wall thickening was noted 19 patients.		

Table 15. Symptoms associated with scrotal swellings

Condition	Pain	Fever	Infertility
Hydrocele	10	4	-
Varicocele	18	-	6
Epididymitis	66	14	-
Epididymo-orchitis	38	11	-
Testicular abscess	5	2	-
Pyocele	3	2	-
Epididymal cyst	6	2	-
Tumor	3	-	-
Scrotal wall thickening	11	4	-
Hernia	10	-	1
Testicular torsion	1	-	-

Associated symptoms included pain, fever and infertility (Table 15). Most of the patients with infectious `causes, such as epididymitis and epididymo-orchitis, testicular abscess and pyocele, predominantly had pain (n = 123). Few patients also had fever. Majority of the patients with inguino-scrotal hernia also had complains of pain. Few patients with larger epididymal cysts also complained of pain.

Next most common complaint was fever (n = 33), predominantly seen in infective/inflammatory lesions. Infertility was seen in seven patients; of whom 6 patients had varicocele and 1 patient had left sided inguino-scrotal hernia with uterus also as a content of hernial sac.

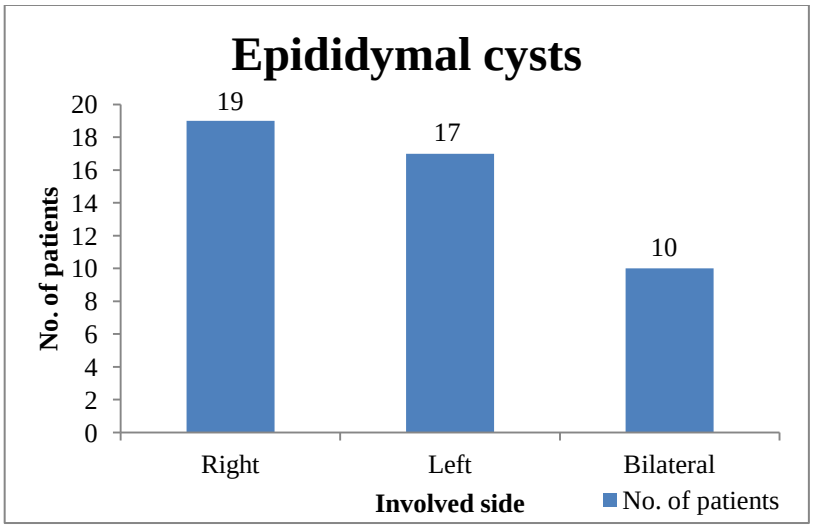

Figure 12. Location of epididymal cysts

Epididymal cysts (Figure 12) were seen in 46 patients, 19 patients had on right side (41.3%), 17 patients on left side (37%), and 10 patients had bilateral epididymal cysts (21.7%) (Table 16). Majority of the patients had no symptoms (n = 40). Only 6 patients had complaints of pain. The largest epididymal cyst measured up to 4.3 cm in maximum dimension causing distortion of adjacent testis (Figure 30).

Table 16. Location of epididymal cysts

Epididymal cysts	No. of patients	%
Right	19	41.3
Left	17	37.0
Bilateral	10	21.7
Total	**46**	**100**

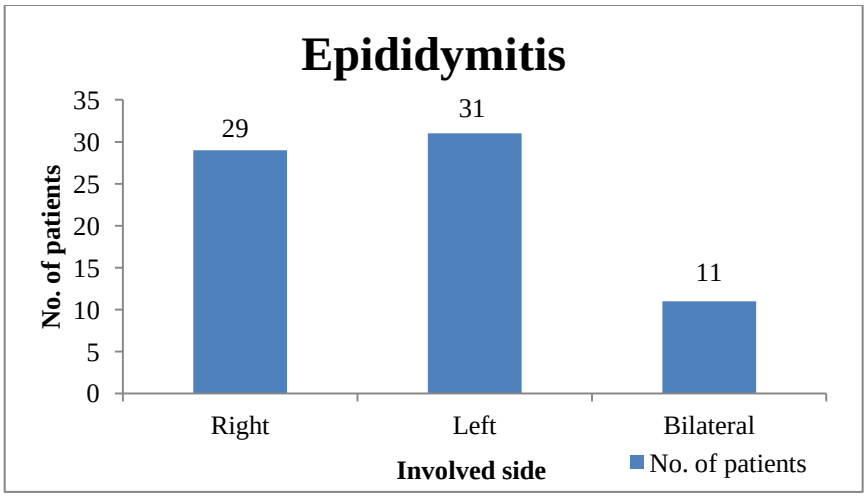

Figure 13. Location of epididymitis

Epididymitis (Figure 13) was common on left side (n = 31; 43.7%), followed by right side (n = 29; 40.8%) and bilateral (n = 11; 15.5%) (Table 17) (Figure 24). There were 8 patients who also presented with funiculitis; four on left side (50%), three on right side (37.5 %) and one on both sides (12.5 %). Three patients had tubercular epididymitis (4.2%), 2 on left and 1 on right side. These patients had tuberculosis elsewhere in the body and showed good response to antitubercular therapy (ATT) on follow-up USG.

Table 17. Location of epididymitis

Epididymitis	No. of patients	%
Right	29	40.8
Left	31	43.7
Bilateral	11	15.5
Total	**71**	**100**

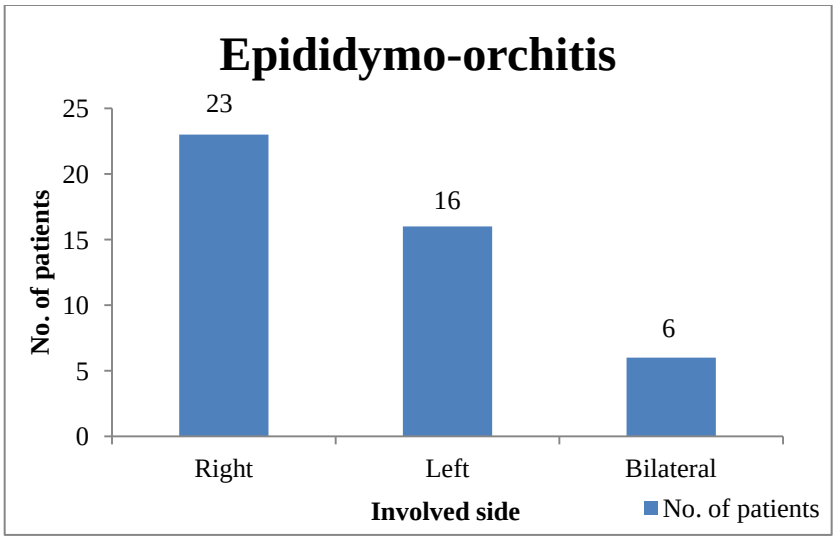

Figure 14. Location of epididymo-orchitis

Epididymo-orchitis (Figure 14) was most commonly seen on right side (n = 23; 51.1%), followed by left side (n = 16; 35.6%) and bilateral (n = 6; 13.3%) (Table 18) (Figure 26). Seven patients also presented with diffuse scrotal wall thickening; possibly due to underlying infective etiology. Four patients had tubercular epididymo-orchitis (8.8%), two on right (4.4%) and left side (4.4%) each. These patients had tuberculosis elsewhere and showed good response to ATT on follow-up USG.

Table 18. Location of epididymo-orchitis

Epididymo-orchitis	No. of patients	%
Right	23	51.1
Left	16	35.6
Bilateral	6	13.3
Total	**45**	**100**

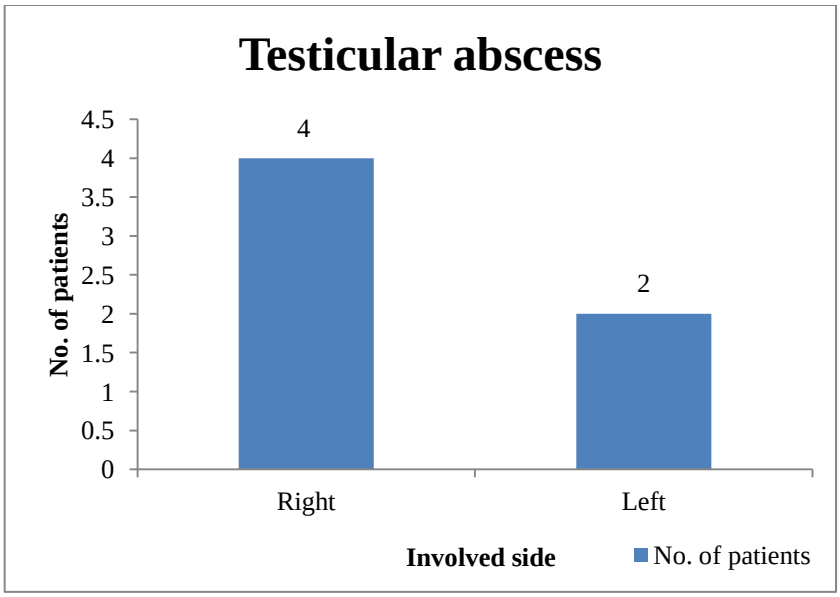

Figure 15. Location of testicular abscess

Testicular abscess (Figure 15) was most commonly seen on right side (n = 4; 66.7%), followed by left side (n = 2; 33.3%) (Table 19). All the patients had enlargement of testis, epididymis and increased vascularity and minimal fluid collection was seen in tunica vaginalis, likely due to inflammatory reaction. Follow-up USG revealed good response to antibiotics in all patients.

Table 19. Location of testicular abscess

Testicular abscess	No. of patients	%
Right	4	66.7
Left	2	33.3
Total	**6**	**100**

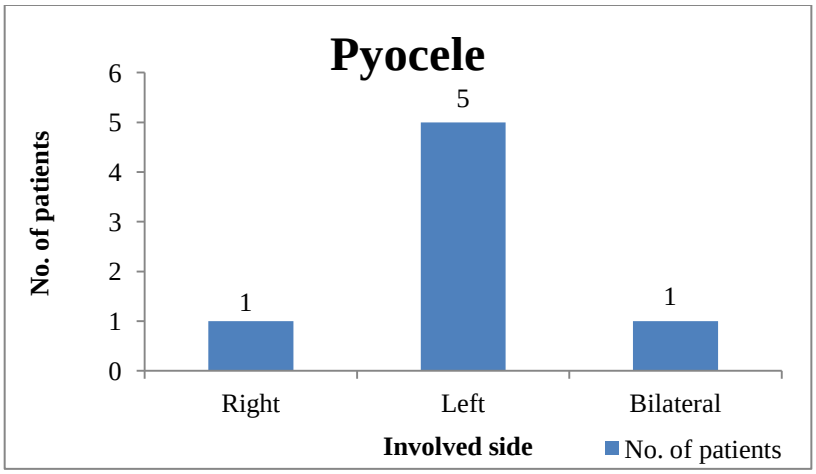

Figure 16. Location of pyocele

Pyocele (Figure 16) was seen in 7 patients, 5 patients had on left side (71.4%), 1 patient on right side (14.3%), and 1 patient had on both sides (14.3%). (Table 20). Majority of the patients (n = 6) had mildly enlarged ipsilateral testes and epididymes. USG in 4 patients revealed fluid collection with internal septations and echogenic debris (3 on left side and 1 on right side), suspecting tubercular etiology (Figure 27). Patients were followed periodically by USG during ATT. All 7 patients showed interval resolution of findings.

Table 20. Location of pyocele.

Pyocele	No. of patients	%
Right	1	14.3
Left	5	71.4
Bilateral	1	14.3
Total	**7**	**100**

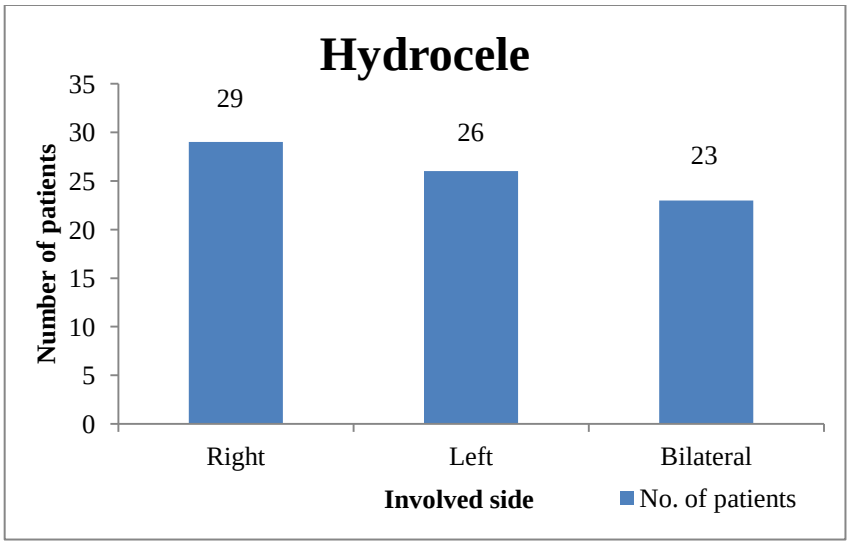

Figure 17. Location of hydrocele

Hydrocele was most commonly seen on right side (Figure 17) (n = 29; 37.2%), followed by left side (n = 26; 33.2%) and bilateral (n = 23; 29.5%) (Table 21). Among them there were eight patients with encysted hydrocele of the cord. Six patients had encysted hydrocele of cord on right (n = 6) and two patients had on left side (n = 2). Two patients had hydrocele, secondary to scrotal filariasis (right side; n = 2) and demonstrated typical "filarial dance" on USG (Figure 31).

Table 21. Location of hydrocele

Hydrocele	No. of patients	%
Right	29	37.2
Left	26	33.3
Bilateral	23	29.5
Total	**78**	**100**

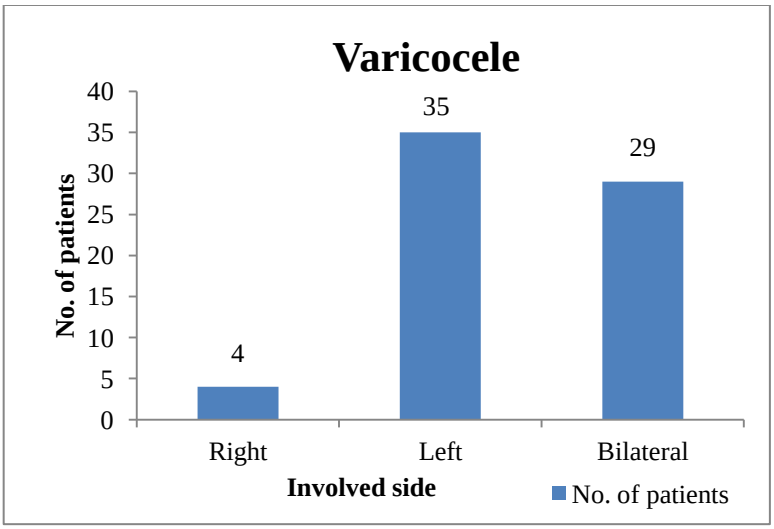

Figure 18. Location of varicocele

Varicocele was most commonly seen on left side (Figure 18) (n = 35; 51.5%), followed by bilateral (n = 29; 42.6%) and on right side alone (n = 4; 5.9%) (Table 22). One patient with bilateral varicocele had intra-testicular type on left side. There were 6 patients with complaints of infertility of whom 4 had bilateral varicocele and 2 patients with left sided varicocele.

Table 22. Location of varicocele

Varicocele	No. of patients	%
Right	4	5.9
Left	35	51.5
Bilateral	29	42.6
Total	**68**	**100**

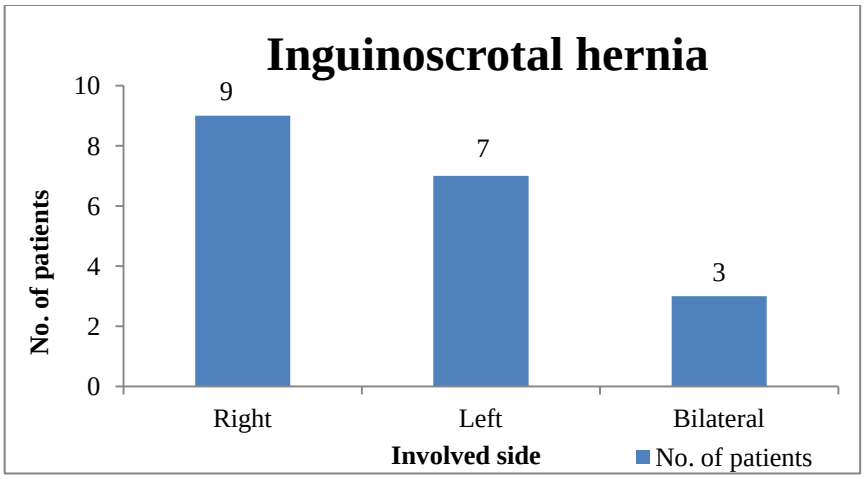

Figure 19. Location of inguino-scrotal hernia

Inguino-scrotal hernia (Figure 19) was seen in 19 patients. It was common on right side (n = 9; 47.4%), followed by left side (n = 7; 36.8%) and bilateral (n = 3; 15.8%) (Table 23) (Figure 32). Herniated contents included omentum in all patients, bowel loops in 9 patients and one patient also showed hypoplastic uterus during surgery. USG in a 20-year-old with clinical features of intestinal obstruction revealed left side obstructed inguinoscrotal hernia and encysted hydrocele of left cord.

Table 23. Location of inguino-scrotal hernia.

	No. of patients	%
Right	9	47.4
Left	7	36.8
Bilateral	3	15.8
Total	**19**	**100**

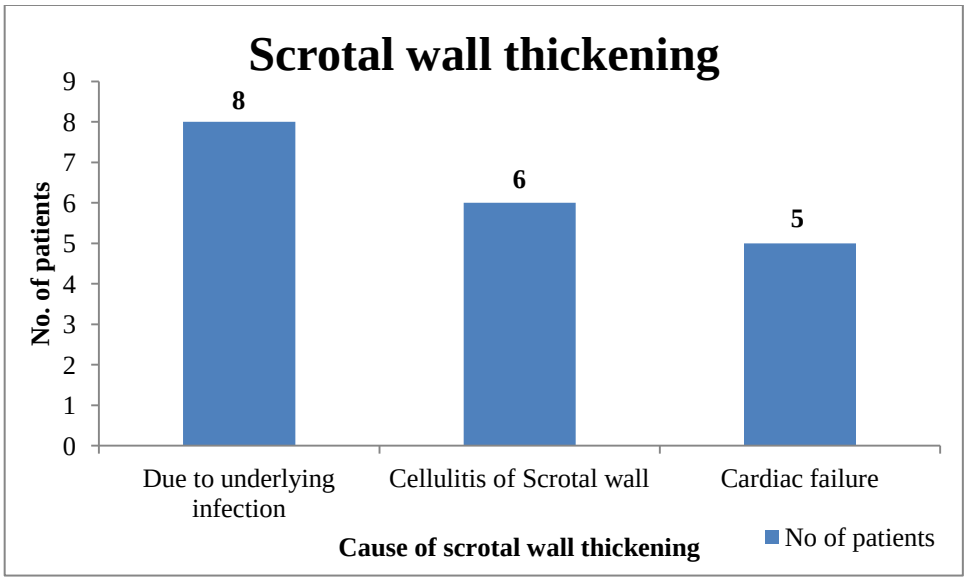

Figure 20. Cause of scrotal wall thickening

There were 19 patients with scrotal wall thickening (Figure 20). Eight patients (42.1%) had scrotal wall edema secondary to underlying infection (i.e. epididymitis, epididymo-orchitis). Six patients had cellulitis of scrotal wall (31.6%) and scrotal wall thickening was seen in 5 patients with cardiac failure (26.3%) (Table 24).

Table 24. Causes of scrotal wall thickening

Scrotal wall thickening	No of patients	%
Due to underlying infection	8	42.1
Cellulitis of Scrotal wall	6	31.6
Cardiac failure	5	26.3
Total	**19**	**100**

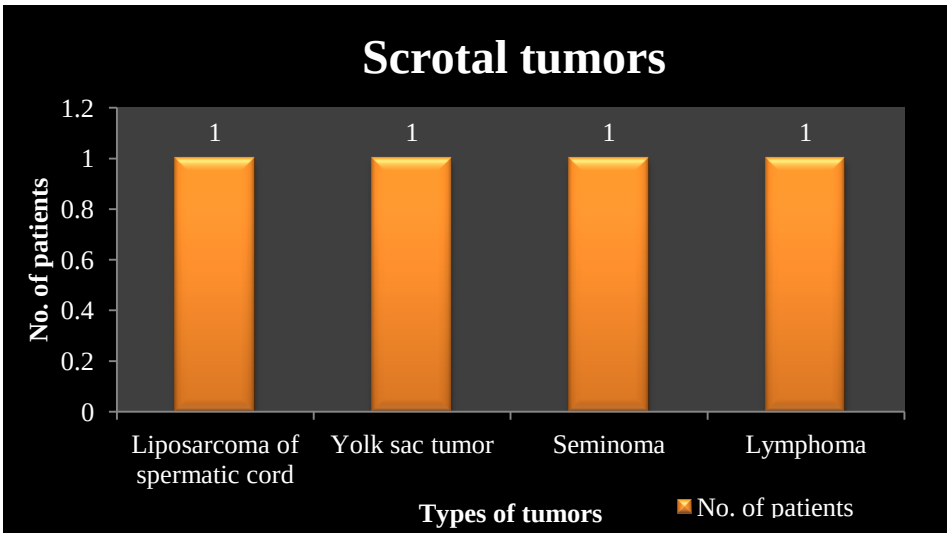

Figure 21. Scrotal tumors

Scrotal tumors (Figure 21) were seen in 4 patients, 3 on right side and 1 on left side (Table 25). A 2-year-old kid presented with scrotal swelling. On USG right testis was enlarged and revealed diffusely increased vascularity. No obvious focal lesion was seen and was diagnosed as acute epididymo-orchitis. He was treated with antibiotics and follow-up USG after 12 days revealed no significant changes. MRI with diffusion weighted imaging was performed, which showed enlarged right testis with restricted diffusion and few mildly enlarged pre and para-aortic lymph nodes, suggestive of aggressive tumor (Figure 34). He was operated and histopathology revealed yolk sac tumor.

A 57-year-old male patient with large right scrotal swelling for eight months with recent onset of pain. USG of scrotum showed a large extratesticular heterogeneously hyperechoic mass lesion on right side with increased vascularity on CDI. It was seen displacing the right testis and epididymis medially, otherwise appeared normal. The left testis appeared normal. There was no obvious inguinoscrotal hernia. With these features, it

was diagnosed as liposarcoma. MRI of the lesion revealed heterogeneous mass in the scrotum on right side arising from the spermatic cord. On fat-saturated sequences there were areas of low attenuation suggestive of fatty components within the lesion (Figure 35). He was operated and histopathology was reported as liposarcoma of the cord.

USG in a 29-year-old patient with scrotal swelling revealed bulky left testis with large lobulated, heterogeneously hypoechoic intratesticular mass lesion (Figure 33). There was increased vascularity on CDI. Contrast enhanced CT of the lung bases, abdomen and pelvis revealed multiple enlarged lymph nodes in the pre and para-aortic region and bilateral inguinal region with splenomegaly. Multiple (3 to 5 in number) enhancing lung nodules of variable size were seen. Histopathology revealed seminoma of testis.

A 70-year-old patient with cachexic features diagnosed with lymphoma, presented with scrotal swelling and USG revealed diffusely enlarged right testis with hypoechoic echotexture with increased vascularity on CDI. There was mild reactive hydrocele and multiple enlarged lymph nodes in bilateral inguinal regions. Histopathology revealed lymphoma.

Table 25. Side of involvement of scrotal tumors.

Tumors		No. of patients
Right	Liposarcoma of spermatic cord (1)	3
	Yolk sac tumor (1)	
	Lymphoma (1)	
Left	Seminoma (1)	1

A comparison between USG diagnosis and final diagnosis is presented in Table 26. There were 46 patients who were diagnosed with epididymal cysts. Majority of them had no significant symptom other than scrotal swelling. Only 6 patients had testicular pain along with swelling (n = 6; 13.04%). The size of cysts ranged from 1.5 cm to 4.3 cm in maximum dimensions. The largest cyst caused mild mass effect in form of smooth indentation on adjacent testis.

There were a total of 135 patients with infective scrotal conditions including epididymitis, epididymo-orchitis, testicular abscess, pyocele and cellulitis of scrotal wall. All of them were followed up by USG after a course of antibiotic therapy and minimum of one week from the time of diagnosis. There were a total of 11 patients with tubercular lesions, such as chronic epididymitis, epididymo-orchitis and pyocele. Six patients had funiculitis, 3 on right side, 2 on left side and 1 patient had on both sides.

A total of 78 patients were diagnosed to have hydrocele. Eight patients had encysted hydrocele of the cord. Two patients had hydrocele secondary to scrotal filariasis. On USG there was typical “filarial dance”. In the remaining 68 patients no further imaging was performed.

There were 71 patients with varicocele (Figure 18). Left sided varicocele was seen in 35 patients, 29 had bilateral and 4 patients had isolated right sided varicocele (Table 22). One patient with bilateral varicocele had left sided intra-testicular type. Six patients had

complaints of infertility of whom 4 had bilateral varicocele, 2 patients with left sided varicocele.

There were 19 patients with inguino-scrotal hernia who were operated and there was correlation between USG and operative findings in 18 patients (94.7%). One elderly patient with USG diagnosis of a large left inguino-scrotal hernia was operated and intraoperative findings revealed a hypoplastic uterus also as content of the hernial sac. On retrospective inquisition he had history of infertile. An adolescent patient with complaints of intestinal obstruction was found to have obstructed left sided inguino-scrotal hernia with encysted hydrocele of cord on USG.

USG diagnosis of scrotal wall thickening was done in 19 patients, of whom eight patients had it secondary to underlying infective scrotal etiology, six patients had cellulitis of scrotal wall and five patients had scrotal wall thickening secondary to cardiac failure. These patients were followed-up with signs of clinical improvement.

There were a total of 4 patients with scrotal tumors. However USG diagnosis of tumor was done in 3 patients. They included liposarcoma of the right spermatic cord, seminoma of testis and testicular lymphoma. One patient was incorrectly diagnosed with right sided acute epididymo-orchitis; however there was no clinical improvement with medical line of treatment. Diffusion Weighted Magnetic Resonance Imaging (Figure 34) revealed restricted diffusion in the right testis prompting it to be a malignant tumor and was operated. Tissue diagnosis was yolk-sac tumor.

There was 1 patient with acute scrotal swelling with CDI was suggestive of torsion testis. The patient underwent surgery and it was found to be non-viable and underwent orchidectomy.

Table 26. Comparison of USG diagnosis and final diagnosis

USG Diagnosis		No. of patients	Final Diagnosis		No. of patients
Hydrocele		78	Hydrocele		78
Varicocele		68	Varicocele		68
Epididymitis	Non-tubercular	68	Epididymitis	Non-tubercular	68
	Tubercular	3		Tubercular	3
Epididymo-orchitis*	Non-tubercular	41	Epididymo-orchitis*	Non-tubercular	40
				Tubercular	4
	Tubercular	4	Neoplastic - Yolk sac tumor		1
Testicular abscess		6	Testicular abscess		6
Pyocele	Non-tubercular	3	Pyocele	Non-tubercular	3
	Tubercular	4		Tubercular	4
Torsion testis		1	Torsion testis		1
Epididymal cyst		46	Epididymal cyst		46
Inguino-scrotal Hernia		19	Inguino-scrotal Hernia†		19
Scrotal wall thickening		19	Scrotal wall thickening		19
Neoplastic - scrotal liposarcoma		1	Neoplastic - Spermatic cord liposarcoma		1
Neoplastic - malignant tumor		2	Seminoma		1
			Lymphoma		1

*****One case was diagnosed as acute epididymo-orchitis on USG. MRI with DWI was performed, and diagnosis of malignant tumor was suggested. He was operated and histopathology confirmed the diagnosis of yolk sac tumor.

† One patient with left inguino-scrotal hernia was operated and intraoperative findings revealed a hypoplastic uterus also as a content of the hernial sac. He had history of infertility.

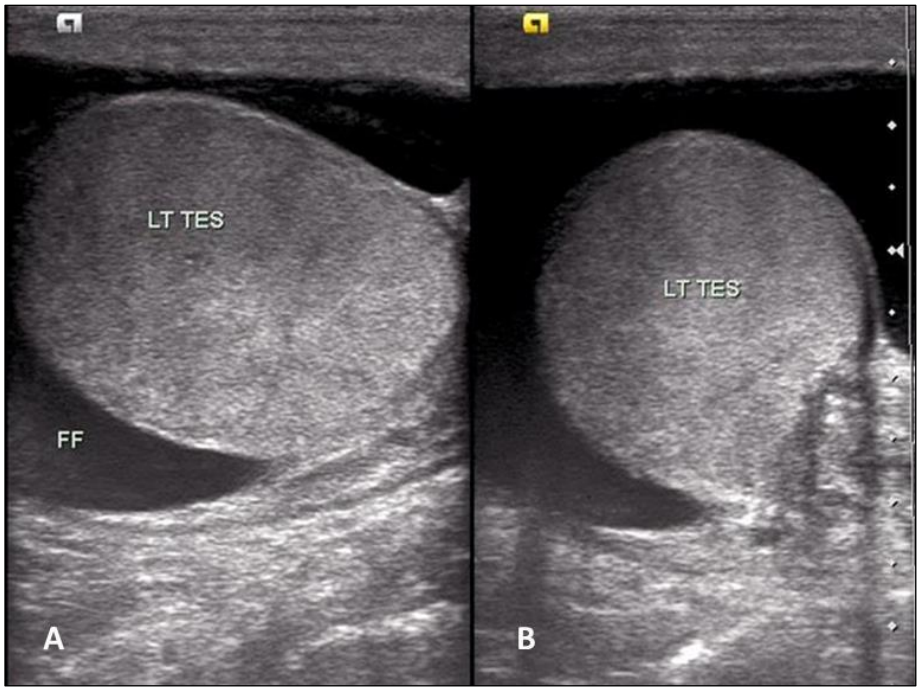

Figure 22. (A) Longitudinal and (B) transverse USG showing bulky left testis with hydrocele in epididymo-orchitis. *[Note: LT TES = left testis; FF = free fluid.]*

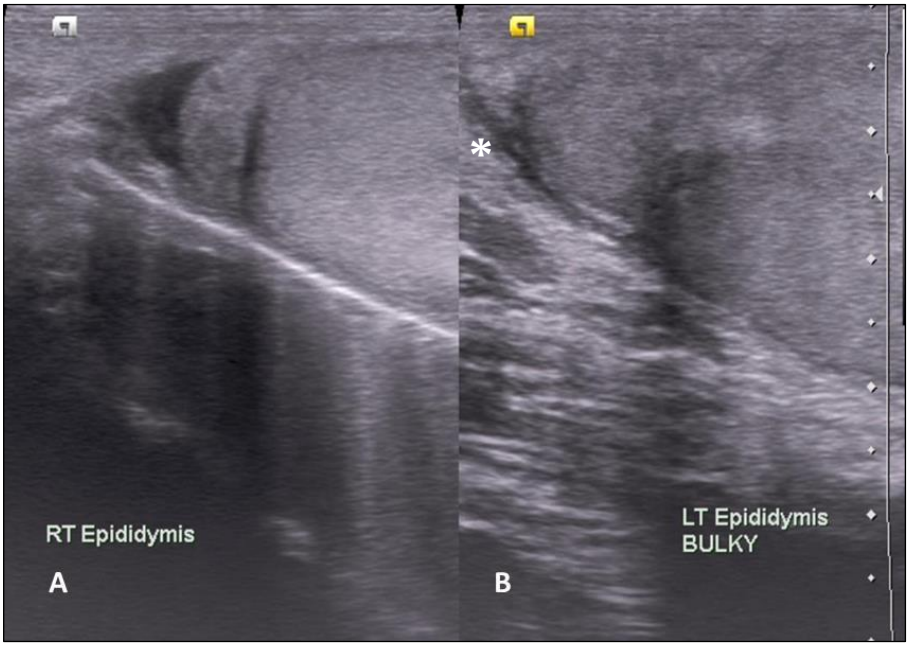

Figure 23. (A) Normal appearance of right epididymis and testis. (B) Diffusely bulky left epididymis (white asterix) and testis in the same patient - left sided acute epididymo-orchitis.

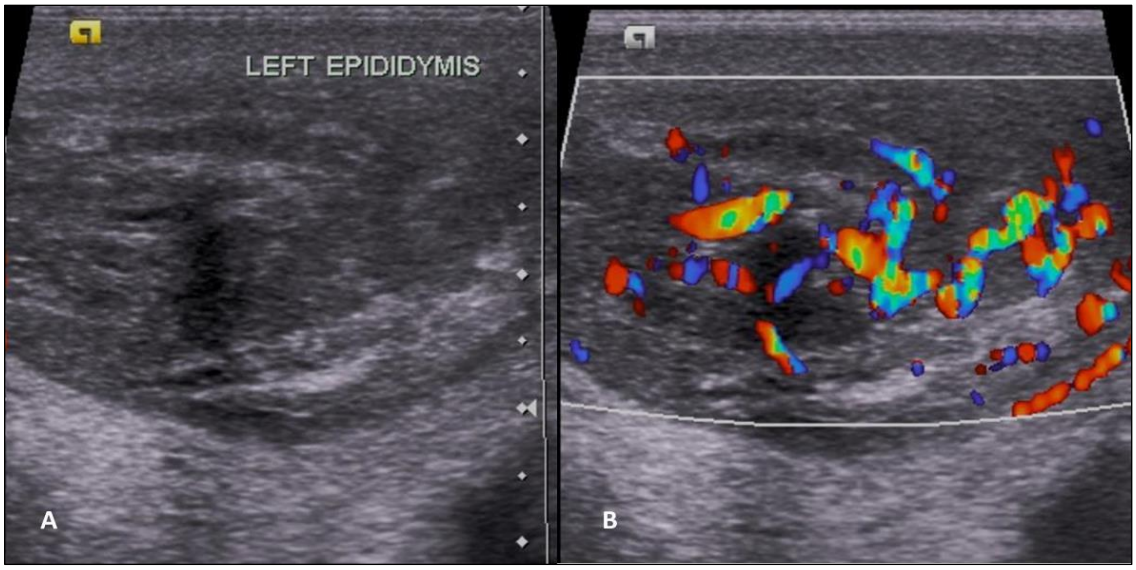

Figure 24. (A) Bulky and heterogeneously hypoechoic left epididymal head. (B) CDI of the same patient shows increased vascularity - Acute epididymitis.

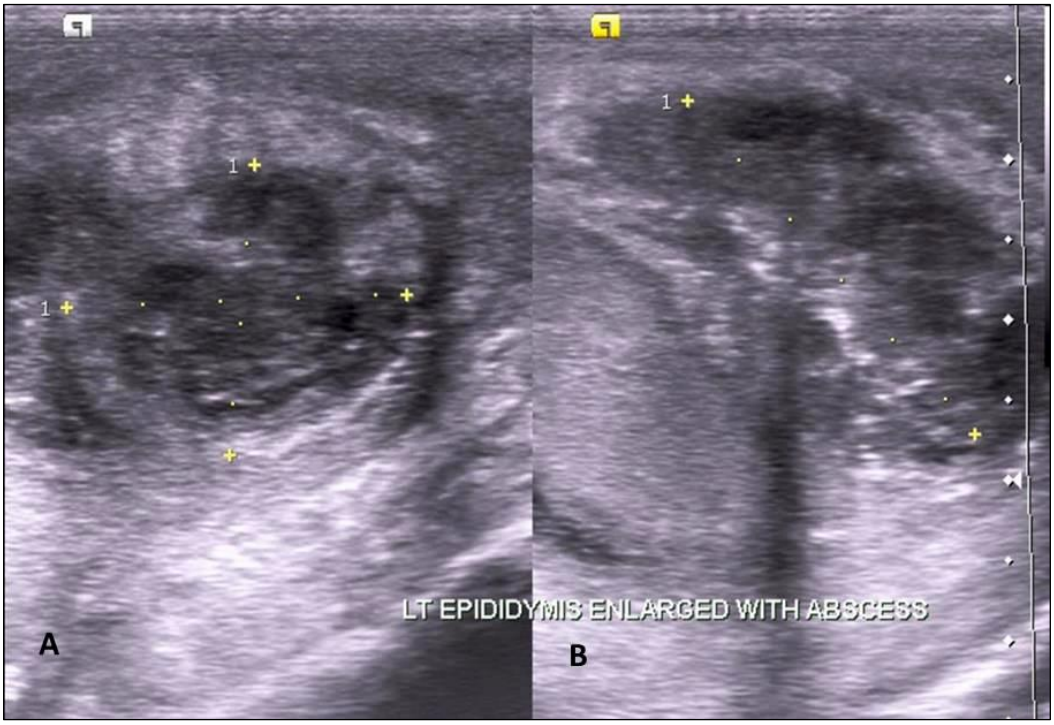

Figure 25. (A) Transverse & (B) longitudinal USG showing bulky hypoechoic left epididymis with abscess formation.

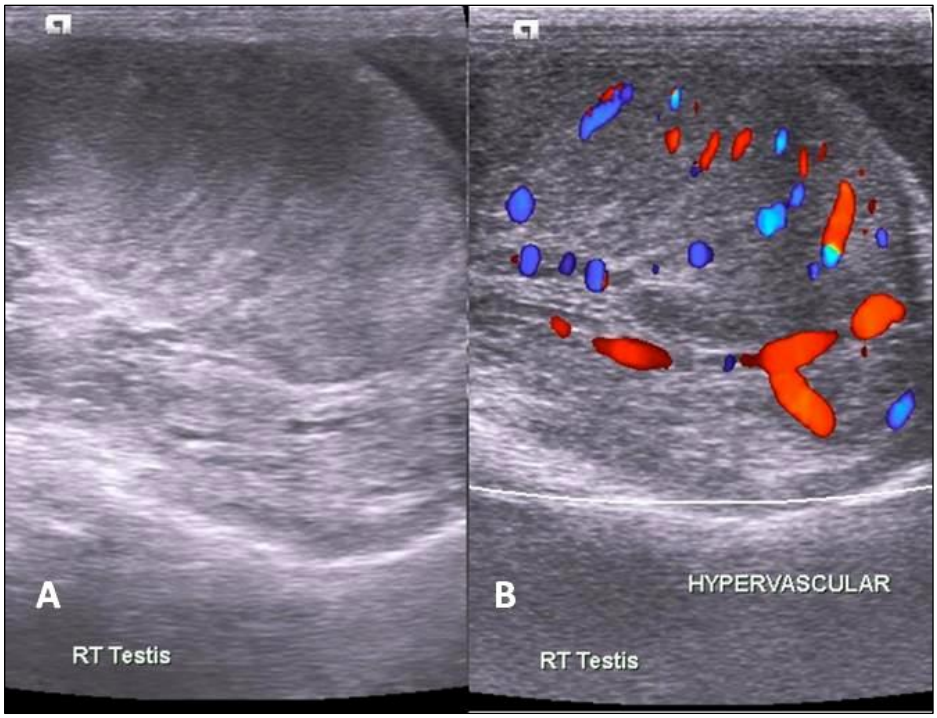

Figure 26. (A) USG & (B) CDI showing diffusely enlarged and heterogeneously hypoechoic right testis with increased vascularity- Acute epididymo-orchitis.

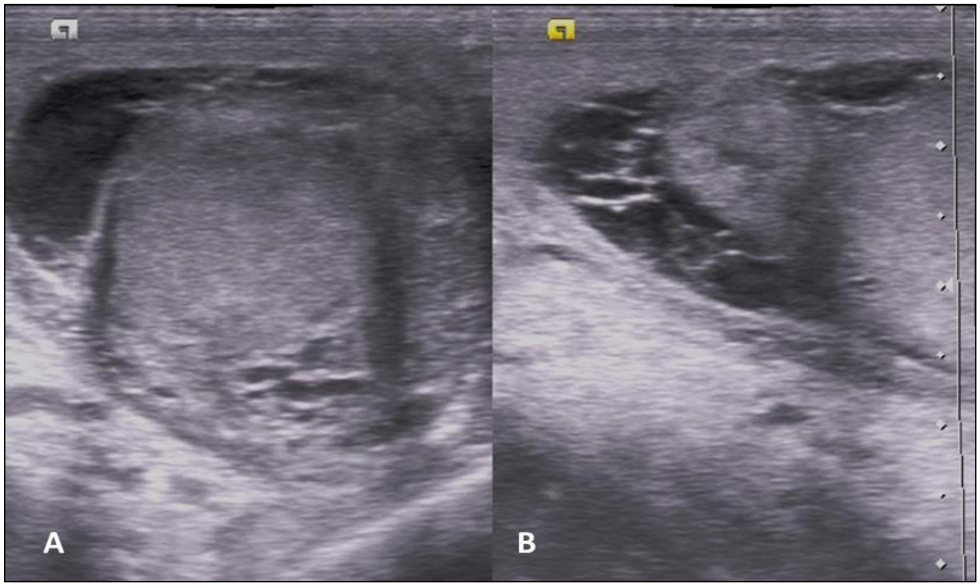

Figure 27. (A) Transverse & (B) longitudinal USG showing bulky epididymis and testis, hydrocele with internal septations and echogenic debris, suggestive of tubercular infection.

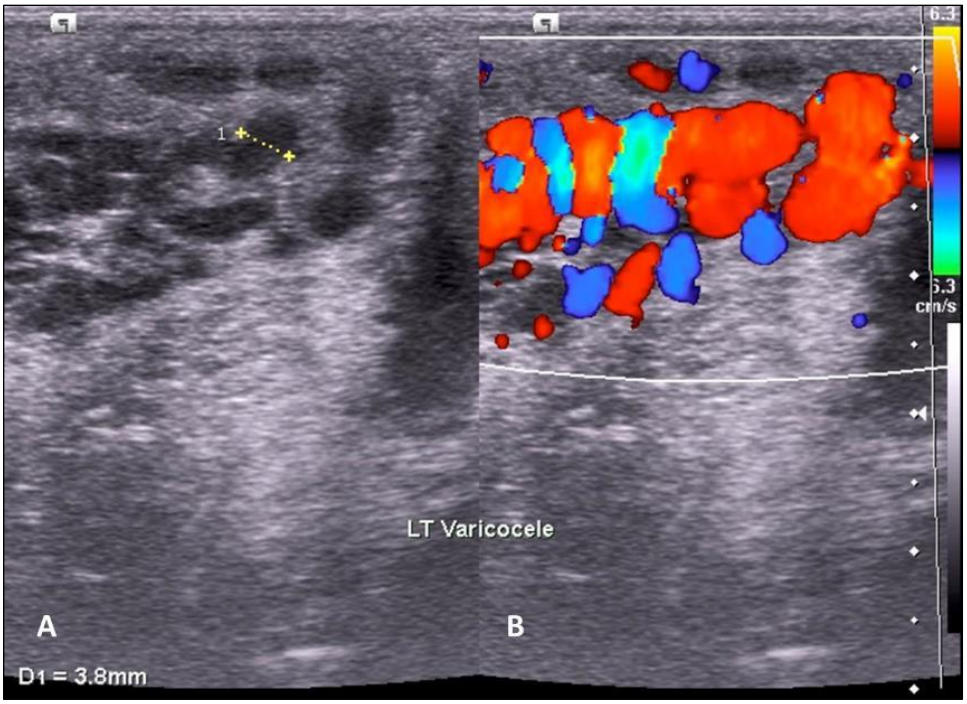

Figure 28. (A) Multiple anechoic areas (yellow cursor) in the left scrotum. (B) CDI shows color flow signal of dilated veins - Varicocele.

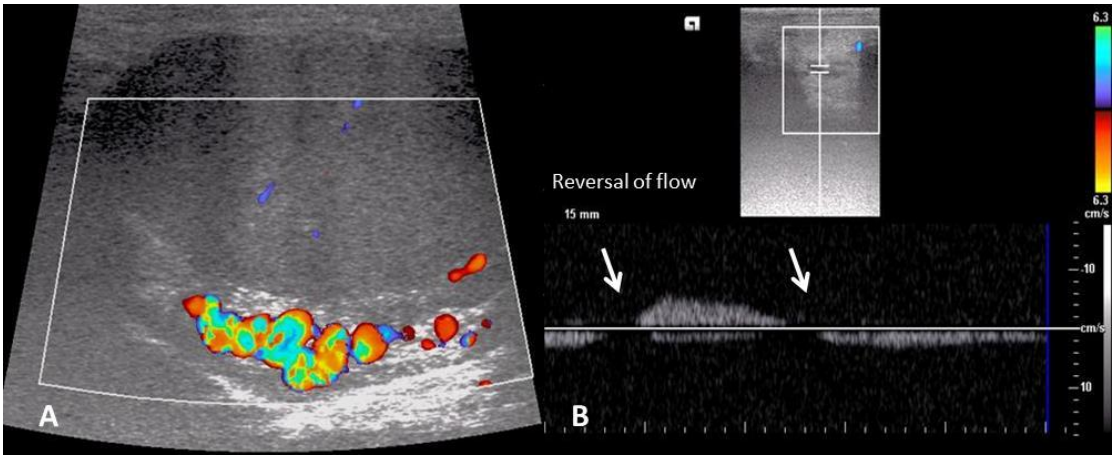

Figure 29. (A) CDI showing multiple tortuous dilated veins, suggestive of varicocele. (B) Spectral wave form in the same patient shows reversal of flow (white arrows) on straining/Valsalva's manoeuvre.

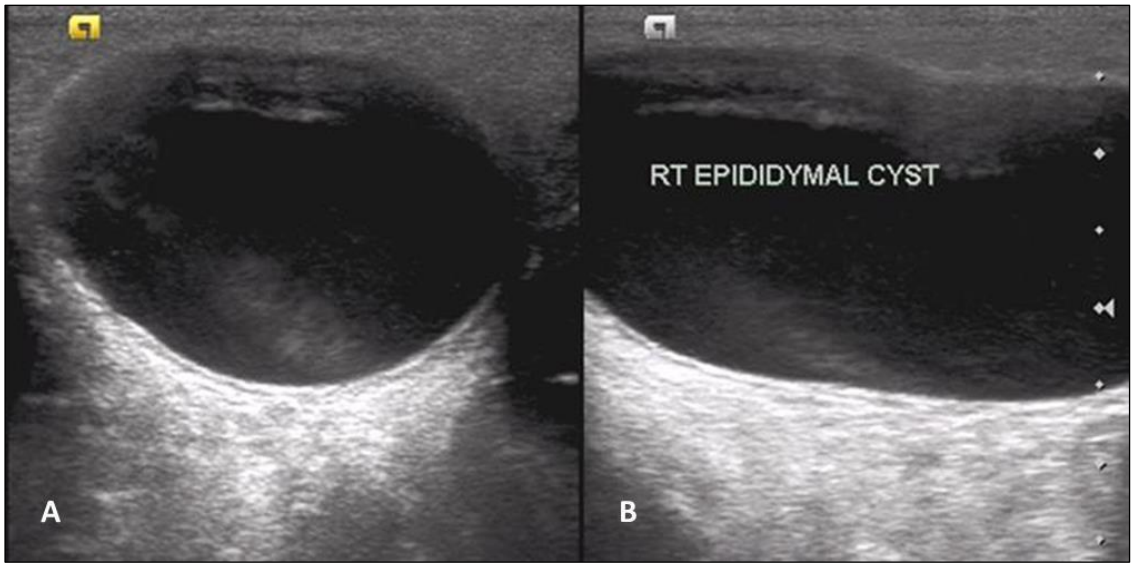

Figure 30. (A) Transverse & (B) longitudinal USG of scrotum showing a large well-defined thin walled cystic lesion arising from the right epididymis – Epididymal cyst

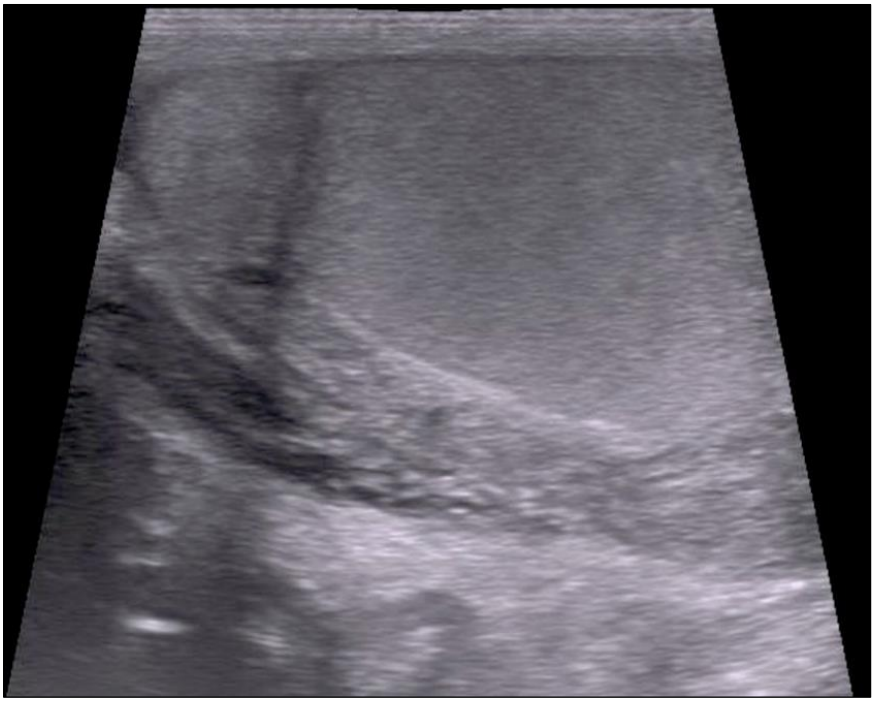

Figure 31. Longitudinal USG of testis and epididymis showing thickening and hypoechogenicity of the epididymis in filariasis.

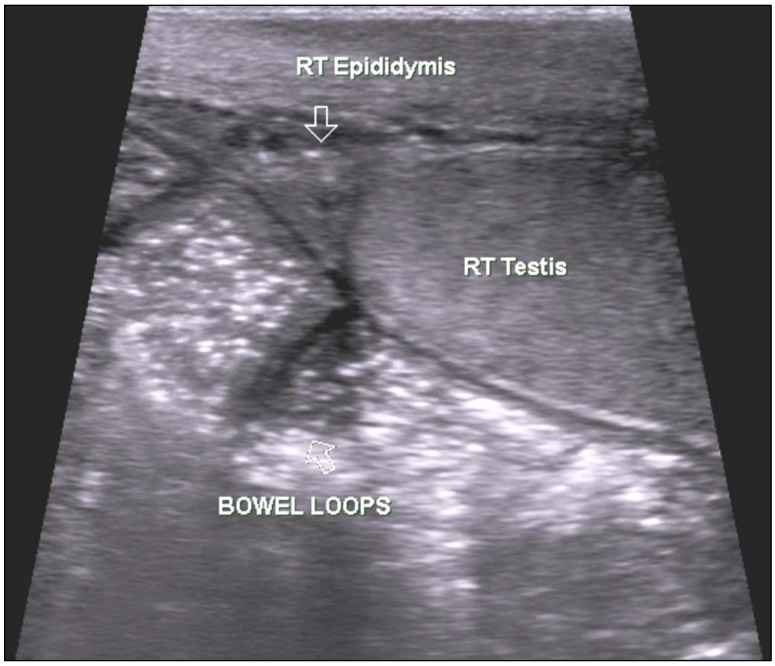

Figure 32. Longitudinal USG scan showing normal right epididymis and testis with small bowel loops - Inguinoscrotal hernia.

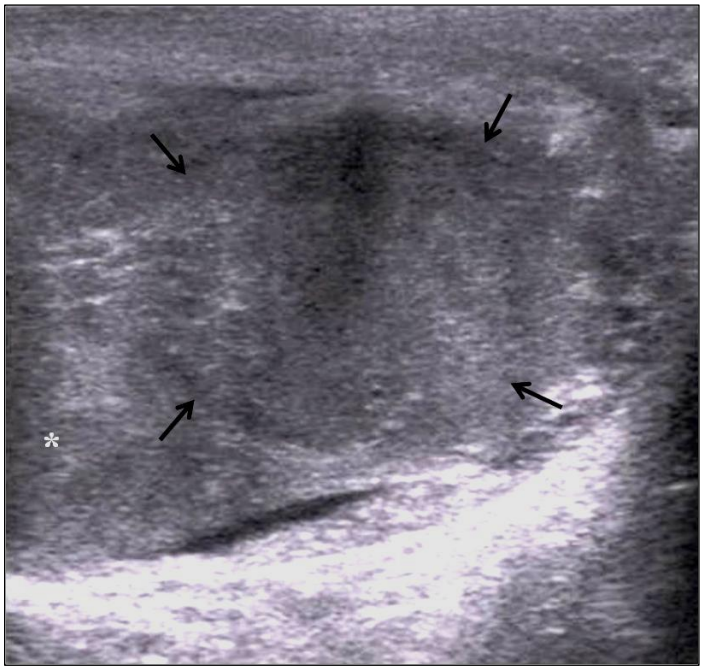

Figure 33. USG of testis showing a fairly well-defined predominantly hypoechoic lesion (black arrows) in the testis – Seminoma.

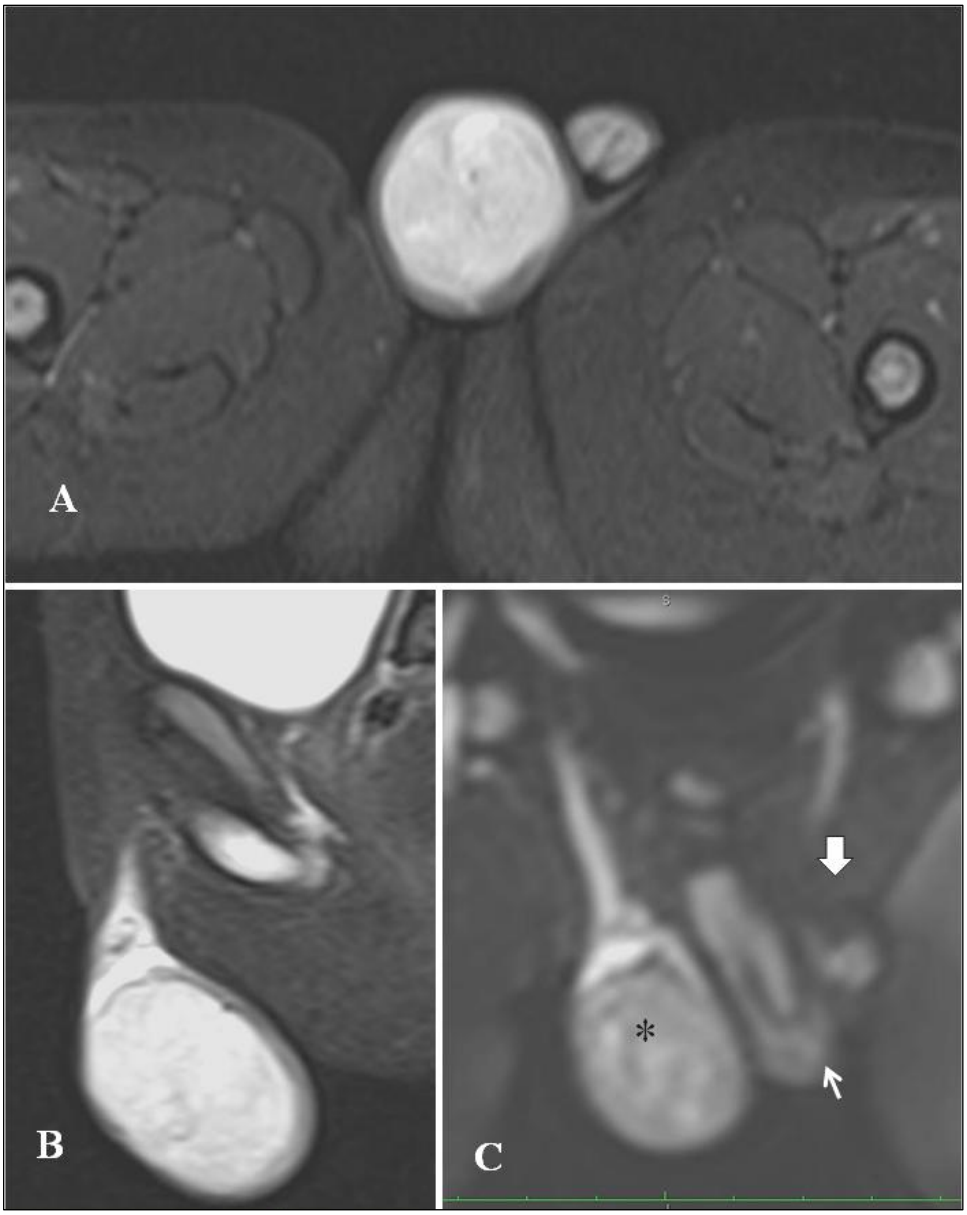

Figure 34. A 2-year-old boy with yolk sac tumor of right testis. MRI (A) Axial & (B) sagittal STIR images showing enlarged right testis with heterogeneously hyperintense signal. (C) DWI-MRI showing restriction, suggestive of aggressive/malignant tumor.*[Note: * = right testis; small arrow = penis; thick white arrow = normal left testis]*.

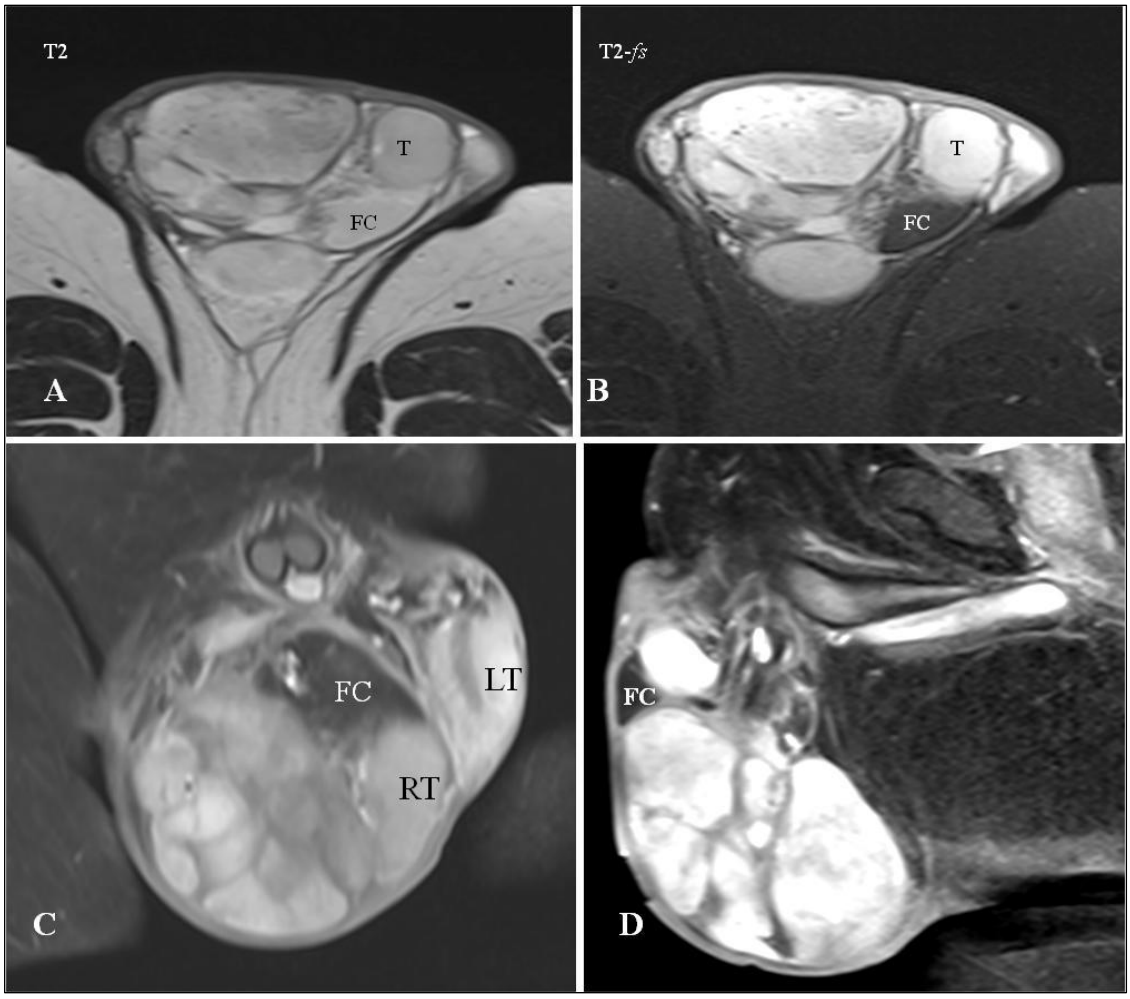

Figure 35. A 57-year-old patient with right spermatic cord liposarcoma. MRI (A) Axial T2 weighted & (B) axial T2 weighted fat-saturated images showing a large heterogeneously T2 hyperintense mass lesion displacing the right testis to left side and few areas of the mass lesion showing hypoattenuation on fat-saturated sequence suggestive of fat component. (C) Coronal and (D) sagittal T1 weighted fat-saturated contrast enhanced images showing heterogeneously enhancing mass in the right side of scrotum. *[Note: T/RT = right testis; LT = left testis; FC = fat component]*.

DISCUSSION

The study included a total of 196 patients. The most commonly involved age group was 31 to 40 years (n = 41; 20.9%) followed by 21 to 30 years (n = 38; 19.4%) and 41 to 50 years (n = 35; 17.9%) altogether constituting 114 patients (54.1%) The least number of patients belonged to age-group of >80 years (n = 2; 2%).

Our results are similar to findings observed by Rizvi et al, who in their study of 122 patients with scrotal swelling reported 2nd and 3rd decade as the commonest age-group involved[3]. A similar age-group distribution of scrotal disorders was also reported by Thinyu et al in their study of 110 cases[14].

In our study 165 patients (84.1%;) had complains of pain in scrotum. Most common cause of pain was infective/inflammatory etiology (n = 123; 62.7%) followed by varicocele (n = 18; 9.1%), inguinoscrotal hernia (n = 10; 5.1%) and hydrocele (n = 10; 5.1%). Our results show relatively increased frequency of pain associated with scrotal swelling when compared to observations made in other studies where the incidence of scrotal pain in patients with scrotal swelling ranged from 62 to 76%[73,74].

Epididymal cysts

There were 46 patients with epididymal cysts (Figure 30), many patients belonged to age groups of 31 to 40 years and 41 to 50 years, 11 patients in each group. The cysts

ranged from 1.5 cm to 4.3 cm. Patients with larger cysts, complained of pain (n = 6), they revealed no vascularity of cyst wall on CDI. They were treated symptomatically.

Infective/inflammatory scrotal swellings

There were 71 patients (36.2 %) diagnosed with epididymitis. A total of 29 patients had right-sided epididymitis (40.8%), 31 patients had left-sided (43.7%) and 11 patients had bilateral epididymitis (15.5%). It was most commonly seen in age group of 31 to 40 years (n = 20; 28.1%). A total of 66 patients complained of pain (92.9%) and 14 patients complained of fever (19.7%) along with scrotal swelling. Six patients had funiculitis, 3 on right side, 2 on left side and 1 on both sides.

USG features seen in epididymitis (n = 68) were enlarged epididymis in 63 patients (88.7%) (Figure 23), increased epididymal vascularity in 67 patients (94.3%) (Figure 24), and altered echogenicity in 66 patients (92.95%). Additionally, scrotal wall thickening was seen in 8 patients (11.2%) and reactive/secondary hydrocele in 27 patients (38.1%). USG features of enlarged epididymis with altered echogenicity and increased vascularity are indicative of epididymitis. Other features such as reactive hydrocele and scrotal wall thickening further augment the diagnosis of epididymitis. Agarwal et al. in their study reported similar findings in terms of hypervascularity & enlargement of epididymis, and reactive hydrocele formation in patients with epididymitis[77]. Similar study done by Smith RP et al reported increased incidence with respect to enlarged epididymis (71.5%),

however hypervascular epididymis was reported in 72.9% and associated scrotal wall thickening in 11.3%[75].

There were 3 patients with tubercular epididymitis (Figure 27) as patients reported relatively longer duration of condition and they did not respond to antibiotics. Their chest radiography revealed lesions typical of tuberculosis. All 3 patients were started on ATT with periodic USG follow up which revealed resolution of findings.

There were 45 patients with epididymo-orchitis (Figure 26). It was most commonly seen in age group of 31 to 40 years (n = 11; 24.4%). Majority of the patients had on right side (n = 23; 51.1%), 16 patients had on left (35.6%) and 6 patients had on both sides (13.3%). There were 6 patients with intra-testicular abscess (13.3%); 4 on right and 2 on left side. Accurate diagnosis of acute epididymo-orchitis was done in 40 of 41 patients (97.5%). Chronic tubercular epididymo-orchitis was diagnosed in 4 of 45 patients (8.8%); ATT was initiated and were followed-up by USG. They showed progressive interval resolution. One patient with enlarged hypervascular testicle was initially diagnosed as acute epididymo-orchitis; however follow-up USG after 12 days revealed no interval changes and DWI-MRI revealed restricted diffusion, suggestive of malignant tumor. He was operated and histopathology was reported as yolk sac tumor.

Our results were similar to study by Rizvi et al, where 52 of 54 patients (96.2 %) were diagnosed as epididymo-orchitis and 2 (3.7%) patients with seminoma were incorrectly diagnosed. The accuracy of diagnosis in our study was as high as 97.5% comparable to 96.2% in their study[3].

Pyocele (Figure 27) was seen in 7 patients, of whom 5 patients had on left side (71.4%), 1 patient had on right side (14.2%) and 1 patient had on both sides (14.2%). There were 4 patients (57.1%) with pyocele due to tuberculosis. They all were conservatively managed with ATT and had periodic follow-up USG.

Hydrocele

There were 78 patients with diagnosis of hydrocele (Figure 22) in our study (39.8%;). Most commonly occurring in age group of 40 to 50 years (n = 16; 19.2%). In 29 patients it was seen on right side (37.2%), 26 patients on left side (33.3%) and 23 patients had bilateral hydroceles (29.5%). Of 78 patients, 8 patients had encysted hydrocele of spermatic cord (10.25%; right side = 6 and left side = 2). There were 23 patients (29.5%) with reactive hydrocele secondary to infective/ inflammatory scrotal lesions. Two patients had hydrocele due to obstruction by filariasis (Figure 31).

In our study hydrocele was the most common finding observed in about 40% of patients, which is greater compared with data from other studies, where the incidence of hydrocele has been reported to be about 21%[3,73].

Varicocele

A total of 68 patients had varicocele (34.3%). Majority of the patients had on left side (n = 35; 51.5%), followed by bilateral (n = 29; 42.6%) and only 4 patients had isolated right sided varicocele (5.9%). The most commonly involved age group was 31 to 40 years (n = 20; 29.4%) followed by 21 to 30 years (n = 18; 25%). One patient with bilateral varicocele had intratesticular type on left side. Six patients were found to have complaints of infertility- 4 patients had bilateral varicoceles and 2 patients had left sided varicocele. Three patients were from age-groups of 21 to 30 years and 31 to 40 years each (Figure 28).

There were 18 patients with varicocele who also complained of dull scrotal pain (25%). Among them 14 patients underwent surgery and there was good correlation with USG findings and intra-operative findings (Figure 29). However post-operative improvement of patients with infertility could not be addressed due to lack of follow up.

Siddique EH et al in their study of 164 patients reported 39 cases of varicoceles (22.9%), however it was the most common condition in the adult age group in their study[73].

Similar studies reported at a much lesser incidence of varicocele at 9.1%, 10.9% and 13.1% by Tinthyu M et al, D'Andrea et al and Rizvi e al respectively. All the three studies reported that 21 to 30 years as the most common age-group for varicoceles[3,14,76].

In our study there were relatively more number of patients with varicoceles; however majority of the patients denied any further surgical care and were managed symptomatically.

Scrotal wall thickening

A total of 19 patients had scrotal wall thickening, 8 patients had underlying inflammatory scrotal condition (42.1%), & 6 patients had cellulitis of scrotal wall (31.6%) and 5 patients had scrotal wall thickening due to cardiac failure (26.3%). In a study by Thinyu S. et al, cellulitis of scrotal wall was reported in only 1 of 110 patients[14].

Inguinoscrotal Hernia

A total of 19 patients were diagnosed with inguino-scrotal hernia (Table 23) (Figure 32). It was seen most commonly seen in age-group of 41 to 50 years. Nine patients had on right (47.4%), 7 had on left (36.8%) and 3 had bilateral (15.8%) inguino-scrotal hernia. Ten patients also complained of pain (52.6%). Nine patients had normal peristalsis of herniated bowel loops. All the patients were operated and the USG findings were found to correlate with intraoperative findings in all the patients; except in 1 patient aged 57 years

with left inguinoscrotal hernia also had a hypoplastic uterus as a content of hernial sac. He had history of infertility. A 20-year-old patient complained of pain abdomen with clinical features of intestinal obstruction. On USG he was diagnosed with obstructed left inguino-scrotal hernia with encysted hydrocele of the cord; however the testicular echogenicity, color flow and vascularity appeared normal. He underwent surgery and intraoperative findings were consistent with USG diagnosis.

Our findings when compared to study by D'Andrea et al show more number of patients with inguinoscrotal hernias. They had reported a total of 5 patients with inguinal hernias and 4 patients had impaired peristalsis suggesting complication of hernia, as compared to 1 patient in our study[76].

Torsion Testis-

There was 1 patient with USG diagnosis of torsion testis (n=1). He had complaints of acute onset of pain for about 20 hours. On USG right testis and epididymis were bulky with diffuse hypoechogenicity. The right spermatic cord at the level superior to the epididymal head revealed characteristic "whirlpool sign", with more than one and a half turn of the spermatic cord. On CDI there was absence of vascularity. Minimal reactive hydrocele was noted. He underwent surgery and was found to be non-viable Our results when compared to other similar studies done elsewhere, there was very less number of patients with torsion testis[3,14, 73,76].

Tumors

Four patients were diagnosed to have scrotal tumors. Three patients had testicular masses and 1 had extratesticular mass. A 2-year-old patient presented with scrotal swelling. On USG the right testis was enlarged and revealed diffuse increased vascularity. No obvious focal lesion was appreciated and was diagnosed as acute epididymo-orchitis. He was treated with antibiotics and follow-up USG after 12 days revealed no significant changes. MRI with diffusion weighted imaging revealed an enlarged right testis with restricted diffusion, suggesting aggressive/malignant nature of tumor (Figure 34). He was operated and histopathology was reported as yolk sac tumor.

A 57 year old patient with large right scrotal swelling of 8 months duration and recent onset of pain was diagnosed by USG as right sided liposarcoma in scrotum. The bilateral testicles, head, body and tails of epididymis were displayed otherwise showed normal USG characteristics. MRI of the lesion revealed heterogeneous mass in the scrotum on right side arising from the spermatic cord. On fat saturated sequences there were areas of low attenuation suggesting fatty components of the mass (Figure 35). He was operated and histopathology reported as liposarcoma of the cord.

USG in a 29-year-old patient with scrotal swelling revealed bulky left testis with large lobulated, heterogeneously hypoechoic intratesticular mass lesion (Figure 33). There was increased vascularity on CDI. Contrast enhanced CT of the lung bases, abdomen and pelvis revealed multiple enlarged lymph nodes in the pre and para-aortic region and

bilateral inguinal region with splenomegaly. Multiple (3 to 5 in number) enhancing lung nodules of variable size were seen in lung bases. Histopathology revealed seminoma of testis.

A 70 year old patient with cachexic features was diagnosed with lymphoma, presented with scrotal swelling and USG revealed diffusely enlarged right testis with ill-defined hypoechoic areas with increased vascularity on CDI. There was mild reactive hydrocele and multiple enlarged lymph nodes in pre- and para-aortic and bilateral inguinal regions. Histopathology revealed lymphoma.

CONCLUSION

High frequency ultrasonography with color Doppler study serves as an excellent diagnostic imaging modality in evaluation of scrotal swellings. It is the investigation of choice as it is highly sensitivity, easy to perform, widely available, repeatable and involves no risk of ionizing radiation, especially to radiosensitive parts like testis.

It helps to arrive at accurate diagnosis in majority of patients with scrotal swellings, thus guiding for further management. When USG findings are inconclusive MRI may be useful.

Periodic follow-up USG studies are recommended for all patients with inflammatory scrotal lesions for monitoring response to treatment or to reveal development of complications.

SUMMARY

The aims and objectives of the study were to describe high frequency ultrasonographic characteristics in patients with non-traumatic scrotal swellings and correlate high frequency ultrasonography and color Doppler study findings with histopathology or follow-up USG.

This descriptive observational study was carried out over a period of 18 months from January 2015 to June 2016 in 196 patients with complaints of scrotal swelling and underwent high frequency ultrasonography and color Doppler imaging at Department of Radiodiagnosis, R. L. Jalappa Hospital & Research Centre, affiliated to Sri Devaraj Urs Medical College. Consecutive patients with scrotal swellings who met the inclusion criteria were included in the study.

The most commonly involved age group was 31 to 40 years (n = 41; 20.9%) followed by 21 to 30 years (n = 38; 19.4%) and 41 to 50 years (n = 35; 17.9%). Common symptoms were pain, fever and infertility.

On USG, the commonest cause for scrotal swelling was hydrocele (n = 78; 21.4%) followed by epididymitis (n = 71; 19.5%), varicocele (n = 68; 18.7%), epididymo-orchitis (n = 45; 12.4%), epididymal cyst (n = 46;12.6%), inguino-scrotal hernia (n = 19; 5.2%), scrotal wall thickening (n = 19; 5.2%), testicular abscess (n = 6; 1.6%), pyocele (n = 7; 1.9%), tumor (n = 4; 1.1%) and testicular torsion (n = 1; 0.3%). Scrotal swellings were

most common on left side (n = 141, 40.6%) followed by right side (n = 123, 35.4%) and bilateral (n = 83, 23.9%). Varicocele was most common on left side (n = 35; 51.5%), followed by bilateral (n = 29; 42.6%) and on right side (n = 4; 5.9%).

Epididymal cysts were seen in 46 patients, 19 patients had on right (41.3%), 17 on left (37%), and 10 patients had bilateral epididymal cysts (21.7%). Majority of the patients had no significant symptoms (n = 40). The largest epididymal cyst measured up to 4.3 cm in maximum dimension.

Epididymitis was common on left side (n = 31; 43.7%), followed by right side (n = 29; 40.8%) and bilateral (n = 11; 15.5%). Six patients also had funiculitis. Three patients had tubercular epididymitis (n = 3; 4.2%), two on left and one on right side. Epididymo-orchitis was most common on right side (n = 23; 51.1%), followed by left side (n = 16; 35.6%) and bilateral (n = 6; 13.3%). Seven patients also had diffuse scrotal wall thickening; likely due to underlying infective etiology. Four patients had tubercular epididymo-orchitis (n = 4; 8.8%); 2 on right and 2 on left side.

Testicular abscess was common on right side (n = 4; 66.7%), followed by left side (n = 2; 33.3%). All the patients had enlargement of testes and epididymes and increased vascularity and minimal fluid collections in tunica vaginalis, likely due to inflammatory reaction.

Pyocele was seen in 7 patients, 5 had on left side (71.4%), 1 on right side (14.3%), and 1 had bilateral pyocele (14.3%). Majority of the patients (n = 6) had mildly enlarged testes and epididymes. USG in 4 patients (n = 4; 57.1%) revealed fluid collection with internal septations and echogenic debris (three on left side and one on right side), suspecting tubercular etiology and were initiated with antitubercular therapy. Further scans showed interval resolution of findings.

Hydrocele was common on right side (n = 29; 37.2%), followed by left side (n = 26; 33.2%) and bilateral (n = 23; 29.5%). Eight patients had encysted hydrocele of cord; six on right side and two on left side. Two patients had right-sided hydrocele secondary to scrotal filariasis.

Varicocele was most commonly seen on left side (n = 35; 51.5%), followed by bilateral (n = 29; 42.6%) and on right side alone (n = 4; 5.9%). There were 6 patients with complaints of infertility of whom 4 had bilateral varicocele and 2 patients with left sided varicocele. One patient with bilateral varicocele had intra-testicular type on left side.

There were 19 patients with scrotal wall thickening. Eight patients (42.1%) had scrotal wall edema due to underlying infection, 6 patients had cellulitis of scrotal wall (31.6%) and 5 patients had scrotal wall thickening secondary to cardiac failure (26.3%).

Inguino-scrotal hernia was seen in 19 patients; it was most common on right side (n = 9; 47.4%), followed by left side (n = 7; 38.6%) and 3 patients had bilateral hernia (n = 3; 15.8%). One elderly patient diagnosed to have left inguino-scrotal hernia with bowel loops and omentum; however intra-operative finding revealed a hypoplastic uterus also as the content of hernial sac. He had history of infertility.

There was 1 patient where color Doppler study was suggestive of torsion testis, and was found to be non-viable at surgery.

Scrotal tumors were seen in 4 patients, 3 patients had on right side and 1 patient on left side. Scrotal tumours seen in the study were liposarcoma arising from right spermatic cord, yolk sac tumor, seminoma with distant metastases and lymphoma.

High frequency ultrasonography with color Doppler study serves as an excellent diagnostic imaging modality in evaluation of scrotal swellings. It is the investigation of choice as it is highly sensitivity, easy to perform, widely available, repeatable and involves no risk of ionizing radiation, especially to radiosensitive parts like testis. It helps to arrive at accurate diagnosis in majority of patients with scrotal swellings, thus guiding for further management. When USG findings are inconclusive MRI may be useful. Periodic follow-up USG studies are recommended for all patients with inflammatory scrotal lesions for monitoring response to treatment or to reveal development of complications.

BIBLIOGRAPHY

1. Coley BD. Sonography of pediatric scrotal swelling. Semin Ultrasound CT MR 2007;28:297-306.
2. Appelbaum L, Gaitini D, Dogra VS. Scrotal ultrasound in adults. Semin Ultrasound CT MR 2013;34:257-73.
3. Rizvi SA, Ahmad I, Siddiqui MA, Zaheer S, Ahmad K. Role of color Doppler ultrasonography in evaluation of scrotal swellings: pattern of disease in 120 patients with review of literature. Urol J 2011;8:60-5.
4. Miskin M, Bain J. B-mode ultrasonic examination of the testes. J Clin Ultrasound 1974;2:307-11.
5. Miskin M, Buckspan M, Bain J. Ultrasonographic examination of scrotal masses. J Urol 1977;117:185-8.
6. Sample WF, Gottesman JE, Skinner DG, Ehrlich RM. Gray scale ultrasound of the scrotum. Radiology 1978;127:225-8.
7. Leopold GR, Woo VL, Scheible FW, Nachtsheim D, Gosink BB. High-resolution ultrasonography of scrotal pathology. Radiology 1979;131:719-22.
8. Subramanyam BR, Balthazar EJ, Raghavendra BN, Horii SC, Hilton S. Sonographic diagnosis of scrotal hernia. AJR Am J Roentgenol 1982;139:535-8.
9. Wolverson MK, Houttuin E, Heiberg E, Sundaram M, Gregory J. High-resolution real-time sonography of scrotal varicocele. AJR Am J Roentgenol 1983;141:775-9.
10. Horstman WG, Middleton WD, Melson GL. Scrotal inflammatory disease: Color Doppler US findings. Radiology 1991;179:55-9.

11. Farriol VG, Comella XP, Agromayor EG, Creixams XS, Martinez De La Torre IB. Gray-scale and power Doppler sonographic appearances of acute inflammatory diseases of the scrotum. J Clin Ultrasound 2000;28:67-72.

12. Aganovic L, Cassidy F. Imaging of the scrotum. Radiol Clin North Am 2012;50:1145-65.

13. Liang T, Metcalfe P, Sevcik W, Noga M. Retrospective review of diagnosis and treatment in children presenting to the pediatric department with acute scrotum. AJR Am J Roentgenol 2013;200:W444-9.

14. Woodward PJ, Schwab CM, Sesterhenn IA. From the archives of the AFIP: extratesticular scrotal masses: radiologic-pathologic correlation. Radiographics 2003;23:215-40.

15. Thinyu S, Muttarak M. Role of ultrasonography in diagnosis of scrotal disorders: A review of 110 cases. Biomed Imaging Interv J 2009;5:e2.

16. Male reproductive system. In: Standring S editor. Gray's anatomy: The anatomical basis of clinical practice. 14th edition. Churchill Livingstone. Spain. P:1261-77.

17. Dogra VS, Gottlieb RH, Oka M, Rubens DJ. Sonography of the scrotum. Radiology 2003;227:18-36.

18. Mirochnik B, Bhargava P, Dighe MK, Kanth N. Ultrasound evaluation of scrotal pathology. Radiol Clin North Am 2012;50:317-32

19. Middleton WD, Bell MW. Analysis of intratesticular arterial anatomy with emphasis on transmediastinal arteries. Radiology 1993;189:157-60.

20. Gooding GA. Sonography of the spermatic cord. AJR Am J Roentgenol 1988;151:721-4.

21. Horstman WG. Scrotal imaging. Urol Clin North Am 1997;24:653-71.

22. Dewbury KC. Scrotal ultrasonography: an update. BJU Int 2000;86 Suppl 1:143-52.

23. Jee WH, Choe BY, Byun JY, Shinn KS, Hwang TK. Resistive index of the intrascrotal artery in scrotal inflammatory disease. Acta Radiol 1997;38:1026-30.

24. Sanders LM, Haber S, Dembner A, Aquino A. Significance of reversal of diastolic flow in the acute scrotum. J Ultrasound Med 1994;13:137-9.

25. Di Donna A, Rizzatto G. Pyocele of the scrotum: Sonographic demonstration of fluid-fluid level and a gas-forming component. J Ultrasound Med 1986;5:99-100.

26. Begley MG, Shawker TH, Robertson CN, Bock SN, Wei JP, Lotze MT. Fournier gangrene: Diagnosis with scrotal US. Radiology 1988;169:387-9.

27. Yang DM, Kim HC, Kim SW, Lee HL, Min GE, Lim SJ. Sonographic findings of tuberculous vasitis. J Ultrasound Med 2014;33:913-6.

28. Chung JJ, Kim MJ, Lee T, Yoo HS, Lee JT. Sonographic findings in tuberculous epididymitis and epididymo-orchitis. J Clin Ultrasound 1997;25:390-4.

29. Cook JL, Dewbury K. The changes seen on high-resolution ultrasound in orchitis. Clin Radiol 2000;55:13-8.

30. Casalino DD, Kim R. Clinical importance of a unilateral striated pattern seen on sonography of the testicle. AJR Am J Roentgenol 2002;178:927-30.

31. Stewart VR, Sidhu PS. The testis: the unusual, the rare and the bizarre. Clin Radiol 2007;62:289-302.

32. Thwaini A, Khan A, Malik A, Cherian J, Barua J, Shergill I, et al. Fournier's gangrene and its emergency management. Postgrad Med J 2006;82:516-9.

33. Breen M, Murphy K, Chow J, Kiely E, O'Regan K. Acute idiopathic scrotal edema. Case Rep Urol 2013;2013:829345.

34. Elder JS. Cryptorchidism: isolated and associated with other genitourinary defects. Pediatr Clin North Am 1987;34:1033-53.

35. Rajfer J, Walsh PC. Testicular descent. Normal and abnormal. Urol Clin North Am 1978;5:223-35.

36. Muttarak M, Chaiwun B. Painless scrotal swelling: Ultrasonographical features with pathological correlation. Singapore Med J 2005;46:196-201

37. Pillai SB, Besner GE. Pediatric testicular problems. Pediatr Clin North Am 1998;45:813-830.

38. Paltiel HJ. Sonography of pediatric scrotal emergencies. Ultrasound Q 2000;16:53-71.

39. Mueller DL, Amundson GM, Rubin SZ, Wesenberg RL. Acute scrotal abnormalities in children: diagnosis by combined sonography and scintigraphy. AJR Am J Roentgenol 1988;150:643-6.

40. Prando D. Torsion of the spermatic cord: sonographic diagnosis. Ultrasound Q 2002;18:41-57.

41. Fitzgerald SW, Erickson S, DeWire DM, Foley WD, Lawson TL, Begun FP, et al. Color Doppler sonography in the evaluation of the adult acute scrotum. J Ultrasound Med 1992;11:543-8.

42. Alcantara AL SY. Imaging of testicular torsion and epididymitis/orchitis: Diagnosis and pitfalls. Emerg Radiol 1998;5:394-402.

43. Lerner RM, Mevorach RA, Hulbert WC, Rabinowitz R. Color Doppler US in the evaluation of acute scrotal disease. Radiology 1990;176:355-8.

44. Atkinson GO, Jr., Patrick LE, Ball TI, Jr., Stephenson CA, Broecker BH, Woodard JR. The normal and abnormal scrotum in children: Evaluation with color Doppler sonography. AJR Am J Roentgenol 1992;158:613-7.

45. Wu VH, Dangman BC, Kaufman RP, Jr. Sonographic appearance of acute testicular venous infarction in a patient with a hypercoagulable state. J Ultrasound Med 1995;14:57-9.

46. Bilagi P, Sriprasad S, Clarke JL, Sellars ME, Muir GH, Sidhu PS. Clinical and ultrasound features of segmental testicular infarction: six-year experience from a single centre. Eur Radiol 2007;17:2810-8.

47. Ledwidge ME, Lee DK, Winter TC, 3rd, Uehling DT, Mitchell CC, Lee FT, Jr. Sonographic diagnosis of superior hemispheric testicular infarction. AJR Am J Roentgenol 2002;179:775-6.

48. Middleton WD, Thorne DA, Melson GL. Color Doppler ultrasound of the normal testis. AJR Am J Roentgenol 1989;152:293-7.

49. Beddy P, Geoghegan T, Browne RF, Torreggiani WC. Testicular varicoceles. Clin Radiol 2005;60:1248-55.

50. Gonda RL, Jr., Karo JJ, Forte RA, O'Donnell KT. Diagnosis of subclinical varicocele in infertility. AJR Am J Roentgenol 1987;148:71-5.

51. Jacobsen GK TA. Atlas of germ cell tumors. J Pathol 1989;160:86-7.

52. Graif M, Hauser R, Hirshebein A, Botchan A, Kessler A, Yabetz H. Varicocele and the testicular-renal venous route: Hemodynamic Doppler sonographic investigation. J Ultrasound Med 2000;19:627-31.

53. Kilciler G, Sancaktutar AA, Avci A, Kilciler M, Kaya E, Dayanc M. Chronic constipation: Facilitator factor for development of varicocele. World J Gastroenterol 2011;17:2641-5.

54. Zucchi A, Mearini L, Mearini E, Fioretti F, Bini V, Porena M. Varicocele and fertility: Relationship between testicular volume and seminal parameters before and after treatment. J Androl 2006;27:548-51.

55. Krone KD, Carroll BA. Scrotal ultrasound. Radiol Clin North Am 1985;23:121-39.

56. Orda R, Sayfan J, Manor H, Witz E, Sofer Y. Diagnosis of varicocele and postoperative evaluation using inguinal ultrasonography. Ann Surg 1987;206:99-101.

57. Rathaus V, Konen O, Shapiro M, Lazar L, Grunebaum M, Werner M. Ultrasound features of spermatic cord hydrocele in children. Br J Radiol 2001;74:818-20.

58. Nye PJ, Prati RC, Jr. Idiopathic hydrocele and absent testicular diastolic flow. J Clin Ultrasound 1997;25:43-6.

59. Black JA, Patel A. Sonography of the normal extratesticular space. AJR Am J Roentgenol 1996;167:503-6.

60. Martinez-Berganza MT, Sarria L, Cozcolluela R, Cabada T, Escolar F, Ripa L. Cysts of the tunica albuginea: sonographic appearance. AJR Am J Roentgenol 1998;170:183-5.

61. Hamm B, Fobbe F, Loy V. Testicular cysts: Differentiation with US and clinical findings. Radiology 1988;168:19-23.

62. Older RA, Watson LR. Tubular ectasia of the rete testis: A benign condition with a sonographic appearance that may be misinterpreted as malignant. J Urol 1994;152:477-8.

63. Oh C, Nisenbaum HL, Langer J, Rowling S, Van Arsdalen KN. Sonographic demonstration, including color Doppler imaging, of recurrent sperm granuloma. J Ultrasound Med 2000;19:333-5.

64. Atchley JT, Dewbury KC. Ultrasound appearances of testicular epidermoid cysts. Clin Radiol 2000;55:493-502.

65. Cho JH, Chang JC, Park BH, Lee JG, Son CH. Sonographic and MR imaging findings of testicular epidermoid cysts. AJR Am J Roentgenol 2002;178:743-8.

66. Bhosale PR, Patnana M, Viswanathan C, Szklaruk J. The inguinal canal: Anatomy and imaging features of common and uncommon masses. Radiographics 2008;28:819-35

67. Coursey Moreno C, Small WC, Camacho JC, Master V, Kokabi N, Lewis M, et al. Testicular tumors: what radiologists need to know--differential diagnosis, staging, and management. Radiographics 2015;35:400-15.

68. Kreydin EI, Barrisford GW, Feldman AS, Preston MA. Testicular cancer: what the radiologist needs to know. AJR Am J Roentgenol 2013;200:1215-25.

69. Grantham JG, Charboneau JW, James EM, Kirschling RJ, Kvols LK, Segura JW, et al. Testicular neoplasms: 29 tumors studied by high-resolution US. Radiology 1985;157:775-80.

70. Woodward PJ, Sohaey R, O'Donoghue MJ, Green DE. From the archives of the AFIP: Tumors and tumor like lesions of the testis: radiologic-pathologic correlation. Radiographics 2002;22:189-216.

71. Yang DM, Kim SH, Kim HN, et al. Differential diagnosis of focal epididymal lesions with gray scale sonographic, color Doppler sonographic, and clinical features. J Ultrasound Med 2003;22:135-42.

72. Alleman WG, Gorman B, King BF, Larson DR, Cheville JC, Nehra A. Benign and malignant epididymal masses evaluated with scrotal sonography: Clinical and pathologic review of 85 patients. J Ultrasound Med 2008;27: 1195-1202.

73. Siddiqui EH, Siddiqui S, Rasool G, Khan N. Scrotal Pathologies: Role of high resolution & Doppler ultrasound in evaluation. Professional Med J 2013;20:924-28.

74. Agarwal Am, Tripathi PS, Shankwar A, Naveen C. Role of Ultrasound with Color Doppler in Acute Scrotum Management. J Family Med Prim Care 2014;3: 409–12.

75. Smith RP, Tracy CR, Kavoussi PK, Witmer MT, Costabile RA. The impact of color Doppler ultrasound on treatment patterns of epididymitis in a university-based healthcare system. Indian J Urol 2013;29:22-6.

76. D'Andrea A, Coppolino F, Cesarano E, Russo A, Cappabianca S, Genovese EA. et al. US in the assessment of acute scrotum. Crit Ultrasound J 2013;5:Suppl 1:S8.

ANNEXURE - I

PROFORMA

Name		**Hospital No.**	
Age		**Date**	
Gender	**Male**	**Contact No.**	

Clinical history:

Local Examination:

Inspection	Skin			
	Swelling			
Palpation	Skin			
	Swelling	Cough impulse		
		Reducibility		
	Testis		R	L
	Epididymis		R	L
	Spermatic cord		R	L
	Inguinal lymph nodes		R	L
Auscultation	Bowel sounds			
Trans-illumination				

Working /differential diagnosis:

Scrotal swelling **:** Right ☐ Left ☐ Bilateral ☐

High frequency USG findings:

	Right testis	**Left testis**	**Right epididymis**	**Left epididymis**
Size				
Shape				
Echogenicity				
Calcification				
Vascularity				
Dilated veins				

Testicular mass : Yes ☐ No ☐

(If yes -)

Extratesticular mass : Yes ☐ No ☐

(If yes -)

Dilated veins : Yes ☐ No ☐

Fluid collection : Yes ☐ No ☐

Inguino-scrotal hernia : Right ☐ Left ☐ Bilateral ☐

Scrotal wall thickening : Yes ☐ No ☐

Abdomen and pelvic USG/CT if any:

Histopathology report if any:

Operative findings if any:

Follow-up USG if any:

ANNEXURE II

INFORMED CONSENT FORM

Study Title: HIGH FREQUENCY ULTRASONOGRAPHY AND COLOR DOPPLER IMAGING IN EVALUATION OF NON-TRAUMATIC SCROTAL SWELLINGS.

Chief researcher/ PG Guide's Name: Dr. ANIL KUMAR SAKALECHA

Principal investigator: Dr. VARUN S.

Name of the Patient:
Age :

a. I, Mr. _____, have been invited to participate in Research project titled "High Frequency Ultrasound and Color Doppler Study in Evaluation of Non-traumatic Scrotal Swellings". It has been explained to me in my vernacular language that this study will be performed with high frequency ultrasound and color Doppler study. Furthermore, I have been assured that no obvious risk will be involved with scan.
b. I understand that the medical information produced by this study will become part of institutional record and will be kept confidential by the said institute.
c. I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).
d. I understand that my participation is voluntary and may refuse to participate or may withdraw my consent and discontinue participation at any time without prejudice to my present or future care at this institution.
e. I will not be paid any financial compensation for participating in this research project.
f. I confirm that Dr. Anil Kumar Sakalecha/Dr. Varun S. (chief researcher/ Principal investigator) has explained to me the purpose of research and the study procedure that I will undergo and the possible risks and discomforts that i may experience, in my own language. I hereby agree to give valid consent to participate as a subject in this research project.

Participant’s name and signature/thumb impression (in case of illiterate)

Signature of the witness (in case of illiterate person): Date:

I have explained to _____ the purpose of the research, the possible risk and benefits to the best of my ability.

Principal investigator/ Guide signature Date:

ANNEXURE-III

Patient Information Sheet

Principal Investigator: Dr. Varun S./ Dr. Anil Kumar Sakalecha

I, Dr. Varun S., post-graduate student in Department of Radiodiagnosis at Sri Devaraj Urs Medical College. I will be performing a study titled "High Frequency Ultrasonography and Color Doppler Imaging in Evaluation of Non-Traumatic Scrotal Swellings" for my dissertation under the guidance of Dr. Anil Kumar Sakalecha, Professor, Department of Radio-Diagnosis. In this study, we will assess the role of ultrasonography and color Doppler imaging in the evaluation of causes for scrotal swellings. There will be no additional expenses incurred by you for participation in this study. Ultrasonography is considered as a safe and very effective diagnostic test and there is no harm whatsoever for you in the study.

The study will help us to understand the causes for scrotal swellings and help in planning appropriate treatment and hence achieve improved care of the patient.

All of your personal data will be kept confidential and will be used only for research purpose by this institution. You are free to participate in the study. You can also withdraw from the study at any point of time without giving any reasons whatsoever. Your refusal to participate will not prejudice us to any present or future care at this institution.

Name and Signature of the Principal Investigator

Date

ANNEXURE-IV

KEY TO MASTERCHART

B	Bilateral
EHC	Encysted hydrocele of cord
En	Enlarged
FIL	Filariasis
Fu	Funiculitis
Hypo	Hypoechoic
ITV	Intratesticular varicocele
L	Left
LM	Lymphoma
LSC	Liposarcoma of cord
P	Present
PHS	Post-hernioplasty status
PM	Pulmonary metastasis
Pos	Post-operative status
R	Right
Sl	Small
SM	Seminoma
Tb	Tuberculosis
Ut	Uterus
VCT	Varicocelectomy
YST	Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
1	14413	45													B						
2	75323	63	P							R						B					
3	40442	44	P							R											
4	14523	45								L						B					
5	6672	23			P											B					VCT
6	74541	53														L					
7	15592	42					Sl								R						
8	11165	35	P													B					VCT
9	40327	55	P													B					
10	32477	6													L						
11	22977	34	P													B					VCT
12	97773	45	P													B					
13	77211	32	P							R						L					
14	88354	75								R					B						
15	930	34	P							L											
16	60369	35	P													L					VCT
17	65720	24													R						
18	86421	7													R						
19	17219	45	P				En		Hypo	B	L	L			L	L					
20	9650	23	P					Hypo				R				L					
21	33744	32	P													L					
22	85447	62	P					Hypo			R	R				L					
23	36686	19	P					Hypo		B	B	R									

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
24	90352	28	P								L										
25	24281	28	P							L	L										
26	91999	58			P										L			L			PHS - Ut
27	43180	38	P													B					VCT
28	77053	64	P				En			B	L										
29	22893	27	P													L					VCT
30	73468	46				En		Hypo			R	R	R		R						Tb
31	51152	36	P				En			L	L				L						
32	46069	65	P				En			L	L				B			L			PHS
33	33565	56	P					Hypo	Hypo			B			B		P				
34	2255	50																B			PHS
35	20314	62	P			En		Hypo			R	R	R		B						Tb
36	42360	24	P													L					
37	29224	55								L					B			L			PHS
38	80765	47													B						
39	19451	27	P				En		Hypo		L	L			L						
40	11096	42	P			En	En				B										
41	28364	56															P				
42	28686	50														L					
43	67531	20	P				En			R	L				L-EHC			L			PHS
44	24850	30					En-														Tb
45	39534	32	P			En		Hypo		R	R	R				R					
46	80144	57	P				En		Hypo	L	L	L			L						

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
47	24165	41	P			En	En			B	B										
48	65060	55	P			Sl	En		Hypo		L	L			L						
49	26877	32	P							R											
50	55359	52	P							L											
51	98258	30			P											B					VCT
52	75681	36					En				L				L						
53	17921	30								B											
54	25400	30	P	P			En		Hypo		L	L				L					
55	83966	75	P				En			L	L										
56	37663	6													R						
57	78044	57	P													L	P			R-LSC	
58	5361	45	P	P		En		Hypo			R	R	R								
59	90674	65	P	P		En	En				B				B						
60	88115	50	P			En				L					B		P				
61	98837	60	P			En	En				B				L						
62	80056	39	P			En		Hypo		R	R	R									
63	6491	65				En		Hypo			R	R				B					Tb
64	15020	27	P													L					VCT
65	10202	34	P			En				R	R		R		R						
66	19235	28			P											L					
67	45668	29	P												R		P				
68	92065	21	P												R	L					
69	27616	35	P				En				L										

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
70	69623	33														B					
71	11167	2	P												B			L			PHS
72	59963	60	P				En				L		L			L	P				
73	58859	23	P													B					VCT
74	23234	2.5				En														R-YST	
75	32857	35	P			En				R	R					L					
76	18759	19	P			En		Hypo	Hypo		R	B									
77	46561	61	P			En		Hypo			R	R			R						R-Fu
78	27075	22	P				En			L											L-Fu
79	74604	60	P				En	Hypo	Hypo	R	B	B					P				B-Fu
80	80667	47	P	P						L				P			P				Tb
81	65461	25	P															L			PHS
82	88187	25	P													L					
83	38044	32								R								B			PHS
84	69152	43	P													B					
85	88410	23	P							R						B					
86	58223	11													L						
87	34261	60	P												R-EHC						
88	36500	68	P															B			PHS
89	53610	35	P			En					R										
90	6339	45	P	P					Hypo		L	L	L	P	L		P				Tb
91	7191	11														L					
92	16576	25				En				R											

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
93	55508	22			P		Sl									L					
94	18377	57					En			L					B						
95	45826	60													B	B					
96	94479	35	P				En		Hypo		L	L			L	L					
97	20815	52	P	P		En	En				B				R	L					
98	94635	28	P			En	En			B						L					
99	73153	44								B						L					
100	64214	37	P												L	B					VCT
101	94801	5																R			PHS
102	43068	66	P													B					
103	32580	85	P			En	En								B						
104	10551	26								R											
105	29850	27	P				En	Hypo		L		R			R	L					
106	12551	32	P			En					R					B					
107	92726	49													R						FIL
108	76563	60													R						
109	83265	58	P				En		Hypo		L	L		P							
110	82207	22	P							R					L	B					
111	5971	34								B					B	B					
112	38952	21	P				En		Hypo		L	L			L						
113	41091	1.3													R						
114	85351	30	P			En					R				R			R			PHS
115	85237	36													R-EHC						

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
116	94264	55	P	P		En		Hypo			R	R									
117	88160	13													R-EHC						
118	12589	8													L						
119	58327	30														R					
120	24058	48													R-EHC						
121	9580	48													R						
122	18306	47	P															L			PHS
123	64178	27	P			En		Hypo			R	R				L					
124	37132	44				En	En			B						L					
125	23061	30	P	P		En		Hypo			R	R									R-Fu
126	12500	60				En				R							P				
127	64739	32	P	P		En	En	Hypo	Hypo		B	B									
128	83287	29	P				En								L					L-SM	PM
129	19060	45								L								L			PHS
130	83999	50	P													L		R			PHS
131	99435	53	P												R						
132	25188	30	P															R			PHS
133	1093	58	P												B						
134	25348	60																R			PHS
135	65301	80	P												L						
136	29570	10	P	P		En					R										
137	76865	43	P												R-EHC						
138	20197	80													B						

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
139	30936	23													R						
140	27225	13	P	P		En	En	Hypo	Hypo		B	B					P				R
141	39646	70	P												B					R-LM	
142	57159	39	P			En		Hypo			R	R									R-Fu
143	32469	32	P				En		Hypo		L	L									Tb
144	37369	38	P				En				L			P							Tb
145	35359	43	P				En				L			P		L					
146	32111	33	P			En		Hypo			R	R									
147	64349	75													B	L					
148	10502	65															P				
149	23393	12	P				En				L										
150	91507	58													L						
151	28391	85															P				
152	77101	40													L						
153	37549	40	P											P	R						
154	95467	75	P							L						L					
155	22366	45	P	P		En-					R										Tb
156	30333	32	P													L					VCT
157	70718	32	P			En					R										
158	89486	74	P				En		Hypo		L	L									Tb
159	45841	25	P				En		Hypo		L	L									
160	27811	72														B					VCT-L-ITV
161	23859	19	P			En		Hypo			R	R									

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
162	40533	58													B						
163	61634	48	P	P			En		Hypo		L	L				L					
164	46972	52	P			En	En								R	B					
165	61836	40													R		P				FIL
166	71600	5	P				En				L										
167	13144	41				En		Hypo		R		R					P	R			PHS
168	19467	26	P	P		En		Hypo			R	R									
169	49057	35	P				En	Hypo				R			B	B					
170	93512	33	P				En		Hypo		L	L			L	L					Tb
171	75976	48	P				En		Hypo		L	L									Tb
172	22763	2.5													L						
173	19114	8													R-EHC						
174	2550	36	P			En		Hypo		B	R	R				B					
175	15470	7	P												L						
176	89510	65	P				En		Hypo		L	L			R		P				L-Fu
177	76651	51													L						
178	31437	60	P	P				Hypo	Hypo		B	B					P				
179	48445	3													L-EHC						
180	90762	66	P			En					R										
181	34902	35	P		P											B					VCT
182	11134	36			P											B					VCT
183	36620	23														R					
184	45564	52														L					

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor

Masterchart – High Frequency Ultrasonography and Colour Doppler Study in Evaluation of Non-Traumatic Scrotal Swellings

Serial No.	Study ID	Age (in years)	Associated symptoms			Epididymes		Echogenicity of Testes		Findings on USG											Others
			Pain	Fever	Infertility	R epididymis	L epididymis	R testis	L testis	Epididymal cyst	Epididymitis	Epididymo Orchitis	Testicular Abscess	Pyocele	Hydrocele	Varicocele	Scrotal wall thickening	Inguino-scrotal hernia	Testicular torsion	Tumour	
185	95877	13													R						
186	85864	45	P			En		Hypo			R	R									
187	2626	53	P													B	P				
188	57651	40	P			En					R				B						
189	38113	51	P	P		En	En			L	B			P	L						Tb
190	53675	49				En					R				B						
191	20500	72	P												B	B					
192	68283	75	P													R	P				
193	8594	35	P	P		En		Hypo			R	R									
194	46848	35	P													B		R			PHS
195	19275	45																R			PHS
196	51851	46	P				En			R	L					L					

B = Bilateral; EHC = Encysted hydrocele of cord; En = Enlarged; FIL = Filariasis; Fu = Funiculitis; ITV = Intra-testicular varicocele; Hypo = Hypoechoic; L = Left; LM = Lymphoma; LSC = Liposarcoma of cord; P = Present; PHS = Post-hernioplasty status; Pos = Post-operative status; Pu = Pulmonary metastases; R = Right; Sl = Small; SM = Seminoma; Tb = Tuberculosis; Ut = Uterus; VCT = Varicocelectomy; YST = Yolk sac tumor