
**“ROLE OF ULTRASONOGRAPHY IN DIAGNOSING
VESICO URETERAL REFLUX IN PAEDIATRIC
PATIENTS WITH URINARY TRACT INFECTION – A
ONE YEAR HOSPITAL BASED CROSS-SECTIONAL
STUDY”**

BY

REG. NO. BS0121001

Dissertation

Submitted to

KAHER, Belagavi, Karnataka,

**In partial fulfilment of the requirements
for the degree of**

M.D.

In

RADIO-DIAGNOSIS

**J. N. MEDICAL COLLEGE,
BELAGAVI -590010. KARNATAKA**

DEC – 2024/JAN – 2025

KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH,
BELAGAVI, KARNATAKA

**Endorsement by the HOD/Principal/ Head of the
Institution**

This is to certify that the dissertation entitled “ROLE OF ULTRASONOGRAPHY
IN DIAGNOSING VESICO URETERAL RELUX IN PAEDIATIC PATIENTS
WITH URINARY TRACT INFECTION – A ONE YEAR HOSPITAL BASED
CROSS SECTIONAL STUDY” is a bonafide research work done by REG NO.
BS0121001.

Santosh
Dr. SANTOSH D. PATIL
M.D. (Radio-Diagnosis)
Professor & HOD
Dept. of Radio-diagnosis
J.N. Medical College, BELAGAVI-10.
M.D. RAC No. 58456

Professor and Head,
Department of Radio Diagnosis,
J. N. Medical College,
Nehru Nagar, Belagavi – 10

MS
Dr N. S. MAHANTASHETTI
M. D. PEDIATRICS

Principal,
J. N. Medical College,
Nehru Nagar, Belagavi – 10

PRINCIPAL
J.N. Medical College,
BELAGAVI- 596 016



Date: 26/06/24
Place: Belagavi

Date : 26/06/24
Place : Belagavi

UNDERTAKING

I, **Reg. No. BS0121001**, hereby declare that the information and the data mentioned in my dissertation entitled “**ROLE OF ULTRASONOGRAPHY IN DIAGNOSING VESICO-URETERAL REFLUX IN PAEDIATRIC PATIENTS WITH URINARY TRACT INFECTION – A ONE YEAR HOSPITAL BASED CROSS-SECTIONAL STUDY**” belongs to me and is original. I am aware of the definition of plagiarism as detailed below:

- An act or instance of using or closely imitating the language and thoughts of another author without authorization and the representation of that author’s work as one’s own, as by not crediting the original author.
- A piece of writing or other work reflecting such unauthorized use or imitation.
- The deliberate or reckless representation of another’s words, thoughts or ideas as one’s own without attribution in connection with submission of academic work, whether graded or otherwise.

I hereby declare that the dissertation prepared by me is original one and does not involve plagiarism anywhere. In case at a later stage, it is found that I have indulged in plagiarism, then I am solely responsible for the same and the institution is at liberty to take any disciplinary action against me including cancellation of dissertation or any other penalties imposed by the University.

Date:25/05/2024

Place: Belagavi



(REG. NO. BS0121001)

PLAGIARISM CERTIFICATE



JAWAHARLAL NEHRU MEDICAL COLLEGE

(A constituent unit of KLE Academy of Higher Education & Research Deemed-to-be-University)

(Recognized by National Medical Commission, New Delhi)

Accredited 'A+' Grade by NAAC (3rd Cycle)

Placed in Category 'A' by MoE (GoI)



Nehru Nagar, Belagavi- 590 010, Karnataka, INDIA

0831 - 2471350

0831 - 2470759

www.jnmc.edu

principal@jnmc.edu

Ref No: MDC/PG/


Date: 25-06-2024

"ACCEPTANCE LETTER"

The softcopy of thesis entitled: "ROLE OF ULTRASONOGRAPHY IN DIAGNOSING VESICO URETERAL REFLUX IN PAEDIATRIC PATIENTS WITH URINARY TRACT INFECTION - A ONE YEAR HOSPITAL BASED CROSS-SECTIONAL STUDY" has been submitted for anti-plagiarism check through Turnitin software. The scan has been carried out and the scanned output reveals a match percentage of 09% which is within the acceptable limits of 10% as per the guidelines given by UGC.


Guide.




Dr. (Mrs.) N.S. Mahantashetti,
Chairperson-Antiplagiarism Committee &
Principal,
J. N. Medical College, Belagavi.

To,
Reg. No. BS0121001
Postgraduate Student,
2021-22 Batch,
Department of Radio-Diagnosis
J. N. Medical College, Belagavi.

PRINCIPAL
J.N. Medical College,
BELAGAVI- 590 010

ETHICAL CLEARANCE CERTIFICATE



K.L.E. ACADEMY OF HIGHER EDUCATION AND RESEARCH
(Deemed - to- be- University)

Accredited 'A+' Grade by NAAC in (3rd Cycle) Placed in Category 'A' by MHRD (GoI)

JNMC INSTITUTIONAL ETHICS COMMITTEE
JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)

Website: <http://www.jnmc.edu>
E-Mail : dome@jnmc.edu

Phone: (+ 91-(0)831 Office : 2472550
Principal: 2471701
Fax No. +91 (0)831 -2470759

Ref No.MDC/JNMCIEC/ 236

Date: 7/10/2022


To.

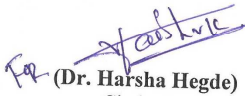
REG. NO. BS0121001

PG Student in Radio-diagnosis,
J. N. Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled
"ROLE OF ULTRASONOGRAPHY IN DIAGNOSING VESICO-URETERAL REFLUX
IN PAEDIATRIC PATIENTS WITH URINARY TRACT INFECTION - A ONE YEAR
HOSPITAL BASED CROSS-SECTIONAL STUDY" is ethical and justifiable. The proposed
research project has been cleared by the JNMC Institutional Ethics Committee.


(Dr. Smita Sonoli)
Member Secretary
JNMC Institutional Ethics Committee
J.N.Medical College, Belagavi.


(Dr. Harsha Hegde)
Chairman,
JNMC Institutional Ethics Committee
J.N.Medical College, Belagavi

LIST OF ABBREVIATIONS

UTI	Urinary tract infections
VUR	Vesicoureteral reflux
MCU	Micturating cystourethrography
USG	Ultrasonography
BBD	Bladder-bowel dysfunction
CAKUT	Congenital abnormalities of the kidneys and urinary tract
RNC	Radionuclide cystography
VCUG	Voiding cystourethrogram
RBUS	Renal and bladder ultrasonography
APN	Acute pyelonephritis
DMSA	^{99m} Tc-dimercaptosuccinic acid
SFU	Society of fetal urology
IVP	Intravenous pyelography
AAP	American Academy of Pediatrics
ceVUS	Contrast-enhanced voiding urosonogram
RS	Renal scarring
APRPD	Anteroposterior renal pelvic diameter

TABLE OF CONTENTS

S.NO	TABLE OF CONTENTS	PAGE NO.
1	INTRODUCTION	1-2
2	AIMS & OBJECTIVES	3
3	REVIEW OF LITERATURE	4-31
4	MATERIALS & METHODS	32-33
5	RESULTS	34-47
6	DISCUSSION	48-51
7	CONCLUSION	52
8	SUMMARY	53-54
9	LIMITATIONS	55
10	BIBLIOGRAPHY	56-65
11	ANNEXURES	
	ANNEXURE I – CONSENT FORM	66-68
	ANNEXURE- II- PROFORMA	69
	ANNEXURE- III- PHOTOGRAPHS	70-73
	ANNEXURE -IV- KEY TO MASTER CHART	74-75

LIST OF TABLES

TABLE NO.	DESCRIPTION	PAGE NO.
1	Age wise distribution of study participants	34
2	Gender wise distribution of study participants	35
3	Distribution of presenting complaints among the study participants	36
4	Distribution of history of congenital anomalies among the study participants	37
5	Distribution of various grades of VUR in MCU among the study participants	38
6	Distribution of cases into unilateral and bilateral cases on MCU	40
7	Depicts renal and ureter parameters on ultrasonography	41
8	Accuracy of ultrasonography in detecting all grade vesico-ureteral reflux	41
9	Accuracy of ultrasonography in grading all grade vesico-ureteral reflux cases	42
10	VUR detection and grading on both MCU and USG	43
11	Depicts accuracy of USG in detection and grading of low grade VUR	44
12	Depicts accuracy of USG in detection and grading of high grade VUR	46

LIST OF GRAPHS

TABLE NO.	DESCRIPTION	PAGE NO.
1	Age wise distribution of study participants	34
2	Gender wise distribution of study participants	35
3	Distribution of presenting complaints among the study participants	36
4	Distribution of history of congenital anomalies among the study participants	37
5	Distribution of MCU findings among the study participants	39
6	Distribution of cases into unilateral and bilateral cases on MCU	40
7	Pie chart depicting accuracy of ultrasonography in detecting all grade vesico-ureteral reflux	42
8	Pie chart depicting accuracy of ultrasonography in grading all grade vesico-ureteral reflux	43
9	Depicts detection & grading of VUR among various grades of VUR on both MCU and USG	44

ABSTRACT

BACKGROUND AND OBJECTIVES:

Urinary tract infections (UTIs) are prevalent bacterial diseases in children, often linked to vesicoureteral reflux (VUR), a common underlying cause. Traditionally, the diagnosis of VUR has relied on invasive micturating cystourethrography (MCU). This study aimed to assess the accuracy of ultrasonography (USG) for predicting and grading VUR in pediatric patients with UTIs.

METHODOLOGY:

The present study was conducted in the Department of (Radiology) Radio-diagnosis, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum (Belagavi) from January 2023 to December, 2023

RESULTS:

It was a one-year observational study where in a cohort of 42 pediatric patients, predominantly in early to mid-childhood (54.7%), underwent evaluation, with a male-to-female ratio of 6:1. USG identified 38 true positive cases of VUR and 4 false negatives, while both USG and MCU showed no false positives or true negatives.

Among the findings, bilateral Grade IV VUR was most prevalent, followed by bilateral Grade V VUR, 90.4 % of all grade VUR were accurately diagnosed and 68.4 % cases were graded accurately, 75% of the low-grade being diagnosed on USG and 44% of cases were accurately graded

96.6 % of the high-grade cases were accurately diagnosed on USG with 75.8 % of them accurately graded

In addition to VUR grading, USG provided insights into kidney size, shape, signs of chronic pyelonephritis, ureteric characterization, intrapelvic echoes indicating persistent infection, poor urine emptying due to reflux, and dynamic reflux assessment. Furthermore, USG detected renal scarring, atrophic changes, and intrapelvic echogenicities, facilitating comprehensive management decisions.

CONCLUSION:

Ultrasonography emerges as a promising non-invasive tool for assessing VUR in pediatric UTI patients, offering reliable diagnostic accuracy and additional parameters for comprehensive clinical management.

Keywords: urinary tract infection, vesicoureteral reflux, ultrasonography, micturating cystourethrography, pediatric nephrology

INTRODUCTION

Urinary tract infection (UTI) is the most prevalent bacterial diseases in children¹. Common causes of UTI include vesicoureteral reflux (VUR), bladder-bowel dysfunction (BBD), congenital abnormalities of the kidneys and urinary tract (CAKUT), and the status of circumcision in young boys^{2,3,4}. Between 85% and 90% of UTIs are brought on by *Escherichia coli*. Additional typical microbes consist of *Klebsiella*, *Proteus*, *Enterococcus*, and *Enterobacter* species^{5,6,7}.

Boys have a higher prevalence of it (3.7%) in the first year of life compared to girls (2%) and beyond infancy, girls have a much higher prevalence^{8,9}. In girls, the incidence during prepubertal age is 3%, whereas in boys, it is 1%. Within the first six to twelve months following the initial UTI, there is a 12% to 30% chance of a recurrence^{10,11}. Timely identification and treatment of UTI are crucial in preventing both acute consequences and kidney scarring & its sequelae. Much research has been done on pediatric UTI in the past 2 decades, especially in the areas of renal imaging and long-term antibiotic prophylaxis following UTI.

One of common cases of bacterial infection in young infants is urinary tract infection (UTI). The developing kidneys may sustain long-term, irreversible damage if diagnosis and therapy are delayed. Hypertension, renal failure, and renal scarring are possible outcomes¹². 20% to 35% of children who are assessed for bacteriuria are thought to experience vesico-ureteral reflux. Following their first UTI, vesicoureteral reflux is diagnosed in over 60% of children under the age of one year¹³.

The traditional method of diagnosing vesico-ureteral reflux is micturating cystourethrography. Despite being a day care procedure, this one procedure has poor compliance, necessitates antibiotic coverage, requires extensive counseling, which requires painful catheterization and should only be done after recovering from a

febrile illness. On the other hand, these kids would greatly benefit from a method or investigative tool that, in the absence of an invasion, yields comparable or almost comparable results in the diagnosis of vesico-ureteral reflux with one tool of USG. Therefore, the goal of this study is to ascertain if ultrasonography should be employed in kids who have vesico-ureteral reflux-related urinary tract infections.

One of the most prevalent urinary tract abnormalities in children is vesicoureteral reflux (VUR), which is linked to reflux nephropathy¹⁴. To prevent the development of reflex nephropathy, it is especially crucial to check for VUR in infants who have hydronephrosis at the prenatal stage or recurrent febrile urinary tract infections¹⁵. The relationship between VUR and chronic nephropathy is still up for debate, though¹⁶. It is frequently advised that high-risk children be kept out of VUR, especially if they have hydronephrosis, kidney damage, or a complex urinary tract infection¹⁷.

Currently, radionuclide cystography (RNC) and retrograde voiding cystourethrogram with X-ray (VCUG)¹⁸ are the two procedures commonly employed to diagnose VUR. Due to their intermittent imaging and irradiation, both approaches have limited sensitivity¹⁹.

When a febrile urinary tract infection (UTI) first occurs, the goal of renal and bladder ultrasonography (RBUS) is to identify any anatomic abnormalities that need to be further evaluated (such as further imaging or urologic consultation). In order to track renal growth, RBUS also assesses the renal parenchyma and renal size²⁰. The clinical situation determines when to perform RBUS. Early on in an acute infection, RBUS may be misleading because, as animal studies have shown, dilatation brought on by an endotoxin from *Escherichia coli* during an acute infection might be mistaken for hydronephrosis, pyonephrosis, or obstruction²¹.

Need for the study:

Vesico-ureteral reflux is most common cause of febrile lower urinary tract infections in paediatric patients. The diagnosis is usually achieved by micturating cystourethrography, which is a invasive and painful procedure experienced by the these children. The use of ultrasonography with its doppler values, if can diagnose the presence of vesico-ureteral reflux will be helpful in diagnosing and then confirming with micturating cystourethrography and treating these children to prevent exacerbation and sequelae of urinary tract infection like pyelonephritis, urosepsis and renal abscess. The ultrasonography has also a regional importance here, as no study has been done in this part in state or country regarding the use of ultrasonography in diagnosis of vesico-ureteral reflux which can either be missed or diagnosed late with the fear of invasiveness of the procedure of micturating cystourethrography which is extensively practised in this regional setup.

AIMS & OBJECTIVES

1. To evaluate the accuracy of ultrasonography in predicting vesico-ureteral reflux cases diagnosed on micturating cystourethrography in paediatric patients.
2. To study the accuracy of ultrasonography in predicting the grade of vesico-ureteral reflux cases diagnosed on micturating cystourethrography in paediatric patients.

REVIEW OF LITERATURE

Background

The probability of permanent renal scarring, which can cause major aftereffects like hypertension, proteinuria, and end-stage renal disease, is assumed to be correlated with the severity of VUR. It is believed that interventions including surgical correction, antibiotic prophylaxis, and follow-up imaging lower the risk of these problems. Due to a dearth of data based on research, most practice guidelines now in use have concentrated on comprehending the pathophysiology of VUR and UTI. As the body of medical literature increases, the pediatric community is now questioning some of the long-held assumptions regarding the management of and role of imaging in UTI and VUR. In addition to discussing recent changes in practice patterns and highlighting some current challenges that may inspire future updates to suggested procedures, this paper will look at the pathophysiology and epidemiology of VUR and UTI.

Definitions of commonly used terms in UTI

Signs and symptoms

Febrile UTI

UTI associated with temperature $>38^{\circ}\text{C}$ (100.4°F)

Symptomatic UTI

UTI associated with fever and/or urinary symptoms

ABU (Asymptomatic bacteruria)

Significant bacteriuria in a child with no symptoms of UTI

Sterile pyuria

Increased white cells in urine in the absence of bacteria on urine culture

Bowel and bladder dysfunction

Spectrum of signs and symptoms, including incontinence, constipation and/or encopresis associated with functional and behavioural abnormalities of the bowel, lower urinary tract, and pelvic floor

Site of infection

Upper-tract UTI

UTI involving kidneys and ureters

Lower-tract UTI

UTI involving bladder and urethra but not upper tract

Pyelonephritis

Kidney infection (febrile UTI may or may not be due to pyelonephritis)

Cystitis

Bladder infection

Severity of infection

Simple UTI

UTI limited to lower urinary tract and with fever

Complicated UTI

UTI in newborns; abdominal and/or bladder mass; kidney and urinary tract anomalies; urosepsis; organism other than E coli; atypical clinical course, including absence of clinical response to antibiotic within 72 h; and renal abscess.

Complicated cystitis

Children with comorbid medical conditions, underlying bladder pathology, indwelling bladder catheter, and atypical clinical course.

Renal status

Reflux nephropathy

Renal cortical abnormalities associated with VUR (may be congenital dysplasia or acquired scarring)

Renal scarring

Acquired renal damage due to APN

Renal dysplasia

Congenital renal cortical abnormalities

Recurrent UTI

occurrence of 2 or more acute UTIs within months or 3 within a year

Concept of VUR

Definition

VUR is a condition marked by retrograde flow of accumulated urine in the bladder through one or both ureters back to the renal calyx or kidney (intra-renal reflux). This occurs when the protective mechanism against reflux is immature or fails due to anatomical or functional abnormalities.

Classification of VUR

When anatomical or functional congenital defects lead to an inadequate or immature preventative mechanism against reflux, primary VUR develops. Secondary VUR occurs when this preventative mechanism in the lower urinary tract is compromised by an organic obstruction and/or neurological malfunction (posterior urethral valve, anterior urethral valve, anterior urethral diverticulum, urethral hypoplasia, and neurogenic bladder)^{23, 24}.

Epidemiology

For girls and boys, respectively, the cumulative risk of UTI during childhood is 8% and 2%²⁵. Between 25% and 40% of children with UTIs are reported to have VUR²⁶. 50–91% of children with feverish UTIs have abnormalities on renal cortical scintigraphy, which suggests acute pyelonephritis (APN)²⁷. On the other hand, scintigraphy reveals renal cortical abnormalities in 79–86% of the kidneys when VUR is present²⁷.

While these figures demonstrate that VUR is a contributing factor to APN, Ditchfield et al.³² discovered that 53% of refluxing kidneys lacked any scintigraphy defect suggesting APN, while 61% of kidneys with evidence of APN on scintigraphy did not have VUR. Thus, it is common for VUR and APN to occur separately^{28,29}. 38–57% of children with APN identified by scintigraphy will experience irreversible skin scarring^{30, 31}. The frequency of APN on renal scintigraphy and the severity VUR grade were found to be correlated in a recent study by Oh et al³²; however, the risk that APN would result in permanent renal scarring was independent of the VUR grade.

Pathophysiology of VUR

The ureteral orifice is reached by the distal ureter running obliquely through the bladder wall (Fig. 1). Urine cannot flow retrogradely into the distal ureter when the bladder expands with pee because of increased compression of the intramural and submucosal portion of the ureter. The length of the distal ureteral, which is located inside the bladder wall, determines how well this valvular function works; a shorter intramural–submucosal segment raises the risk of VUR. In children, the usual length of the intramural–submucosal segment ranges from 7 to 12 mm³³ and has a ratio of

5:1 (length:diameter) at vesicoureteric junction, is called as pollitano's rule. This length fluctuates with age. In order to extend the intra mural–submucosal segment, ureteral reimplantation surgery for VUR aims to tune a more angled ureteral path through the bladder wall.

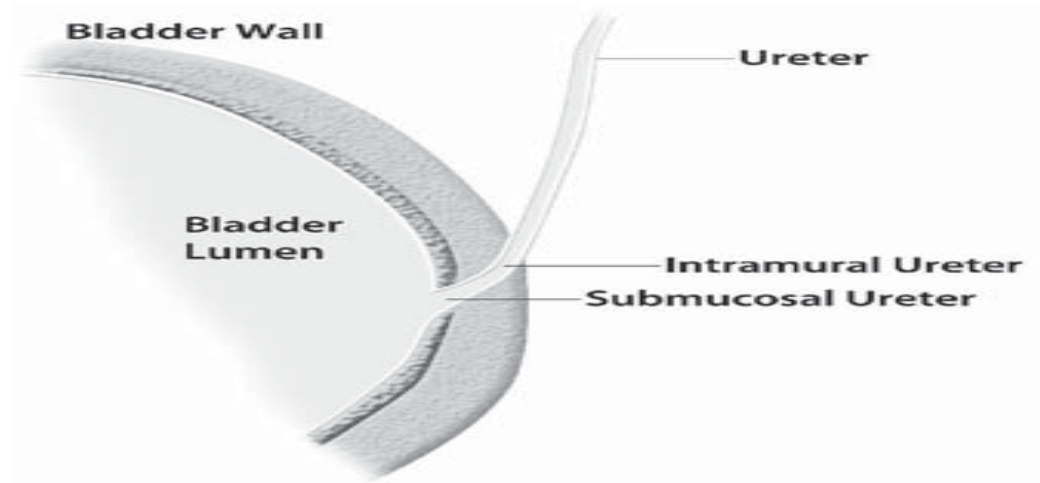


Fig. 1—Drawing shows pathophysiology of vesico-ureteral reflux (VUR). Shorter intramural–submucosal segment of distal ureter increases likelihood of VUR.

Pathophysiology of Pyelonephritis and Renal Scarring

Instead of hematogenous spread, ascending bacterial infections in the urinary system are typically the cause of pyelonephritis. Urine in the renal pelvis is more susceptible to infection due to VUR and urinary stasis (Fig. 2). The renal parenchyma can then become infected with bacteria, which causes swelling and inflammation. Compression of the parenchymal microvasculature might result in necrosis, microabscess development, and ischemia. Loss of parenchymal volume and function as well as persistent renal scarring may occur if the renal parenchyma is unable to heal from these wounds. The preferred imaging method for identifying APN and renal scarring is renal cortical scintigraphy with ^{99m}Tc -dimercaptosuccinic acid (DMSA)

due to its high sensitivity³⁴; both entities show up as photopenic defects on DMSA scans, and the interpreting physician must rely on the clinical time-course to differentiate between the two.

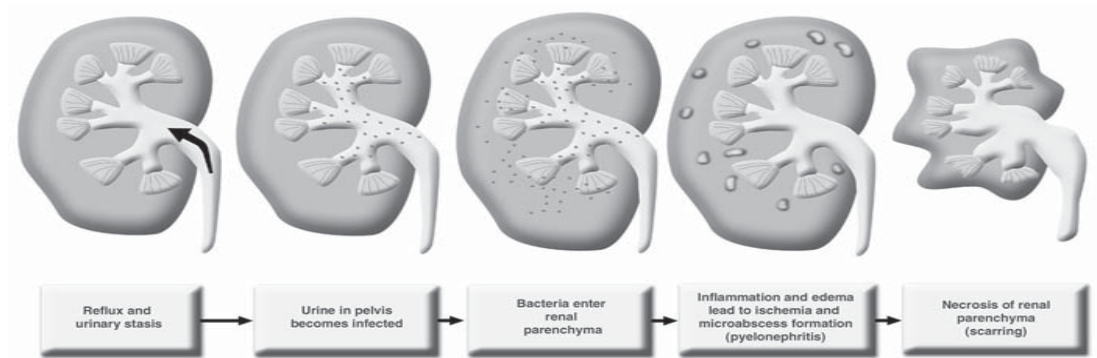


Fig. 2—Drawing shows pathophysiology of pyelonephritis and renal scarring. Ascending urinary infection allows bacteria to enter renal parenchyma. Inflammatory edema causes compression of parenchymal microvasculature that can result in ischemia, microabscess formation, necrosis, and permanent renal scarring.

Settings of diagnosis (patients with suspected VUR)

VUR is frequently diagnosed in UTI patients²⁸. Additionally, due to the increased prevalence of VUR discovered during screening in children with fetal hydronephrosis identified by ultrasound, thorough examinations for familial VUR and baby health checks using ultrasound are now becoming more common. When examining patients with BBD for voiding and/or storage symptoms, VUR is found. When proteinuria or kidney failure symptoms are discovered during school health exams, VUR is identified in patients with advanced renal dysfunction.

Basic Assessment

The basic assessment must include taking a history, doing a physical examination, doing a urine test, and doing an ultrasound. Having a complete family history is especially crucial due to the possibility of familial VUR. In young children, fever is frequently the sole observable sign of a UTI; symptoms of urgency, frequency, dysuria, and stomach pain may occur only after the kid has finished potty training and is verbally able to communicate. If the kid is able to communicate the need to urinate, midstream urine can be collected; however, younger children, regardless of gender, will have their clean-catch urine collected using a urine collection pack. Pyuria (urinary white blood cell count ≥ 10 /high-power field) and/or bacteriuria will be used to diagnose UTIs. When measured by culture, a bacterial count of $\geq 10^5$ cfu/mL accurately indicates the causative organism.

Upper urinary tract dilatation shown on ultrasounds may be a sign of VUR, and aberrant bladder wall morphology or hyperplasia may indicate voiding dysfunction linked to VUR. With upper urinary tract dilatation associated with SFU grade 3 or 4 hydronephrosis, the presence of VUR should therefore be assessed via VCUG. Though the chance of VUR cannot be completely ruled out, significant urinary tract deformity is unlikely if postnatal ultrasonography does not reveal hydronephrosis. Even though the hydronephrosis has cleared in newborns with antenatally diagnosed fetal hydronephrosis, the occurrence of fUTI should raise suspicions for VCUG^{35,36}.

STANDARD RADIOLOGICAL STUDIES

An voiding cystourethrography (VCUG) and conventional imaging investigations were initially performed on children who presented with UTIs. The relatively noninvasive ultrasonography has progressively replaced the IVP as the preferred anatomical study over time. However, vesicoureteral reflux cannot be diagnosed with ultrasound alone since it lacks specificity and sensitivity³⁷. The majority of doctors agree that it is a suitable screening test to rule out significant abnormalities, despite some research suggesting that it is of limited value³⁸. High-quality ultrasounds can detect serious congenital abnormalities; if prenatal readings are normal, the yield of a subsequent ultrasound may be poor. These ultrasounds are typically performed in the last trimester of pregnancy. Since the 1960s, the VCUG has been routinely utilized. It can be carried out either with a radionuclide or as a regular contrast examination.

In general, the contrast study is preferred for the initial investigation because it provides more anatomic detail; however, some investigations have indicated that the radionuclide cystogram has a higher sensitivity³⁹. Although opinions on when to conduct a VCUG study vary, it is widely agreed that the investigation can begin as soon as the kid is afebrile and has a negative urine culture⁴⁵. Additionally, it seems that compliance improves when the VCUG is carried very quickly following a UTI⁴⁶. There's no denying that the VCUG is a highly reliable reflux detector, even though no test is flawless. However, considering the paucity of data demonstrating the advantages of prophylactic antibiotic use, concerns have been expressed regarding whether routine work-up with VCUG is the appropriate course of action to enhance long-term results^{42,43}.

Evolution of Imaging Practice Patterns

The American Academy of Pediatrics (AAP) set practice guidelines in 1999 that directed medical professionals in the assessment of urinary tract infections (UTIs) in infants and children for a long time⁴⁴. The guidelines for the imaging workup were extensive, including radionuclide cystography (RNC) (Fig. 5) and voiding cystourethrography (VCUG) (Fig. 4) or ultrasound (Fig. 3) for all newborns and young children (< 2 years old) with UTI. According to the AAP, there is still uncertainty regarding the function of renal cortical scintigraphy with 99mTc-DMSA (Fig. 3).

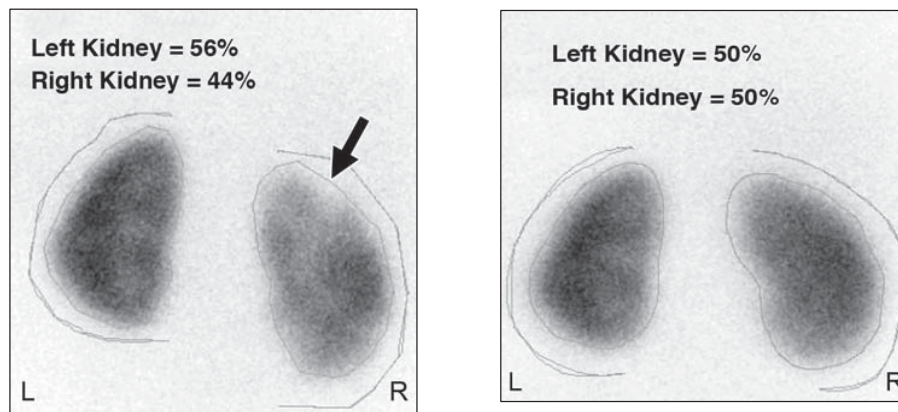
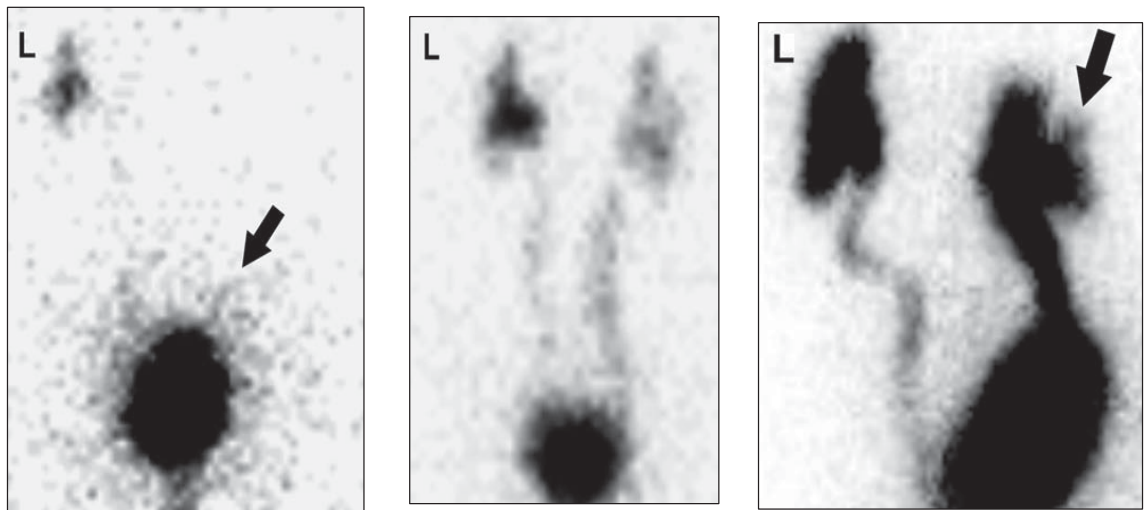


Fig. 3—2 year old girl with fever. A and B, Grayscale (A) and color Doppler (B) ultrasound images show round, hypoechoic, poorly perfused abnormality (arrow) in upper pole of right kidney, consistent with acute pyelonephritis. C and D, Dimercaptosuccinic acid (DMSA) renal cortical scintigraphy scan obtained same day as ultrasound (C) shows corresponding photopenic defect (arrow). Followup DMSA scan obtained 8 months later (D) shows resolution of defect, consistent with recovered pyelonephritis.



A **B** **C** **D** **E**

Fig. 4—Voiding cystourethrography (VCUG) images.



A **B** **C**

Fig. 5—Radionuclide cystography (RNC) performed in three different patients with bilateral vesicoureteral reflux (VUR). L = left side of patient. A, In RNC image in 15yearold girl, left reflux reaches renal pelvis. Very subtle right reflux only reaches distal ureter (arrow). B, In RNC image in 16yearold girl, bilateral VUR reaches renal pelvis. C, RNC image in 13year old boy shows bilateral VUR with tortuosity of both ureters and marked dilatation of right renal pelvis and ureter (arrow).

Following UTI treatment, the American Academy of Family Physicians advised DMSA scanning to check for irreversible renal scarring⁴⁵ (Fig. 6). The "bottom-up" method refers to this imaging algorithm and its variations, since the primary diagnostic issue is VUR detection. Following a diagnosis of VUR, the patient is considered to be at heightened risk for renal scarring. To identify any permanent renal scarring, DMSA scanning is conducted many months later. The corpus of research-based literature and the breadth of medical professionals' experience in treating juvenile UTIs have both increased since the 1999 recommendations.

Consequently, there has been a slow retreat from the AAP standards, leading to an abundance of more complex imaging algorithms that vary among different medical professionals, practice groups, towns, nations, and continents. Just 61% of respondents to a recent Shah et al.⁴⁶ survey reported following the AAP imaging standards. A few typical deviations include, particularly in females, delaying imaging workup until the second UTI and varying the frequency and timing of DMSA scanning. The 2007 European Society of Pediatric Radiology recommendations⁴⁷ represent the most notable change in practice guidelines (Fig. 6).

All pediatric UTI patients are subjected to an ultrasound examination according on this strategy. If the ultrasound results are normal and there is a clinical suspicion of APN, early DMSA screening is carried out as soon as the infection becomes acute. If the DMSA scan reveals APN, VCUG or RNC testing is then carried out to check for VUR⁴⁸.

Normal results from DMSA scanning prevent VCUG or RNC later on. The term "top-down" technique refers to this inversion of the order in which DMSA scanning and cystography are performed, since APN, not VUR, is the main diagnostic

concern. These latest guidelines are justified by the fact that only 47% of VUR is severe enough to result in acute pneumonia.

Early identification of babies and children who are at risk of permanent renal scarring is an important clinical goal in order to prevent catastrophic long-term consequences including hypertension and renal failure. When determining who is at risk for renal scarring, DMSA renal scintigraphy detection of APN may be a more appropriate and sensitive screening method than VCUG or RNC.

A significant constraint associated with ^{99m}Tc-DMSA renal scintigraphy pertains to the radiopharmaceutical's accessibility. Due to sporadic shortages brought on by technical production issues, there are relatively few commercial facilities globally that produce DMSA reagent kits and ^{99m}Tc generators.

RBUS, VCUG and ^{99m}Tc-DMSA renal scintigraphy were used.

RBUS:

It is possible to diagnose urinary tract malformations with accuracy, including hydronephrosis, hypoplastic kidney, duplicated ureters, megaloureters, and ureterocele. This modality's ease of use and little invasiveness make it beneficial. Pyelectasis, aberrant echogenicity, variations in renal dimensions between the right and left kidney, ureterocele, uneven shape and dilatation of the lower ureters at the dorsal part of the bladder are examples of ultrasound findings that are significant because they may be risk factors for urinary tract infections. In 46–60% of patients with VUR identified by VCUG⁴⁹, ultrasound screening revealed no abnormalities.

Based on the presence or lack of ultrasound abnormalities, the diagnosis of VUR is not very accurate; the sensitivity is 18–46%, the specificity is 76–88%, the positive predictive value is 24–66%, and the negative predictive value is 71–83%.

For all young children experiencing their first feverish UTI as well as older children experiencing recurring UTIs, a renal ultrasonography evaluation is recommended. It is necessary to do renal and bladder ultrasonography to look for structural or anatomical abnormalities²¹. The clinical scenario determines when to perform an ultrasonographic evaluation.

Children who are really unwell or who do not get better as soon as they should (typically within 12 to 36 hours) should have ultrasonography within the first few days to rule out obstructive anatomic abnormalities or renal abscess. Kids with less severe illnesses can have USG once the acute phase of the virus has gone in order to avoid false positive results from kidney inflammation, which can persist till 1 – 2 weeks.

- The most widely used technique to assess for anatomic abnormalities such as duplication, dilatation, and blockage in the genitourinary tract; non-invasive, reasonably priced, and safe in any age range.
- NICE guidelines: In children younger than six months old or older than six months old with an unusual or recurrent UTI, recommend RBUS following the first febrile UTI. AAP guidelines: After a child's first febrile UTI, recommend RBUS for ages 2 to 24 months⁵⁰.

Grade	Ultrasonography classification of vesicoureteral reflux ⁵¹
I	Reflux of urine into the distal ureter
II	Reflux (+) and upper and lower ureteral filling
III	Reflux (+) with mild dilatation of the ureter and pelvicalyceal system
IV	Reflux (+) with moderate dilatation of the ureter and pelvicalyceal system
V	Reflux (+) with massive dilatation of the ureter and pelvicalyceal system

VCUG:

A common imaging test used to diagnose VUR is called VCUG. It provides comprehensive anatomical data that allows for the determination of the international classification's severity grade in addition to the presence or absence of VUR. In order to diagnose VUR and examine the lower urinary tract, VCUG is necessary⁵²⁻⁵⁵.

Voiding Cystourethrography:

The standard diagnostic method for vesicoureteral reflux (VUR) is a voiding cystourethrogram (VCUG), which helps establish the existence and severity of VUR. Routine VCUG after the initial UTI²¹ is not recommended. It should only be considered in cases of recurrent feverish urinary tract infection (UTI) or when hydroureter, hydronephrosis or scarring are seen on RBUS.

If the pathogen is unusual or the clinical situation is complex, it might be taken into consideration following the initial UTI⁵⁶.

If ureteral dilatation is seen on postnatal ultrasonography, if there is moderate to severe hydronephrosis, or if there are bladder abnormalities suggesting bladder outlet obstruction, a VCUG is recommended for newborns with a history of antenatal

hydronephrosis. Routine VCUG may not be necessary following a first febrile UTI due to its intrusive nature, cost, discomfort, potential for UTI, and radiation risks.

In order to identify individuals with VUR, this test should be taken into consideration in cases with recurrent UTI and upper tract abnormalities on ultrasound.

VUR is graded as low-grade (I-III) and high-grade (IV-V). The International Reflux study group classifies VUR into 5 grades as follows⁵⁷:

- Grade I: Reflux into the distal and middle of the ureter without dilation
- Grade II: Reflux into the ureter and collecting system without dilation
- Grade III: Reflux into the ureter and collecting system with mild dilation and mild blunting of calyces
- Grade IV: Reflux into the ureter and collecting system with gross dilation and severe blunting of calyces
- Grade V: Massive reflux with gross dilation of ureter and collecting system, blunting of all calyces, and tortuosity of the entire collecting system with loss of fornices and papillary impressions

Contrast-Enhanced Voiding Urosonogram:

An option called a contrast-enhanced voiding urosonogram (ceVUS) has been proposed to reduce radiation exposure in children requiring VCUG. Bladder catheterization is necessary for this test, which is not comfortable for younger patients. When the patient is being checked ultrasonically, they will be instructed to void and given an infusion of contrast material.

False-negative outcomes are reported by 3% of patients. Even though ceVUS isn't available in every facility, doctors should use it to diagnose obstructive uropathies and VUR in real time without radiation exposure^{56,57}.

- The most widely used technique to assess for VUR is intrusive, costly, and radiation-exposed to patients.

99mTc-DMSA renal scintigraphy:

Renal parenchymal damage can be diagnosed by 99mTc-DMSA renal scintigraphy, which is also a useful test for evaluating divided renal function and renal scarring in VUR patients.

- This procedure is costly, time-consuming, invasive, and radiation-exposed for patients. However, it can reveal details on the degree of renal inflammation and scarring.
- Children on VCUG who have acute DMSA alterations are more likely to develop VUR grades III–V.
- DMSA should not be used in the regular evaluation of a child's first febrile UTI, according to both NICE and AAP guidelines.
- There is ongoing debate on the usefulness of DMSA in assessing clinically severe renal scarring that results from infection.
- AAP guidelines did not include the use of DMSA in their recommendations⁵⁰.
- NICE guidelines: Recommend DMSA 4-6 months after:
 - Atypical or recurring infection in children under 3 years of age.
 - Recurring infection in children over 3 years of age.

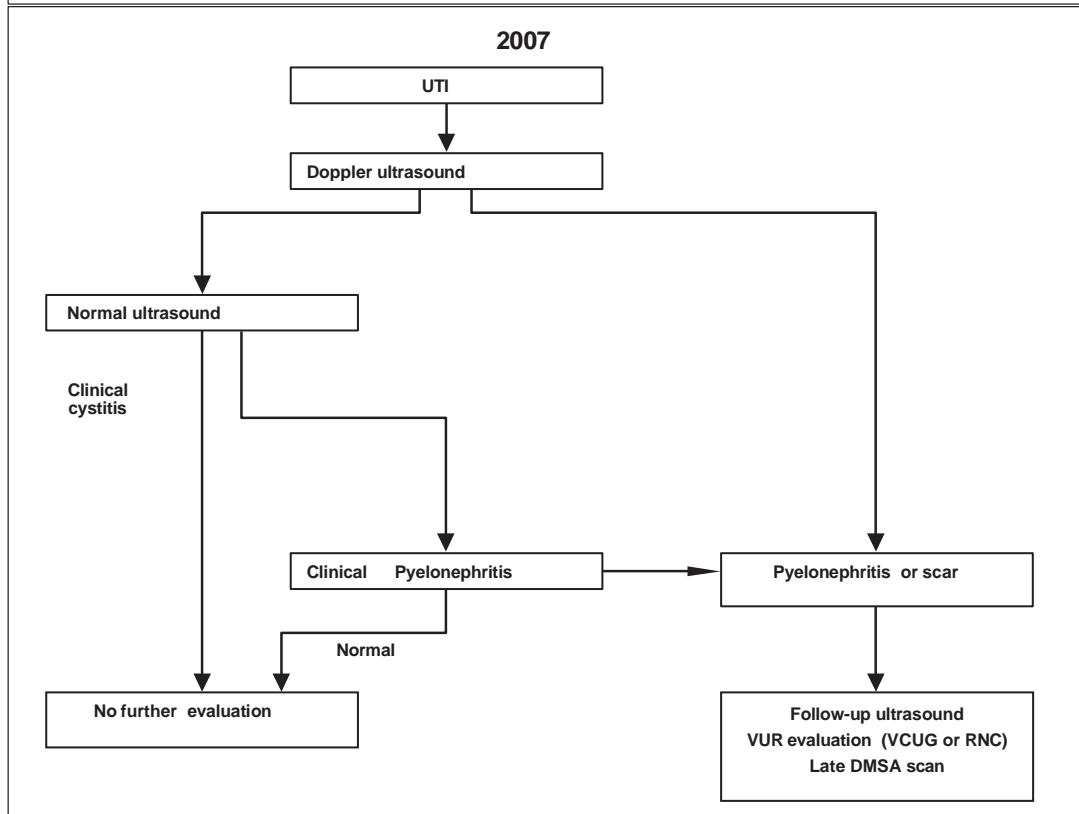
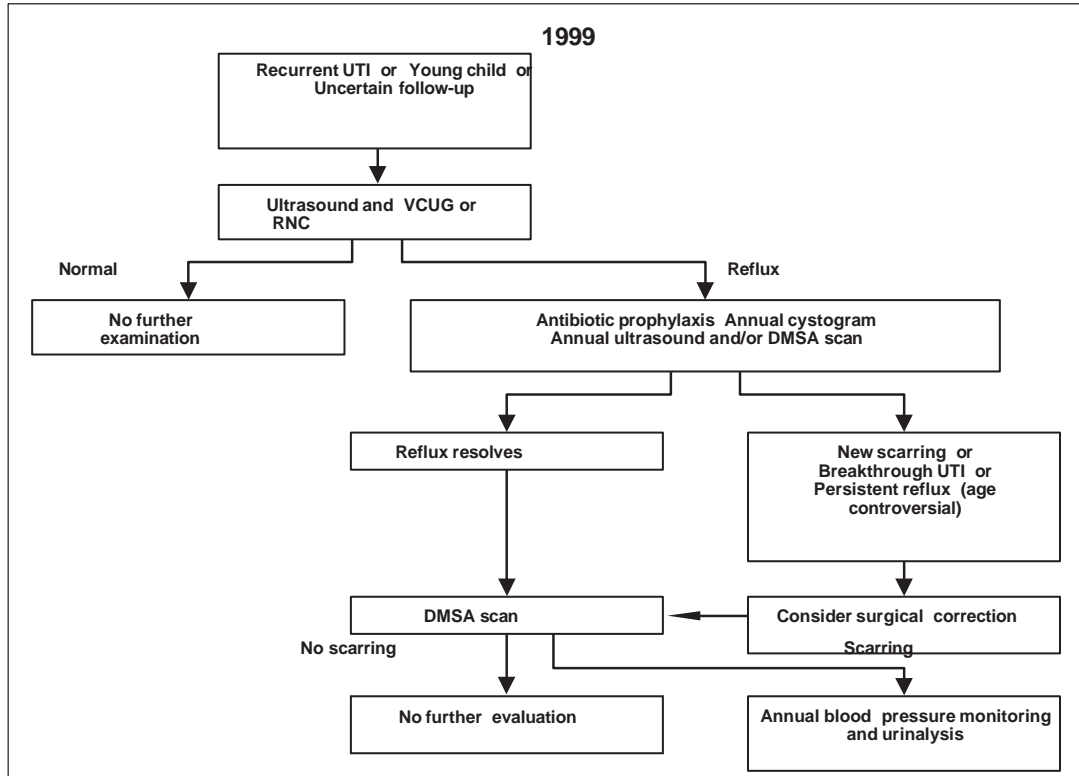


Fig. 6—Diagrams show evolution of practice guidelines for urinary tract infection (UTI) and vesicoureteral reflux (VUR).

A, In 1999, “bottomup” approach was advocated: performing voiding cystourethrography (VCUG) or radionuclide cystography (RNC) first, followed several months later by ^{99m}Tc dimercaptosuccinic acid (DMSA) renal cortical scintigraphy to evaluate for renal scarring. (Adapted with permission from⁴⁵).

B, In 2007, “topdown” approach was recommended: performing DMSA renal cortical scintigraphy first to evaluate for acute pyelonephritis, followed by VCUG if DMSA scanning findings are abnormal. (Adapted with permission from⁴⁷).

Review of Studies:

In 2020, Zamir G comprised all children aged 0–5 who had spent two years in a medium-sized institutional regional medical center for a first uncomplicated febrile UTI.

Children who were known to have anomalies in their urine or who had received antibiotic treatment within seven days prior to admission were not allowed to enter. During their hospital stay, all of the enrolled children had renal ultrasonography and within two to six months, voiding cystourethrography (VCUG). The test's yield was evaluated using its ability to detect renal abnormalities, as well as its sensitivity, specificity, positive and negative predictive values for the identification of vesicoureteral reflux (VUR), and its impact on the treatment of urinary tract infections (UTIs). Of the 255 children involved in the study, only nine exhibited VUR on VCUG, but 33 of them had mild to severe renal pelvis dilatation on RUS, which was indicative of VUR. However, the RUS was normal in 36 children with VUR on VCUG. When it came to identifying VUR, aberrant RUS's sensitivity, specificity, positive predictive value, and negative predictive value were, respectively, 17.7%, 87.6%, 23.5%, and 83.2%. It was not need to alter the management of any of the patients with abnormal RUS during or after their hospital stay. The data suggest that there is doubt about the effectiveness of RUS in treating children who are experiencing their first uncomplicated UTI⁶⁵.

A retrospective assessment of the ultrasound and voiding cystourethrogram (VCUG) results of 162 children under the age of five who were admitted for the first time within a two-year period due to a urinary tract infection (UTI) was carried out by Mahant S et al in 2003. If there was "dilatation of the collecting system" of one or both kidneys, "dilatation of the ureters," or "dilatation of the pelvi-calyces," the

ultrasound results were thought to be suggestive of VUR. A total of 162 patients, with a median age of 85 days and 71 (44%) females, met the inclusion criteria. Twenty-two percent of people had VUR. Thirty-seven out of the 127 patients without VUR on VCUG had positive ultrasound results for VUR, and 14 out of the 35 patients with confirmed VUR on VCUG had positive results. 14 individuals had grade II reflux, 5 had grade III reflux, and 2 had grade IV reflux out of the 21 patients who had a normal ultrasound but had VUR on VCUG. When it came to indicating VUR, ultrasound's sensitivity and specificity were 40% and 76%, respectively. Ultrasonography had a 32% positive predictive value and an 82% negative predictive value when it came to predicting VUR. In children with a first UTI, renal ultrasonography results are not sensitive nor specific for VUR⁵³.

In 2010, Leory S. et al. conducted a prospective hospital-based cohort research comprising children who had urinary tract infections (UTIs). The study received permission from the institutional review board and parental agreement was acquired. Analysis and comparison were done on renal length, ureteral dilatation, pelvic dilatation, and corticomedullary differentiation. There were seventeen patients total, consisting of 71 females and 46 (or 39%) boys. The data were analyzed using a two-level logistic regression model, and computations of diagnostic accuracy were made. Of the youngsters, eight (7%) had VUR of grade 3 or higher, and thirty-two (27%) had all-grade VUR. With 25% sensitivity and 88% specificity, ureteral dilatation was the only factor that was substantially correlated with all-grade VUR.

Significantly, dilatations of the urinary tract, pelvis, and ureter were linked to VUR of grade 3 or above (ORs of 20.2, 13.7, and 20.0, respectively). The ureteral dilatation criterion, which showed 73% sensitivity and 88% specificity for high-grade VUR, was the best balance between sensitivity and specificity. Additionally, they

came to the conclusion that uretral dilatation might provide the most accurate US-based diagnosis of high-grade and all-grade VUR. This US criterion may be used in an evidence-based selective strategy to limit cystography in children with UTIs, possibly in conjunction with other predictors⁶¹.

Nelson CP et al. (2014) examined 3995 clinical visits that had VCUG and RBUS tests for a history of UTI, spanning from January 1, 2006, to December 31, 2010. Patients with a history of prenatal hydronephrosis or postnatal genitourinary imaging in the past were not accepted. The RBUS's predictive values, specificity, and sensitivity for VCUG abnormalities were established. They found 2259 individuals younger than 60 months old for whom imaging was indicated due to a UTI. "Normal" RBUS was recorded in 75% of cases. 41.7% of patients with VCUG had any vesicoureteral reflux (VUR), 20.9% had VUR grade >II, and 2.8% had VUR grade >III. The range of RBUS sensitivity for any aberrant results on VCUG was 5% to 28%. The range of sensitivity for VUR grade >III was 18% to 55%. The positive predictive value of RBUS was 37% to 47% for VUR grade >II among the 1203 children ages 2 to 24 months who were scanned following their first febrile UTI; the negative predictive value was 72% to 74% for VUR grade >II. They came to the additional conclusion that RBUS is a subpar genitourinary abnormality screening test. It is appropriate to see RBUS and VCUG as complementary since they offer distinct but equally significant information⁶².

A study by Kovanlikaya A et al. (2014) involved 134 infants born between January 2005 and December 2012 who had voiding cystourethrography (VCU) evidence of VUR and who also had recurrent bladder infections (RBU) within a month of the VCU. On RBU and VCU, standard methods were employed to grade hydronephrosis and VUR. Using MCU' findings of, reflex as the gold standard,

diagnostic accuracy assessments including sensitivity, specificity, PPV and NPV were performed for HUN and ureteral visibility on USG. There was a strong correlation between reflux grade and the degree of HN. Ultrasonography's sensitivity, NPV, and accuracy were much higher when predicting reflux for grades more than IV reflux than when predicting reflux for lower reflux grades.

Furthermore, ultrasonography demonstrated a high and constant specificity for reflux prediction across all the reflux grade, suggests it can be a valuable tool for screening. Additionally, they concluded that normal USG is unusual for reflux grades IV to V and moderate to severe hydronephrosis is uncommon with reflux less than grade IV. USG is good test to figure out who with a first-time UTI needs to get VCU. Aberrant USG is defined by the Society for Fetal Urology classification⁶³ as including all levels of hydronephrosis.

In a 2015 study, Park HW, et al. included 917 children who were hospitalized at our facility between January 2001 and October 2010 due to a febrile UTI episode for the first time. RBUS was performed on every child upon admission. The follow-up period averaged 7.9 months. The rates of UTI recurrence were computed using a variety of clinical factors.

Using bivariate and multiple logistic regression models, they examined the possible predictive value of age, sex, aberrant renal USG results, abnormal DMSA kidney scan points, or renal USG findings parameters for urinary tract infection recurrence, higher-grade VUR, or renal scarring. Congenital kidney and urinary tract abnormalities, as well as hydronephrosis, were significant predictors of recurrent UTIs on RBUS.

Their odds ratios are, nevertheless, lower than those of typical RBUS results. There were no RBUS results that strongly predicted aRS. High grade VUR, aberrant

RBUS results, and recurrent UTIs all strongly indicated aRS. According to this study, RBUS is helpful in determining if severe congenital RS, obstructive uropathy, and kidney abscess should be ruled out following the first incidence of a feverish UTI⁶⁴.

In 2015, Hung TW carried out a study wherein hospitalized children who were younger than two years old and had experienced their first febrile UTI were prospectively assessed through imaging studies such as US, voiding cystourethrography, and a (99m)Tc dimercaptosuccinic acid (DMSA) scan. 105 (33.9%) of the 310 kids examined—195 boys and 115 girls—had aberrant US. 194 children (62.6%) had abnormal acute DMSA scans, of which 89 (45.9%) also had concurrently abnormal US. 107 children (34.5%) had VUR, of which 79 (25.5%) had VUR in Grades III–V. Of the 85 children with RS (27.4%), 55 (64.7%) had abnormal US. Thirty-three (31.4%) of the 105 children with abnormal US required further therapy, which included surgical intervention, parental counseling, or renal function monitoring. RS risk factors were Grades III–V VUR and nephromegaly on the baseline US examination. They came to the conclusion that abnormal US could be associated with a high risk of Grades III–V VUR and renal scarring and could have an impact on many children's future care. Nephromegaly on the first ultrasonogram and Grades III–V VUR are highly correlated together a higher chance of developing RS. As a result, children who have had their first febrile UTI should have US performed, and those who have a normal US may not need voiding cystourethrography⁶⁵.

In a study published in 2018, Zhang W found that between August 2016 and October 2017, ninety children who were at risk of VUR were hospitalized to the Tongji Hospital's Pediatric Nephrology Department and had CeVUS. One milliliter of the SonoVue second-generation USA contrast agent was injected intravenously with a trans urethral bladder catheter. Adverse event incidence was seen. Culture and

analysis of urine were done. In order to screen for VUR, a total of 90 youngsters (47 females and 43 males; mean age, 36.6 months) with 178 Pelvi-Ureteral Units (PUUs) had CeVUS procedures. 64/178 PUUs (36.52%) and 44/90 pediatric patients (48.89%) have VUR found by CeVUS.

The 65 PUUs with VUS were distributed into the following grades: Grade I, 3, Grade II, 9, Grade III, 14, Grade IV, 22, and Grade V, 17. The current study's CeVUS accuracy was in line with earlier findings. Adverse events and urethral abnormalities were not observed. It has been shown that CeVUS is a secure, accurate, and dependable imaging method for identifying VUR in children, especially newborns, who are at high risk. The current study's findings indicate that CeVUS can be used in China as the main screening and follow-up technique for pediatric VUR diagnoses⁶⁶.

In 2020, Salib, A. et al. observed When screening adult patients with complex UTIs or recurrent pyelonephritis, urologists should have an index of suspicion for VUR because the true frequency of the condition in this population is yet unknown. Adult VUR patients with recurrent pyelonephritis have been successfully treated endoscopically in a number of case series and smaller retrospective investigations. Adult patients who do not respond to endoscopic treatment for vein transplant rejection may still consider venereal reimplantation. Because there is a dearth of evidence, the current recommendations and treatments for VUR in adults have been extrapolated from the pediatric population. Since VUR is rare in the adult population, a clinician must have a high degree of suspicion. Patients can avoid hospitalization, recurring infections, and the need for repeated antibiotic use when VUR is accurately diagnosed and treated⁶⁷.

In this cohort study, 380 patients' kidneys were investigated by Dogan GM et al. in 2022. Three age categories were used to group the patients: 0-2, 3-5, and 6-17 years old. Anteroposterior renal pelvic diameter (APRPD), kidney parenchyma, kidney size, and ureter size were all reported in US studies. APRPD is considered pathogenic when it is >5 mm or >10 mm. The sensitivity, specificity, PPV, and NPV were assessed individually for all age groups under two conditions. In every age group, a correlation was discovered between the VCUG and US results (sensitivity, specificity, and NPV of the US were, respectively, 86.99%, 60.26%, and 88.13%). Conversely, sensitivity, specificity, and NPV were 79.45%, 79.91%, and 71.17%, respectively, when pathologic APRPD was greater than 10 mm. The US age group of 0–2 had the highest sensitivity and NPV. This study found that US will help VCUG diagnose VUR if it is carried out by radiologists skilled in the pediatric urinary system and if it adds additional parameters with APRPD. As a result, radiation exposure in clinical practice can be reduced⁶⁸.

In 2023, Sharifiaghdas F. et al. Participants in this retrospective analysis were younger than 12 years old who had received both a DMSA scan and a VCUG scan at our institution between 2005 and 2020 and were diagnosed with their first febrile UTI. 208 patients in all (mean age 3.34 ± 2.54 years; 59/149 males and females) were enrolled. On VCUG, VUR was found in 261 out of 416 renal units (62.7%).

The DMSA scan's sensitivity, specificity, PPV, and NPV for identifying VUR were 52%, 75%, 78%, and 48%, respectively. Following age subgroup analysis, 50 patients (M/F: 8/42) and 158 patients (M/F: 51/107) were older than 4 years. Using a DMSA scan, the PPV and NPV for predicting VUR were 85.6% and 46.3% for patients under 4 years old, and 55.5% and 56.2% for those over 4 years old. The study's findings demonstrated that, in comparison to VCUG, the DMSA scan is not as

accurate in predicting VUR since it fails to identify a significant number of patients who have high-grade VUR when used in isolation for the initial evaluation of children with a febrile UTI⁶⁹.

Patients between the ages of two months and two years who were examined in a tertiary pediatric hospital over a two-year period who were diagnosed with UTI were included in a study done in 2023 by Aydin O et al. In compliance with the standards set forth by the American Academy of Pediatrics (AAP), RBUS and voiding cystourethrography (VCUG) were conducted. Subsequently, they reviewed our records and assessed the frequency of kidney issues discovered when we limited RBUS testing to individuals with an unusual cause of their initial UTI or multiple UTIs. This investigation comprised 128 patients who had UTIs monitored throughout time. In 104 cases (58.5%), the identified pathogen was E. Coli, and in 74 cases (41.6%), it was unusual. Thirty patients underwent VCUG, of whom sixteen had vesicoureteral reflux (VUR) and one had PUJ obstruction. Only two serious kidney abnormalities would have been overlooked by a different diagnostic strategy that required the presence of an unusual pathogen at the initial UTI or a fUTI recurrence in order to perform the RBUS. It was noted that RBUS might drop by 40.4% and VCUG might drop by at least 20%⁷⁰.

Study participants with suspected UTIs were assessed for APN using ultrasound between March 2019 and January 2021 in a study led by Lee HB in 2023. Changes in renal pelvis dilatation, parenchymal echogenicity, and the presence of a focal suspected lesion were assessed by conventional grayscale ultrasonography. The location and existence of a decreased perfusion area were evaluated by color Doppler ultrasonography (CDUS) and CEUS. The agreement between each ultrasonic

examination and a ^{99m}Tc -dimercaptosuccinic acid (DMSA) scan was assessed using the κ value. To assess the lesion's most evident time, CEUS was utilized.

In this study, twenty-one individuals with isolated urinary tract infections were enrolled; their ages ranged from 2.0 to 61.0 months, with 8.0 months being the median. While fourteen renal pelvic dilatations (33.3%) and five increased parenchymal echotextures (11.9%) were confirmed, grayscale imaging did not show any localized lesions. On CDUS and CEUS, lower local perfusion indicative of APN was seen in two and five kidneys, respectively. While there was a substantial level of agreement ($\kappa = 0.80$, $P = 0.010$) between the results of the DMSA scan and CEUS, there was a lack of agreement ($P > 0.05$) between the results of the other grayscale and CDUS tests. The late parenchymal phase on CEUS provided the finest view of all lesions. without being sedated or exposed to radiation

CEUS can identify renal perfusion abnormalities in pediatric patients with suspected APN; as a result, it may be a useful and practical diagnostic method⁷¹.

Updated, evidence-based clinical practice guidelines for the therapy of primary vesicoureteric reflux (VUR) and urinary tract infections (UTI) in children are presented by Hari P et al in 2024 on behalf of the Indian Society of Pediatric Nephrology (ISPN). These guidelines meet international standards; openness, rigor, and thoroughness in the guideline creation were ensured by using checklists from the Institute of Medicine and AGREE. These guidelines are relevant worldwide for the management of VUR and UTI due to the rigorous methodology. There are seventeen suggestions and eighteen clinical practice points developed. The following are some of the main suggestions and guidelines. If there is a high clinical suspicion of UTI in a newborn, a urine culture with more than 10^4 colony forming units/mL is considered relevant for the diagnosis of the condition. When a child has a suspected UTI, urine

leukocyte esterase and nitrite testing can be performed as a substitute screening test for urine microscopy. For seven to ten days, an infant who is not toxic can be treated with oral antibiotics for acute pyelonephritis. It is not advised to perform an acute-phase DMSA scan when evaluating a UTI. Micturating cystourethrography (MCU) is recommended for individuals under 2 years old with non-E. coli UTIs, recurrent UTIs in children, and abnormal kidney ultrasonography. The use of dimercaptosuccinic acid scanning (DMSA scanning) is limited to children who have high-grade (3–5) VUR and recurrent UTIs. In children who recover from a UTI and have a normal urinary tract, prophylaxis with antibiotics is not recommended. In kids with higher grade VUR and bladder-bowel dysfunction (BBD), prophylaxis is advised to prevent UTI. If a child with VUR is potty trained, free of BBD, and hasn't had a UTI in the previous year, prophylaxis should be discontinued. When a kid develops recurrent breakthrough febrile UTIs while receiving antibiotic prophylaxis, parents may choose for surgical surgery in high-grade VUR⁷².

MATERIALS AND METHODS

Source of Data:

Patients visiting to the paediatric & paediatric surgery OPD, admitted in paediatric & paediatric surgery ward and referred to radiology department of KLEs Dr.Prabhakar Kore Hospital and MRC. The patients with the diagnosis of vesico-ureteral reflux by micturating cystourethrography were counseled and subjected to ultrasonography during the 1 year period from January 2023 to December 2023.

Study Design:

Prospective cross-sectional study

Study Period:

January 2023 to December 2023

Sample Size:

The minimum sample size formula based on prevalence rate is $n = Z\alpha^2(1-P)/d^2$ Where P is the percentage of prevalence and d is the percentage likely difference in the prevalence. $Z\alpha$ is linked with the level of significance. For 5% level of the significance $Z\alpha$ 1.96. Ref: With P 60% and d= 15% of P= 9%, the sample size is 40.97. This sample size will be raised to 42.

Sampling technique:

Purposive sampling. Patients of age 2 months to 12 years with diagnosis of urinary tract infection will be included in the study.

Inclusion Criteria:

- Patients of age 2 months to 12 years of both the sexes
- Clinically diagnosed cases of urinary tract infection.

Exclusion Criteria:

- Operated cases of vesico-ureteral reflux.
- Children with multi-system anomalies.

Study protocol:

The study will be conducted using GE VOLUSON P8 ultrasonography machine manufactured by GE Healthcare. All the cases of vesico-ureteral reflux will be subjected to ultrasonography by single senior radiologist and the findings will be noted and analysed. The findings of micturating cystourethrography would not be revealed to the radiologist except the presence of urinary tract infection. Consent will be taken from all the patients or parents. All the data collected will be entered in to MS Excel sheet, data will be tabulated & tables, charts and graphs will be prepared.

Data collection procedure:

Ultrasonography of the patients fulfilling all the inclusion and exclusion criteria as described above.

Statistical Method

Data was analyzed using statistical software R version 4.2.0 and Microsoft Excel. Categorical variables were represented by frequencies and percentages. Continuous variables were represented by Mean \pm SD / Median (Min, Max) form. Only descriptive analysis was applicable for the parameters we had taken as there was neither the comparison group nor the controls.

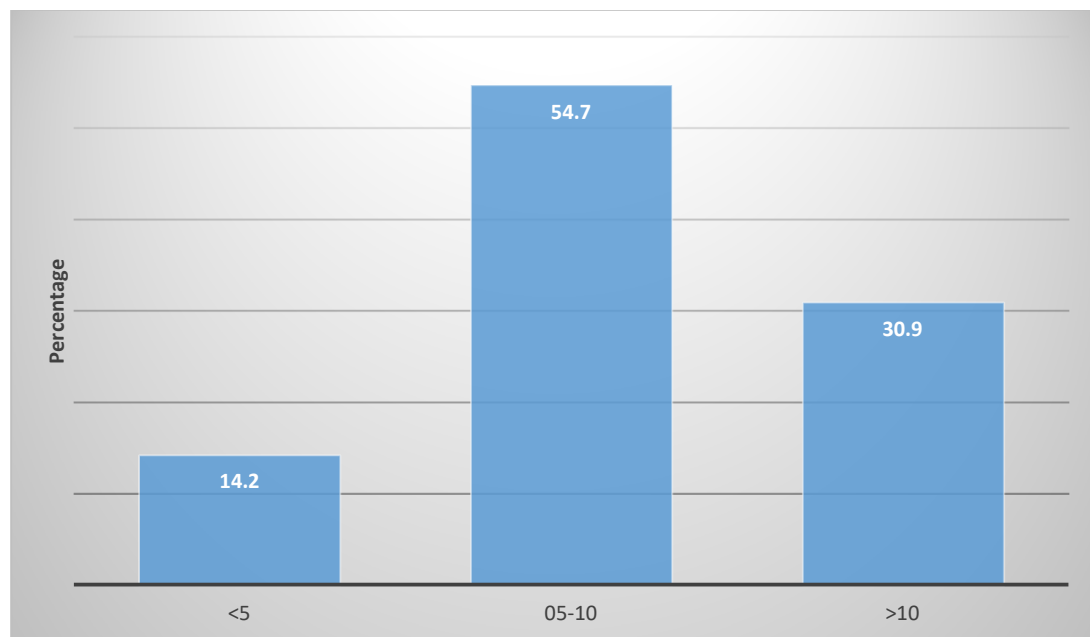
OBSERVATION & RESULTS

Results

Table 1: Age wise distribution of the study participants (N=42)

S/no	Age	Frequency	Percentage
1	<5	6	14.2
2	5-10	23	54.7
3	>10	13	30.9

Figure 1: Age wise distribution of the study participants (N=42)



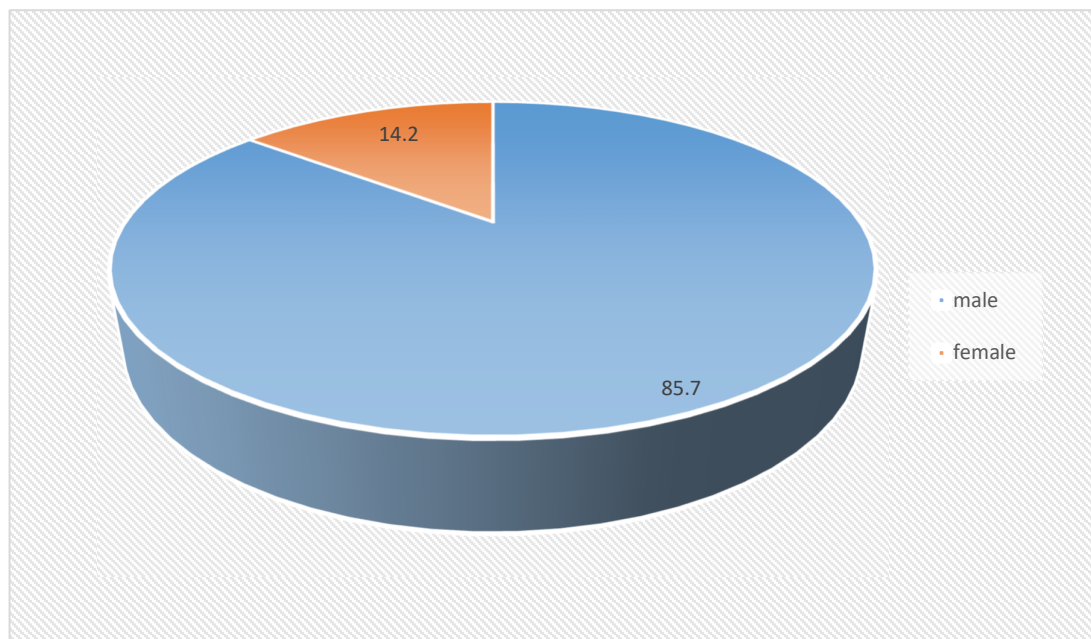
The mean age of the study population is 8.2 years. The first age group, consisting of children under 5 years, accounts for 6 individuals, which constitutes 14.2% of the total surveyed population. This indicates a relatively smaller proportion of very young children in the sample. The second age group, comprising individuals aged between 5 to 10 years, is the largest, with 23 individuals. This group represents a significant majority, making up 54.7% of the total population. This suggests that the majority of the surveyed individuals are in the early to mid-childhood range. The third age group,

which includes individuals older than 10 years, has 13 members, corresponding to 30.9 % of the total population. This indicates a substantial presence of older children and adolescents in the sample.

Table 2: Gender wise distribution of the study participants (N=42)

Sno	Gender	Percentage
Male	36	85.7
Female	6	14.2

Figure 2: Gender wise distribution of the study participants (N=42)

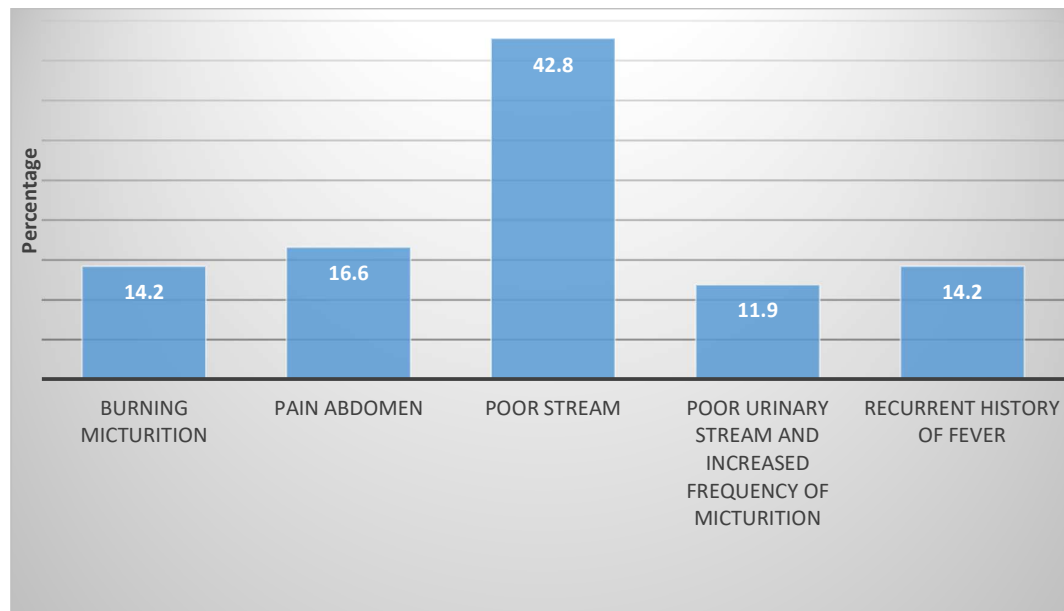


The study involved 36 male participants, comprising 85% of the population, and 6 female participants, comprising 14.2% of the population.

Table 3: Distribution of presenting complaints among the study participants (N=42)

Sl. no	Presenting complaints	Frequency	Percentage
1	Burning micturition	6	14.2
2	Pain abdomen	7	16.6
3	Poor stream	18	42.8
5	Poor urinary stream and increased frequency of micturition	5	11.9
6	Recurrent history of fever	6	14.2

Figure 3: Distribution of presenting complaints among the study participants (N=42)



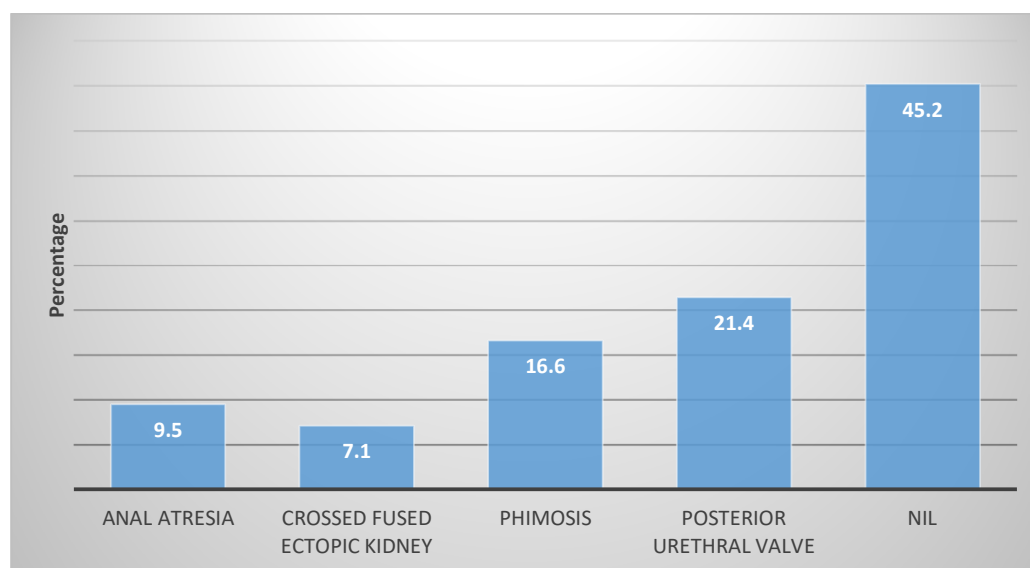
The most common complaint is "Poor stream," reported by 18 individuals, which constitutes 42.8 % of the surveyed population. This indicates that nearly half of the individuals experienced issues with the flow of urine. Two other complaints are reported by an equal number of individuals, each by 6 people, making up 14.2 % of the population each. These complaints are "Burning micturition," and "Recurrent history of fever." Pain abdomen was reported by 7 people, making up 16.6 % of the population. This distribution shows that a significant portion of the population

experiences discomfort or pain during urination, abdominal pain, or recurrent fever episodes. Additionally, the complaint of "Poor urinary stream and increased frequency of micturition" is reported by 5 individuals, representing 11.9 % of the population. This indicates that a smaller, but notable, fraction of the population suffers from both a weak urinary stream and frequent urination.

Table 4: Distribution of history of congenital anomalies among the study participants (N=42)

Sl.No	History of congenital anomalies	Frequency	Percentage
1	Anal atresia	4	9.5
2	Crossed fused ectopic kidney	3	7.1
3	Phimosis	7	16.6
4	Posterior urethral valve	9	21.4
5	Nil	19	45.2

Figure 4: Distribution of history of congenital anomalies among the study participants (N=42)

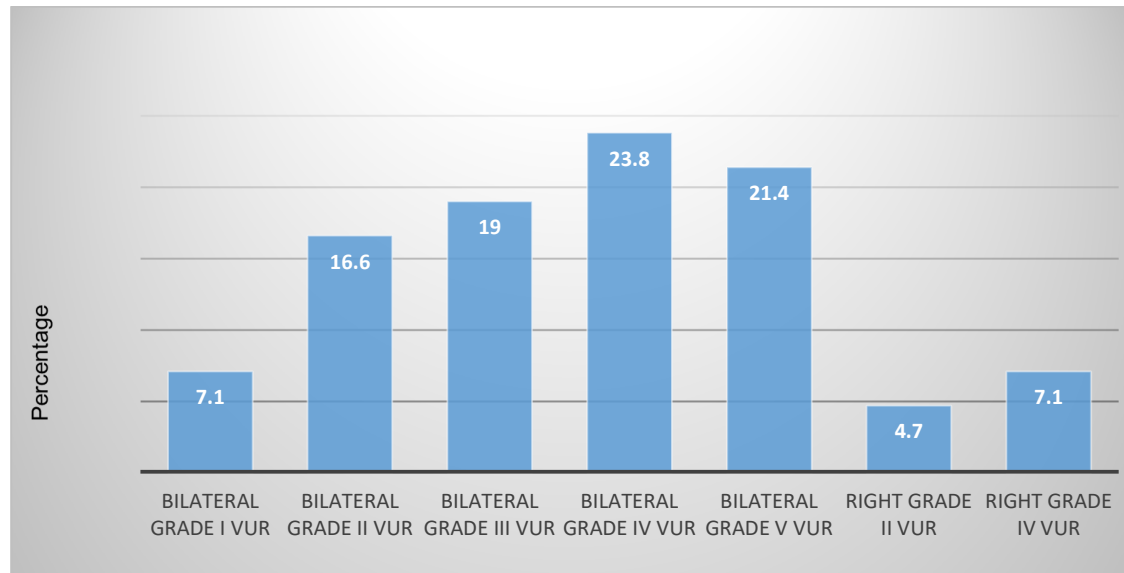


The most frequently reported condition is "posterior urethral valve," which is observed in 9 individuals, accounting for 21.4 % of the surveyed population. This indicates that this condition is relatively a common congenital anomaly in this group. Phimosis is noted in 7 individuals corresponding to 16.6 % of population. Anal atresia is reported in 4 individuals and Crossed fused ectopic kidney in 3 individuals. These conditions constitute 9.5% and 7.1 % of the population respectively. This suggests that these two congenital anomalies are less common but still present in a notable portion of the surveyed individuals. The largest category, however, is those with no history of congenital anomalies, labeled as "Nil." This group includes 19 individuals, making up 45.2 % of the population. This indicates that a significant portion of the surveyed individuals do not have any reported congenital conditions.

Table 5: Distribution of various grades of VUR in MCU among the study participants (N=42)

Slno	MCU findings	Frequency	Percentage
1	Bilateral Grade I VUR	3	7.1
2	Bilateral Grade II VUR	7	16.6
3	Bilateral Grade III VUR	8	19
4	Bilateral Grade IV VUR	10	23.8
5	Bilateral Grade V VUR	9	21.4
6	Right Grade II VUR	2	4.7
7	Right Grade IV VUR	3	7.1

Figure 5: Distribution of MCU findings among the study participants (N=42)

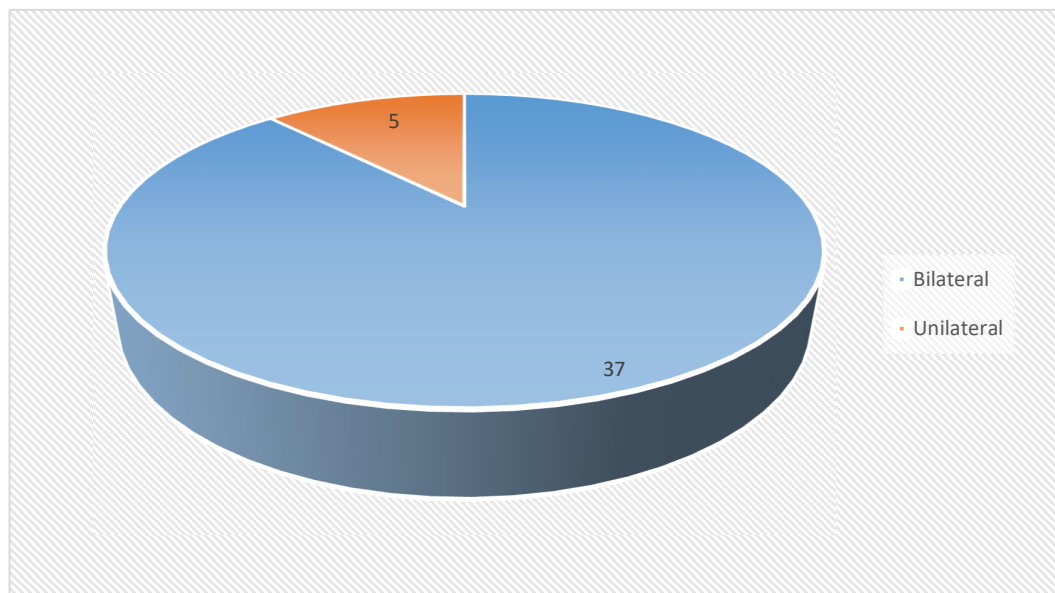


The most prevalent finding is "Bilateral Grade IV VUR," observed in 10 individuals, which constitutes 23.8 % of the surveyed population.

"Bilateral Grade V VUR" is identified in 9 individuals, accounting for 21.4 % of the population. This higher-grade reflux, although less common than Grade IV, still represents a significant portion of the surveyed individuals, indicating a notable presence of more severe VUR. "Bilateral grade III VUR " is identified in 8 individuals each, accounting for 19 % of population each. "Bilateral grade I and Right grade II VUR " is identified in 2 individuals each, accounting for 4.7 % of population each. "Right grade IV VUR" is noted in 3 individuals, accounting for 7.1 % of the population. This indicates that unilateral VUR is present but less frequent compared to the bilateral cases.

Table 6: Distribution of cases into unilateral and bilateral cases on MCU (N=42)

Sl. no	vesico-ureteric reflux	Frequency	Percentage
1	Unilateral	37	88.1
2	Bilateral	5	11.9

Figure 6: Distribution of cases into unilateral and bilateral cases on MCU (N=42)

The study found that 88.1% of the population, comprising 37 individuals with bilateral vesicoureteral reflux and 11.9% with unilateral vesicoureteral reflux, indicating that the majority of the population suffers from bilateral vesicoureteral reflux.

Table 7: Depicts renal and ureter parameters in accurately graded cases on ultrasonography

Grade	Anteroposterior renal pelvis diameter (cm)		Proximal ureter (cm)		Distal ureter (cm)	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
I	0.3	0.3	-	-	0.5	0.6
II	0.7	0.8	0.5	0.8	0.4	0.7
III	1.5	1.7	0.6	0.8	0.7	0.8
IV	1.6	2.4	0.9	1.6	0.8	1.7
V	2.2	2.6	1.3	1.7	1.2	1.7

Table 8: Accuracy of ultrasonography in detecting all grade vesico-ureteral reflux (N=42).

VUR	POSITIVE CASES	NEGATIVE CASES
MCU	42	0
USG	38	4

Among the cases diagnosed, USG identified 38 true positive cases (positive on both USG and MCU) and 4 false negative cases (negative on USG but positive on MCU). There were no false positives (positive on USG but negative on MCU), and no true negatives (negative on both USG and MCU).

Figure 7: Pie chart depicts the accuracy of ultrasonography in detecting vesico-ureteral reflux cases (N=42).

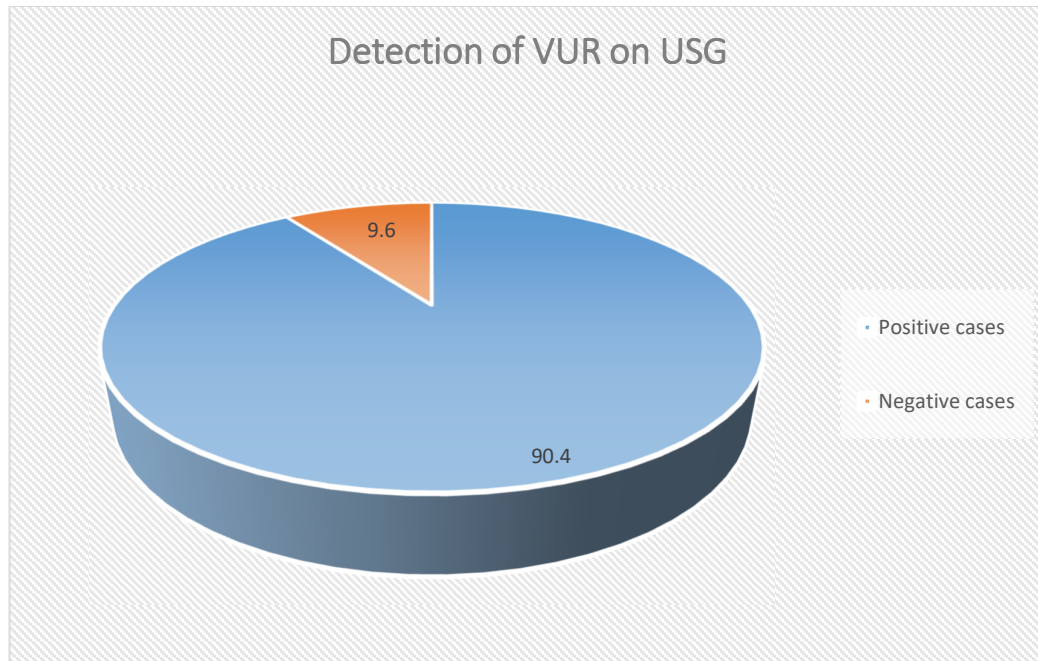


Table 9: Accuracy of ultrasonography in grading all grade vesico-ureteral reflux cases (N=38).

	Number of cases	Percentage
Accurately graded	26	68.4
Not accurately graded	12	31.6

Of the 38 cases (or 90.4% of all cases discovered in USG), 26 cases constituting 68.4 % were graded appropriately, while 12 cases i.e. 31.6% were not graded correctly.

Figure 8: Pie chart depicts the accuracy of ultrasonography in grading all grade vesico-ureteral reflux cases (N=38).

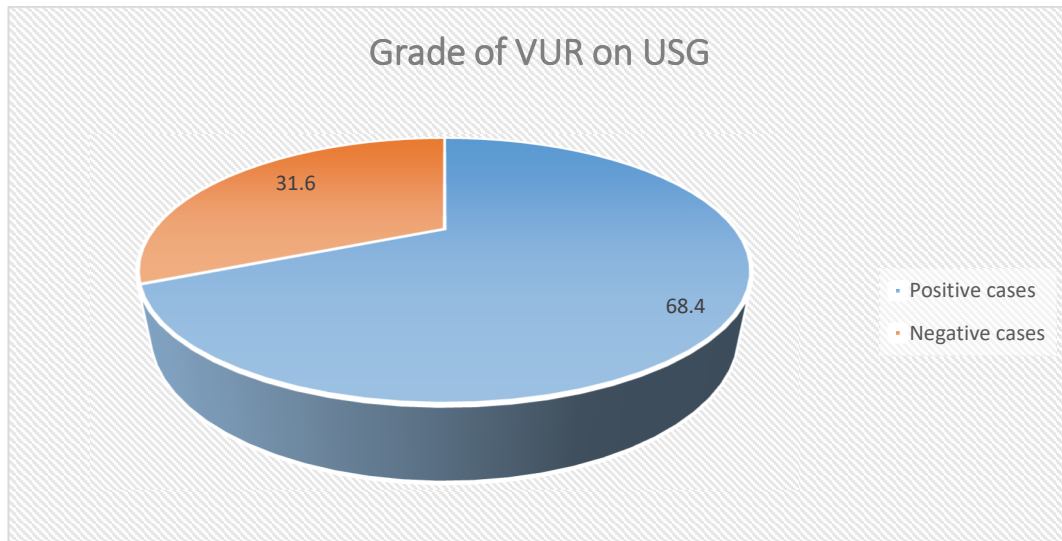


Table 10: VUR detection and grading on both MCU and USG

	prediction and grading of VUR on MCU (+)	Detection of VUR on USG (+)	Grading of VUR on USG (+)	Grading of VUR on USG (-)	Detection of VUR on USG (-)
Bilateral grade I VUR	3	2	1	1	1
Bilateral grade II VUR	7	5	2	3	2
Bilateral grade III VUR	8	7	4	3	1
Bilateral grade IV VUR	10	10	7	3	0
Bilateral grade V VUR	9	9	9	0	0
Right grade II VUR	2	2	1	1	0
Right grade IV VUR	3	3	2	1	0
Total	42	38	26	12	4

Figure 9: Depicts detection & grading of VUR among various grades of VUR on both MCU and USG

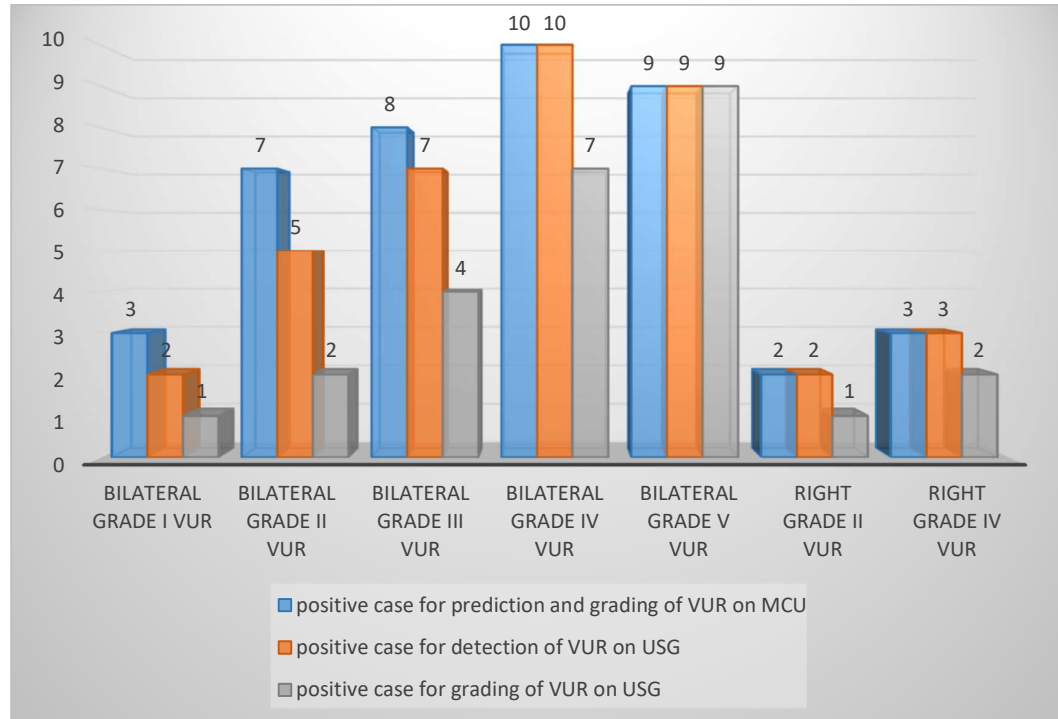


Table 11: Depicts accuracy of USG in detection and grading of low grade VUR (grade I and II) on USG

	prediction and grading of VUR on MCU (+)	Detection of VUR on USG (+)	Grading of VUR on USG (+)	Grading of VUR on USG (-)	Detection of VUR on USG (-)
Bilateral grade I VUR	3	2	1	1	1
Bilateral grade II VUR	7	5	2	3	2
Right grade II VUR	2	2	1	1	0
Total	12	9	4	5	3

Among the study population of 42,

12 children were diagnosed and graded with low-grade VUR (grade I and grade II) on MCU.

2 cases (66.6%) among the 3 cases of bilateral grade I VUR were diagnosed on USG and one (50%) among them were accurately graded.

5 cases (71.4 %) among the 7 cases of bilateral grade II VUR were diagnosed on USG and 2 (40 %) among them were accurately graded.

All the cases (2 cases) right grade II VUR were diagnosed on USG and 1 (50 %) among them were accurately graded.

9 cases of low-grade VUR were diagnosed on USG, constituting for 75% cases, 4 children were correctly graded on USG, constituting for 44.4 % cases among the cases diagnosed on USG.

3 children among the 12 children were not detected with VUR on USG and 5 children were not correctly graded among the 9 diagnosed children.

Table 12: Depicts accuracy of USG in detection and grading of high grade VUR (grade III, IV and V) on USG

	Detection and grading of VUR on MCU (+)	Detection of VUR on USG (+)	Grading of VUR on USG (+)	Grading of VUR on USG (-)	Detection of VUR on USG (-)
Bilateral grade III VUR	8	7	4	3	1
Bilateral grade IV VUR	10	10	7	3	0
Bilateral grade V VUR	9	9	9	0	0
Right grade IV VUR	3	3	2	1	0
Total	30	29	22	7	1

Among the study population of 42,

30 children were diagnosed and graded with high-grade VUR (grade III, grade IV and grade V) on MCU.

7 cases (87.5%) among the 8 cases of bilateral grade III VUR were diagnosed on USG and 4 (57.1 %) among them were accurately graded.

All the cases (13 cases) of right grade IV and bilateral grade IV VUR were diagnosed on USG, however 2 cases (66.6 %) of right grade IV, 7 cases (70%) of bilateral grade IV were accurately graded.

All the cases (9 cases) of bilateral grade V were accurately diagnosed and correctly graded on USG.

29 cases are diagnosed on USG, constituting for 96.6 % cases and 22 children were correctly graded on USG, constituting for 75.8 % cases among the cases diagnosed on USG.

1 child among the 30 children was not detected with VUR on USG and 7 (24.1 %) children were not correctly graded among the 29 diagnosed children.

DISCUSSION

The purpose of this study was to evaluate the accuracy of ultrasonography in predicting vesico-ureteral reflux cases diagnosed on micturating cystourethrography in paediatric patients and further grade those cases.

In the present study, the sample size is 42, A thorough clinical history was noted, symptoms were recorded, and any associated congenital anomalies were studied.

Three age groups comprise the sample: children under five years old, those between five and ten years old, and those above ten years old. There are fewer very young children in the first age group, which makes up 14.2% of the overall population. With 54.7% of the population in this age bracket, the majority of people fall into the early to mid-childhood range. Older children and teenagers make up 30.9% of the third age group.

In the present study, males outnumbered females (36 males; 85.7 % and 6 females; 14.2 %).

Arzu Kovanlikaya et al.'s study did not specify age distribution in detail, focusing more on the presence and grading of VUR across 268 renal units in 134 cases. This broad age inclusion may differ from our more segmented approach, potentially impacting the observed prevalence and diagnostic parameters due to the varying physiology and disease presentation in different age groups⁶³.

Huang et al.'s study included 310 children aged up to 2 years, with a median age of 5 months. The majority (86.1%) were under 1 year old, including 89.7% of boys and 80% of girls. This study's focus on a younger cohort, primarily infants, contrasts with our broader age range and could explain differences in diagnostic

performance metrics, as VUR presentation and detection might vary significantly between infants and older children⁶⁵.

Urine flow was a problem for most of the people surveyed, with "poor stream" being the most often mentioned concern. Six individuals reported burning micturition and recurring fever, while seven reported stomach pain, indicating pain or discomfort during urination or recurrent fever episodes. A lower percentage, 11.9%, reported more frequent micturition and a weak urine stream, suggesting that a sizable segment of the population experiences these problems.

The most common congenital anomaly in the surveyed population is posterior urethral valve, observed in 21.4% of individuals. Phimosis is reported in 16.6% of individuals, while anal atresia and crossed fused ectopic kidney are less common but still present in 9.5% and 7.1% of the population, respectively. The largest category is "Nil," comprising 45.2% of the population.

In Grade I reflux cases, reflux of urine is seen in the distal ureter with its dilatation, however proximal ureter was not dilated.

In Grade II reflux cases, reflux of urine is seen in the ureter and renal pelvis, however pelvis was not dilated.

In the higher grade refluxes (Grade III, IV and V), along the reflux, dilatation of the ureter and pelvicalyceal system was seen.

Grade III, Grade IV and Grade V showed mild, moderate and severe dilatation of the pelvicalyceal system respectively with blunting of calyces in grade IV and grade V vesicoureteral reflux.

According to the study, bilateral Grade IV VUR is the most prevalent, making up 23.8% of the participants in the survey. 21.4 % of the population has bilateral Grade V VUR, which is a more severe form of VUR. 19% of those surveyed have

bilateral Grade II and III VUR, whereas 4.7% and 7.1% of participants had bilateral Grade I and Right Grade II VUR, respectively.

The study reveals that 88.1% of the population has bilateral reflux, with 37 individuals having bilateral vesicoureteral reflux and 11.9% having unilateral reflux.

Among the diagnosed cases, the USG found 38 true positive cases and 4 false negative cases; neither the USG nor the MCU found any false positives or true negatives.

Of the 38 cases (or 90.4% of all cases discovered in USG), 26 cases constituting 68.4 % were graded correctly, while 12 cases i.e. 31.6% were not graded correctly.

12 cases were diagnosed with low-grade VUR on MCU, with 9 cases (75%) being diagnosed on USG. 44% of cases were correctly graded on USG, while 3 (25%) children were not detected with VUR and 5 (66%) were not correctly graded among the 9 diagnosed children.

Even though the accuracy of detection and grading of the lower grade VUR on USG is low, the surgical management is not advised in lower-grade cases and have better prognosis.

29 were diagnosed with high-grade VUR on MCU, with 22 cases (75.8 %) correctly graded on USG. Out of these, 1 child was not detected with VUR on USG, and 24.1 % children were not correctly graded.

Study conducted by Leroy et al demonstrate that ureteral dilatation has the best diagnostic accuracy (compared with renal length, pelvic dilatation, urinary tract dilatation, and corticomedullary differentiation, with 73% sensitivity and 88% specificity for the detection of high-grade VUR⁶¹

USG is a safer and less stressful procedure compared to MCU, which requires a catheter insertion and contrast material. It uses sound waves to produce images, protecting both patients and medical staff. USG is accessible in most medical settings, unlike MCU which requires specialized equipment and personnel. It is particularly beneficial for young patients.

USG, while not as detailed as MCU, can dynamically assess bladder and ureters using color flow or Doppler imaging to detect reflux during voiding. Its ability to provide serial monitoring of VUR without repeated radiation doses is crucial, especially in pediatric cases.

While MCU remains valuable for detailed grading and real-time assessment of VUR severity, USG offers significant advantages in terms of safety, accessibility, and cost-effectiveness, especially for initial screening and follow-up evaluations.

MCU stops at the kidney, but USG looks at the kidney with respect to size, shape (shows signs of chronic pyelonephritis) and helps in ureteric characterization, persistent infection in the form of intrapelvic echoes and poor emptying of refluxed urine.

USG is also helpful in picking up additional parameters such as renal scarring, atrophic kidney, intrapelvic echogenicities, and dilated ureter.

USG is also helpful in prognosticating the disease process and providing a non-hesitant view of management and whether observational uroprophylaxis or surgical treatment is to be planned for the given clinical scenario.

CONCLUSION

Our study supports the use of USG as a valuable tool for screening, diagnosis as well as follow-up of vesicoureteral reflux cases and grading of the vesico-ureteral reflux in paediatric patients in higher-grade cases. Renal pelvis diameter and ureteral dilatation shows best accuracy in diagnosing & grading all-grade and high grade vesico-ureteral reflux.

SUMMARY

- Urinary tract infections (UTI) are the most common bacterial diseases in children, with vesico-ureteral reflux being the one of the most common cause.
- Over 60% of children under one year old are diagnosed with vesicoureteral reflux after their first UTI.
- The traditional method is micturating cystourethrography, which is painful and invasive. This study aims to evaluate the accuracy of ultrasonography in predicting and grading vesicoureteral reflux cases in pediatric patients with urinary tract infections.
- The sample size is 42, with 54.7% of the population being in the early to mid-childhood range and male-female (6:1).
- Urine flow was a problem for most of the people surveyed, with "poor stream" being the most often mentioned concern.
- 88.1% of the population has bilateral reflux and Bilateral Grade IV VUR is the most prevalent followed by bilateral Grade V VUR,
- USG found 38 (90.4%) true positive cases and 4 false negative cases; neither the USG nor the MCU found any false positives or true negatives
- 68.4 % cases were graded correctly, 75% of the low-grade being diagnosed on USG and 44% of cases were correctly graded
- 96.6 % of the high-grade cases were diagnosed on USG with 75.8 % of them correctly graded
- USG evaluates the kidney with respect to size, shape (shows signs of chronic pyelonephritis), ureteric characterization, persistent infection in the form of intrapelvic echoes, poor emptying of refluxed urine, and the dynamicity of reflux.

- USG is also helpful in picking up additional parameters such as renal scarring, atrophic kidney, intrapelvic echogenicities, providing a non-hesitant view of management
- The study has several limitations, including a small sample size of 42 patients, a cross-sectional design, and a lack of follow-up data. The sensitivity of USG in detecting high-grade VUR is high, but its accuracy in detecting low-grade VUR is lower, potentially leading to underdiagnosis or misclassification.
- USG's non-invasive nature may not provide the same level of detail as MCU, especially for low-grade VUR. The study acknowledges these limitations and acknowledges the need for long-term evaluation of USG's efficacy.

LIMITATIONS

- One of the limitations of this study is the small sample size of 42 patients. A small sample size limits the statistical power of the study, making it difficult to make inferences. Additionally, in this study the sampling of participants was limited to known cases of VUR, thus inherently carrying risk of selection bias.
- The study's cross-sectional design limits the follow-up duration when ideally long-term follow-up is essential to assess the progression of VUR and the impact of early diagnosis and intervention on patient outcomes.
- While the accuracy of USG in detecting high-grade VUR (grades III-V) are reported to be high, the accuracy in detecting low-grade VUR (grades I-II) is lower. This discrepancy highlights a limitation in the diagnostic capability of USG for less severe cases of VUR, which may lead to underdiagnosis or misclassification of the condition in some patients.
- USG is advantageous due to its non-invasive nature and lack of radiation exposure, it may not provide the same level of detail as MCU, particularly for low-grade VUR.

BIBLIOGRAPHY

1. Zorc JJ, Levine DA, Platt SL, et al.; Multicenter RSV-SBI Study Group of the Pediatric Emergency Medicine Collaborative Research Committee of the American Academy of Pediatrics. Clinical and demographic factors associated with urinary tract infection in young febrile infants. *Pediatrics*. 2005;116(3):644–648
2. Shaikh N, Morone NE, Bost JE, Farrell MH. Prevalence of urinary tract infection in childhood: a meta-analysis. *Pediatr Infect Dis J*. 2008;27(4): 302–308
3. Kanellopoulos TA, Salakos C, Spiliopoulou I, Ellina A, Nikolakopoulou NM, Papanastasiou DA. First urinary tract infection in neonates, infants and young children: a comparative study. *Pediatr Nephrol*. 2006;21(8):1131–1137
4. Conway PH, Cnaan A, Zaoutis T, Henry BV, Grundmeier RW, Keren R. Recurrent urinary tract infections in children: risk factors and association with prophylactic antimicrobials. *JAMA*. 2007;298(2):179–186
5. Dai B, Liu Y, Jia J, Mei C. Long-term antibiotics for the prevention of recurrent urinary tract infection in children: a systematic review and meta-analysis. *Arch Dis Child*. 2010; 95(7):499–508
6. Peters CA, Skoog SJ, Arant BS Jr., et al. Summary of the AUA guideline on management of primary vesicoureteral reflux in children. *J Urol*. 2010;184(3):1134–1144
7. Shaikh N, Ewing AL, Bhatnagar S, Hoberman A. Risk of renal scarring in children with a first urinary tract infection: a systematic review. *Pediatrics*. 2010;126(6):1084–1091

8. Bensman A, Dunand O, Ulinski T. Urinary Tract Infections. In: Avner DWH, Niaudet P, Yoshikawa N, eds. *Pediatric Nephrology*, 6th ed. Berlin, Germany: Springer, 1299–1309
9. Akram M, Shahid M, Khan AU. Etiology and antibiotic resistance patterns of community-acquired urinary tract infections in J N M C Hospital Aligarh, India. *Ann Clin Microbiol Antimicrob*. 2007;6:4
10. Chakupurakal R, Ahmed M, Sobithadevi DN, Chinnappan S, Reynolds T. Urinary tract pathogens and resistance pattern. *J Clin Pathol*. 2010 Jul;63(7):652-4. doi: 10.1136/jcp.2009.074617. Epub 2010 May 24. PMID: 20501451.
11. Lutter SA, Currie ML, Mitz LB, Greenbaum LA. Antibiotic resistance patterns in children hospitalized for urinary tract infections. *Arch Pediatr Adolesc Med*. 2005;159(10):924–928
12. Bell LE, Mattoo TK. Update on childhood urinary tract infection and vesicoureteral reflux. *Semin Nephrol*. 2009;29(4):349–359
13. Sudha EK, Afsana J, Kiran PS. Urinary Tract Infection in Children, Standard Treatment Guidelines 2022, Indian Academy of Paediatrics.
14. Jay L.G, James A.O, Arnold G.C, Eric W.F, Genitourinary disorders. *Pediatric surgery*[Book]: Mosby;2006. p.1742
15. Roić G, Roić AC, Palčić I, Grmoja T and Batos AT: Contrast enhanced voiding urosonography (cevus) in the diagnosis of vesicoureteral reflux. *Lijecnicki Vjesnik* 138: 39-46, 2016 (In Croatian).
16. Coulthard MG: Vesicoureteric reflux is not a benign condition. *Pediatr Nephrol* 24: 227-232, 2009.
17. Venhola M and Uhari M: Vesicoureteral reflux, a benign condition. *Pediatr Nephrol* 24: 223-226, 2009.

18. Subcommittee on Urinary Tract Infection: Reaffirmation of AAP clinical practice guideline: The diagnosis and management of the initial urinary tract infection in febrile infants and young children 2-24 months of Age. *Pediatrics* 138: pii: e20163026, 2016.
19. Kenda RB, Kenig A, Novljan G, Ponikvar R and Ponikvar JB: Cyclic voiding urosonography for detecting vesicoureteric reflux in renal transplant recipients. *Nephrol Dial Transplant* 16: 2229-2231, 2001.
20. Lim R: Vesicoureteral reflux and urinary tract infection: Evolving practices and current controversies in pediatric imaging. *AJR Am J Roentgenol* 192: 1197-1208, 2009.
21. Subcommittee on Urinary Tract Infection. Steering Committee on Quality Improvement and Management, Roberts KB. Urinary tract infection: clinical practice guideline for the diagnosis and management of the initial UTI in febrile infants and children 2 to 24 months. *Pediatrics* 2011;128:595-610.
22. Roberts JA. Experimental pyelonephritis in the monkey, part III: pathophysiology of ureteral malfunction induced by bacteria. *Invest Urol* 1975;13:117-20.
23. Khoury AE, B€agli DJ. Vesicoureteral Reflux. *Campbell-Walsh Urology*, Vol. 4, 10th edn. Philadelphia, Saunders, 2011.
24. Cendron M. Reflux nephropathy. *J. Pediatr. Urol.* 2008; 4: 414–21.
25. Jakobsson B, Esbjorner E, Hansson S. Minimum incidence and diagnostic rate of first urinary tract infection. *Pediatrics* 1999; 104:222–226
26. Cleper R, Krause I, Eisenstein B, Davidovits M. Prevalence of vesicoureteral reflux in neonatal urinary tract infection. *Clin Pediatr (Phila)* 2004; 43:619–625

27. Rushton HG, Majd M. Dimercaptosuccinic acid renal scintigraphy for the evaluation of pyelone phritis and scarring: a review of experimental and clinical studies. *J Urol* 1992; 148:1726–1732
28. Ditchfield MR, De Campo JF, Cook DJ, et al. Vesicoureteral reflux: an accurate predictor of acute pyelonephritis in childhood urinary tract infection? *Radiology* 1994; 190:413–415
29. Sastre JB, Aparicio AR, Cotallo GD, Colomer BF, Hernandez MC. Urinary tract infection in the newborn: clinical and radio imaging studies. *Pediatr Nephrol* 2007; 22:1735–1741
30. Lin KY, Chiu NT, Chen MJ, et al. Acute pyelone phritis and sequelae of renal scar in pediatric first febrile urinary tract infection. *Pediatr Nephrol* 2003; 18:362–365
31. Zaki M, Badawi M, Al Mutari G, Ramadan D, Adul Rahman M. Acute pyelonephritis and renal scarring in Kuwaiti children: a follow-up study using ^{99m}Tc DMSA renal scintigraphy. *Pediatr Nephrol* 2005; 20:1116–1119
32. Oh MM, Jin MH, Bae JH, Park HS, Lee JG, Moon du G. The role of vesicoureteral reflux in acute renal cortical scintigraphic lesion and ultimate scar formation. *J Urol* 2008; 180:2167–2170
33. Cussen LJ. Dimensions of the normal ureter in infancy and childhood. *Invest Urol* 1967; 5:164–178
34. Ataei N, Madani A, Habibi R, Khorasani M. Evaluation of acute pyelonephritis with DMSA scans in children presenting after the age of 5 years. *Pediatr Nephrol* 2005; 20:1439–1444
35. Skoog SJ, Peters CA, Arant BS Jr et al. Pediatric vesicoureteral reflux guidelines panel summary report: clinical practice guidelines for screening siblings of

- children with vesicoureteral reflux and neonates/infants with pre natal hydronephrosis. *J. Urol.* 2010; 184: 1145–51.
36. Hunziker M, Colhoun E, Puri P. Renal cortical abnormalities in siblings of index patients with vesicoureteral reflux. *Pediatrics* 2014; 133: e933–7.
37. Mahant, S., J. Friedman, and C. MacArthur. 2002. Renal ultrasound findings and vesicoureteral reflux in children hospitalised with urinary tract infection. *Arch. Dis. Child.* 86:419–420.
38. Hoberman, A., C. M., Hickey, R. W., Baskin, M., Kearney, D. H., Wald, E. R. 2003. Imaging studies after a first febrile urinary tract infection in young children. *N. Engl. J. Med.* 348:195–202.
39. Polito, C., P. F. Rambaldi, A. La Manna, L. Mansi, and R. Di Toro. 2000. Enhanced detection of vesicoureteric reflux with isotopic cystography. *Pediatr. Nephrol.* 14:827–830.
40. Mahant, S., T. To, and J. Friedman. 2001. Timing of voiding cystourethrogram in the investigation of urinary tract infections in children. *J. Pediatr.* 139:568–571.
41. McDonald, A., M. Scranton, R. Gillespie, V. Mahajan, and G. A. Edwards. 2000. Voiding cystourethrograms and urinary tract infections: how long to wait? *Pediatrics* 105:E50.
42. Williams, G., A. Lee, and J. Craig. 2001. Antibiotics for the prevention of urinary tract infection in children: a systematic review of randomized controlled trials. *J. Pediatr.* 138:868–874.
43. Williams, G. J., A. Lee, and J. C. Craig. 2001. Long-term antibiotics for preventing recurrent urinary tract infection in children. *Cochrane Database Syst. Rev.* CD001534. [Online.] <http://www.cochrane.org/cochrane/revabstr/ab001534.htm>

44. [No authors listed]. Practice parameter: the diagnosis, treatment, and evaluation of the initial urinary tract infection in febrile infants and young children. American Academy of Pediatrics, Committee on Quality Improvement, Subcommittee on Urinary Tract Infection. *Pediatrics* 1999; 103:843–852
45. Ross JH, Kay R. Pediatric urinary tract infection and reflux. *Am Fam Physician* 1999; 59:1472–1478, 1485–1486
46. Shah L, Mandlik N, Kumar P, Andaya S, Pata masucon P. Adherence to AAP practice guidelines for urinary tract infections at our teaching institution. *Clin Pediatr (Phila)* 2008; 47:861–864
47. Riccabona M, Avni FE, Blickman JG, et al. Imaging recommendations in paediatric urology: minutes of the ESPR workgroup session on urinary tract infection, fetal hydronephrosis, urinary tract ultrasonography, and voiding cystourethrography, Barcelona, Spain, June 2007. *Pediatr Radiol* 2008; 38:138–145
48. Nikibakhsh AA, Yekta Z, Mahmoodzadeh H, Karamiyar M, Fazel M. Technetium tc 99m dimercaptosuccinic acid renal scintigraphy in diagnosis of urinary tract infections in children with negative culture. *Urol J* 2006; 3:139–144
49. McLaren CJ, Simpson ET. Direct comparison of radiology and nuclear medicine cystograms in young infants with vesico-ureteric reflux. *BJU Int* 2001; 87:93–97
50. Schmidt B, Copp HL. Work-up of Pediatric Urinary Tract Infection. *Urol Clin North Am.* 2015 Nov;42(4):519-26. doi: 10.1016/j.ucl.2015.05.011. Epub 2015 Aug 4. PMID: 26475948; PMCID: PMC4914380.
51. Oak SN, Kulkarni B, Chaubal N. Color flow Doppler sonography: a reliable alternative to voiding cystourethrogram in the diagnosis of vesicoureteral reflux

- in children. *Urology*. 1999 Jun;53(6):1211-4. doi: 10.1016/s0090-4295(99)00124-7. PMID: 10367854.
52. Cascio S, Chertin B, Yoneda A, Rolle U, Kelleher J, Puri P. Acute renal damage in infants after first urinary tract infection. *Pediatr Nephrol* 2002; 17: 503–505
53. Mahant S, Friedman J, MacArthur C. Renal ultra sound findings and vesicoureteral reflux in children hospitalised with urinary tract infection. *Arch Dis Child* 2002; 86:419–420
54. Huang HP, Lai YC, Tsai IJ, Chen SY, Tsau YK. Renal ultrasonography should be done routinely in children with first urinary tract infections. *Urology* 2008; 71:439–443
55. Ataei N, Madani A, Esfahani ST, et al. Screening for vesicoureteral reflux and renal scars in siblings of children with known reflux. *Pediatr Nephrol* 2004; 19:1127–1131
56. Mattoo TK, Shaikh N, Nelson CP. Contemporary Management of Urinary Tract Infection in Children. *Pediatrics*. 2021 Feb;147(2) [PubMed]
57. Olbing H, Hirche H, Koskimies O, Lax H, Seppänen U, Smellie JM, Tamminen-Möbius T, Wikstad I. Renal growth in children with severe vesicoureteral reflux: 10-year prospective study of medical and surgical treatment: the International Reflux Study in Children (European branch). *Radiology*. 2000 Sep;216(3):731-7. [PubMed]
58. Yousefifard M, Toloui A, Rafiei Alavi SN, Madani Neishaboori A, Ahmadzadeh K, Ghelichkhani P, Safari S, Abbasi A, Ataei N, Hosseini M. Contrast-enhanced voiding urosonography, a possible candidate for the diagnosis of vesicoureteral reflux in children and adolescents; a systematic review and meta-analysis. *J Pediatr Urol*. 2022 Feb;18(1):61-74. [PubMed]

59. Duran C, Beltrán VP, González A, Gómez C, Riego JD. Contrast-enhanced Voiding Urosonography for Vesicoureteral Reflux Diagnosis in Children. *Radiographics*. 2017 Oct;37(6):1854-1869. [PubMed]
60. G Zamir, W Sakran, Y Horowitz, A Koren, D Miron. Urinary tract infection: is there a need for routine renal ultrasonography? *Isreal* [cited 2000] Available from: <https://adc.bmj.com/content/89/5/466>
61. Leroy S, Vantalón S, Larakeb A, Ducou-Le-Pointe H, Bensman A. Vesicoureteral reflux in children with urinary tract infection: comparison of diagnostic accuracy of renal US criteria. *Radiology*. 2010 Jun;255(3):890-8. doi: 10.1148/radiol.10091359. PMID: 20501726.
62. Nelson CP, Johnson EK, Logvinenko T, Chow JS. Ultrasound as a screening test for genitourinary anomalies in children with UTI. *Pediatrics*. 2014 Mar;133(3):e394-403. doi: 10.1542/peds.2013-2109. Epub 2014 Feb 10. PMID: 24515519; PMCID: PMC3934332.
63. Kovanlikaya A, Kazam J, Dunning A, Poppas D, Johnson V, Medina C, Brill PW. The role of ultrasonography in predicting vesicoureteral reflux. *Urology*. 2014 Nov;84(5):1205-10. doi: 10.1016/j.urology.2014.06.057. Epub 2014 Oct 24. PMID: 25443935.
64. Park HW, Jin H, Jeong SJ, Lee JH. Association of Renal and Bladder Ultrasonography Findings with Urinary Tract Infection Recurrence, High-Grade Vesicoureteral Reflux, and Renal Scarring . *Child Kidney Dis*. 2015;19(2):125-130. doi: 10.3339/chikd.2015.19.2.125
65. Hung TW, Tsai JD, Liao PF, Sheu JN. Role of Renal Ultrasonography in Predicting Vesicoureteral Reflux and Renal Scarring in Children Hospitalized with a First Febrile Urinary Tract Infection. *Pediatr Neonatol*. 2016

- Apr;57(2):113-9. doi: 10.1016/j.pedneo.2015.06.001. Epub 2015 Jun 14. PMID: 26163341.
66. Zhang W, Cai B, Zhang X, Zhou J, Qiu L, Yi H. Contrast-enhanced voiding urosonography with intravesical administration of ultrasound contrast agent for the diagnosis of pediatric vesicoureteral reflux. *Exp Ther Med*. 2018 Dec;16(6):4546-4552. doi: 10.3892/etm.2018.6793. Epub 2018 Sep 25. PMID: 30542403; PMCID: PMC6257520.
67. Salib, A., Rudnick, B. & Murphy, A. Vesicoureteral Reflux in Adults with Urinary Tract Infections: Is There a Role for Treatment?. *Curr Urol Rep* **21**, 35 (2020). <https://doi.org/10.1007/s11934-020-00990-3>
68. Dogan GM, Sığircı A, Elmas AT, Tabel Y. The role of ultrasound in the diagnosis of vesicoureteral reflux disease. *J Surg Med*. 2022;6(1):102-105.
69. Sharifiaghdas, Dadpour, Salimi/et al. Comparison of VCUG and DMSA scan in the detection of vesicoureteral reflux in children during first febrile urinary tract infection. *Curr Pediatr Res* 2023; 27 (03): 1812-1816
70. Aydin O, Karademir S, Bülbül M. Evaluating the requirement of ultrasonography for children with their first urinary tract infection. *J Pediatr Urol*. 2023 Oct 28:S1477-5131(23)00455-2. doi: 10.1016/j.jpurol.2023.10.026. Epub ahead of print. PMID: 37932198.
71. Lee HB, Lee S, Choi YH, Cheon J-E, Lee SB, Cho YJ, et al. (2023) Contrast-enhanced ultrasound for the diagnosis of acute pyelonephritis in pediatric patients

with urinary tract infection: A feasibility study. PLoS ONE 18(4): e0284016.
<https://doi.org/10.1371/journal.pone.0284016>

72. Hari, P., Meena, J., Kumar, M. *et al.* Evidence-based clinical practice guideline for management of urinary tract infection and primary vesicoureteric reflux. *Pediatr Nephrol* **39**, 1639–1668 (2024). <https://doi.org/10.1007/s00467-023-06173-9>

ANNEXURES – I
INFORMED CONSENT FORM

**“ROLE OF ULTRASONOGRAPHY IN DIAGNOSING VESICO-URETERAL
REFLUX IN PAEDIATRIC PATIENTS WITH URINARY TRACT INFECTION
– A ONE YEAR HOSPITAL BASED CROSS-SECTIONAL STUDY”**

This procedure even though a day care procedure, involves thorough counselling, requires antibiotic coverage, has poor compliance and is only done after recovering from febrile illness. However if we have a procedure, an investigative tool which without invasion gives similar results & near similar results in diagnosis of vesico-ureteral reflux, would be of immense help to these children. Hence the study here is to find the role of ultrasonography in diagnosing and grading of vesicoureteral reflux.

Explanation of procedure: The patients referred to the Radiology department for the micturating cystourethrography will simultaneously undergo the ultrasonography.

Withdrawal from participation in the study: Participation in this study is voluntary. You will be free to decide whether to participate in this study or continue participation once enrolled. In case you decide to withdraw your participation, you are free to do so. However, please convey the decision to the principal investigator.

Possible benefits from participating in the study: You will/will not have nor get any benefits by participating in this study. The data gathered will help the population at large.

Possible risks from participating in the study: There are no risks involved in participating in this study.

Privacy and confidentiality: The information collected from you will be coded, to prevent any person from identifying you. Your identity will never be revealed. The data collected from you will be kept confidential and only processed or aggregated data will be used for publication.

Financial incentives: You will not receive any payment for participating in this study.

Authorization for publication of aggregated data: Results obtained after processing of the aggregated data will be published for scientific purposes and or presented to scientific groups.

However, your identity will never be revealed.

Questions: In case of any questions with regard to this study, you are free to contact:

“Reg No: BS0121001, Phone No: 9108606838, email ID: adarsh.c.m212@gmail.com”

If you have any question or complaints with regard to your right as study participant you may contact Dr Harsha Hegde, Chairperson, Ethical committee of JNMC, 0831-2473777 Extension 4052.

Legal rights: By signing this consent form, we are not waving any of your legal rights.

CONSENT TO PARTICIPATE IN RESEARCH STUDY:

1. I understand that I am participating in the study, which includes ultrasonography
2. I confirm that I have read and understood the information in the patient information sheet. Procedure is explained to me in detail along with information about the advantages and disadvantages of taking part in the study. I have been given the opportunity to discuss all aspects of the trial, to ask questions and hereby consent to participation in the trial outlined above.
3. I understand that the decision to take part in this study is completely voluntary and I am aware that I can choose to withdraw from the study at any point of time.
4. I consent to the photographing or recording of the procedure to be performed including appropriate portions of my body, for medical, scientific or educational purposes provided my identity is not revealed in the pictures or by the descriptive texts accompanying them.
5. I understand that there is no significant risk involved in the test that would be done in this study.
6. No guarantee or assurance has been given by anyone as to the results that may be obtained.
7. My signature on this form signifies that I have willingly decided to participate after understanding the above information

Participant's Name/ legally authorized _____ representative

Signature _____

Name and signature of witness _____

Name and signature of interviewer _____

Date:

Place:

ANNEXURE – II – PROFORMA

PROFORMA FOR DATA COLLECTION

NAME _____

AGE & SEX _____

OP/IP NO _____

MOBILE NO: _____

ADDRESS _____

USG NUMBER: _____

PRESENTING COMPLAINTS:- _____

PAST H/O VESICO-URETERAL SURGERY: _____

H/O OTHER CONGENITAL ANOMALIES: _____

	RIGHT	LEFT
AP diameter of renal pelvis		
Maximum diameter of proximal ureter		
Maximum diameter of distal ureter		
Vesicoureteral reflux (present /absent)		
Grade of vesicoureteral reflux		
Cortical thickness		
Cortical thinning		

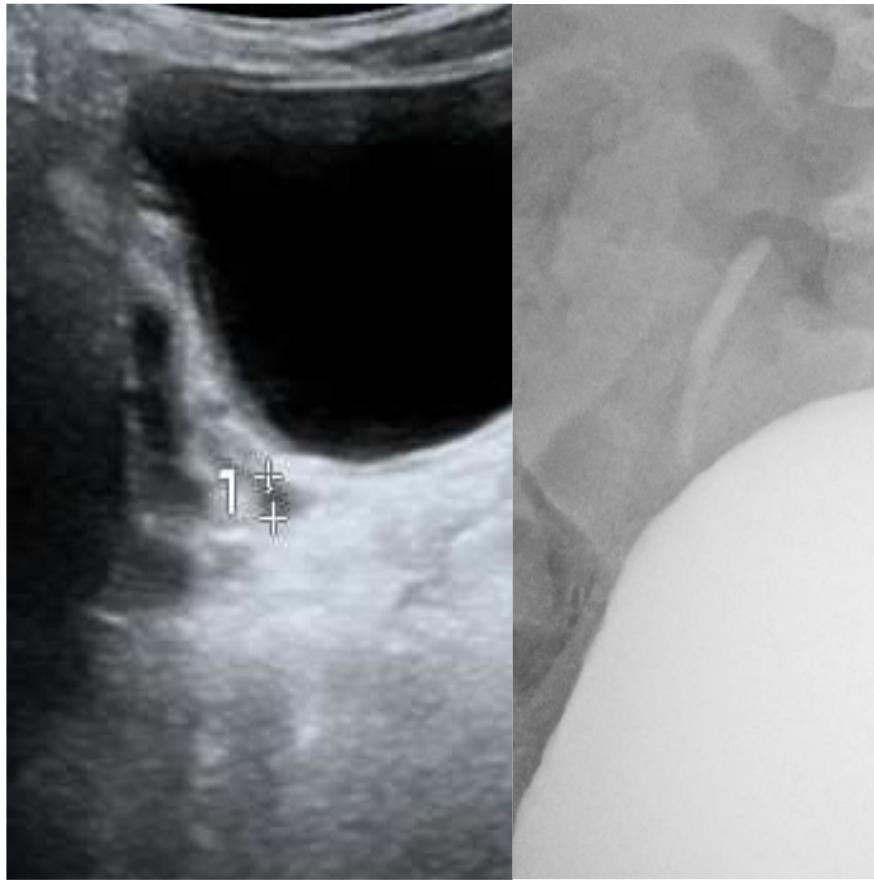
MCU FINDINGS: _____

ANNEXURE- III – FIGURES



GE VOLUSON P8 USG MACHINE USED FOR THE STUDY

PHOTOGRAPHS OF CASES



(a)

(b)

Figure 1; Ureteral dilatation with grade I reflux

(a). Transverse renal US image shows distal ureteric dilatation (b) Corresponding cystogram shows grade I VUR

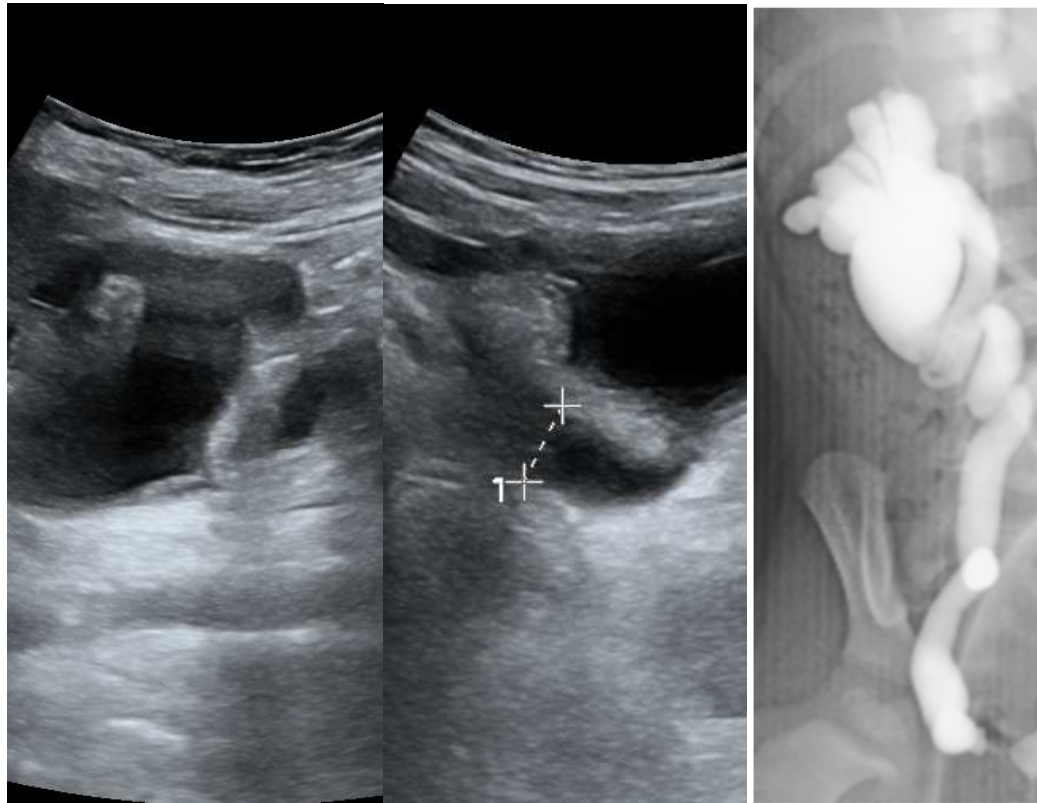


(a)

(b)

Figure 2; Ureteral dilatation with grade II reflux

(a). Transverse renal US image shows proximal ureteric dilatation with no dilatation of the renal pelvis (b) Corresponding cystogram shows grade II VUR



(a)

(b)

(c)

Figure 3: Ureteral dilatation with grade V reflux

(a) Transverse renal US image shows dilatation of pelvicalyceal system and proximal ureter (b) dilatation of the distal ureter (c) Corresponding cystogram shows grade V VUR

ANNEXURE IV: KEY TO MASTERCHART

H/O	HISTORY OF
M	MALE
F	FEMALE
CONG ANO	CONGENITAL ANOMALIES
APD	ANTEROPOSTERIOR DIAMETER
RT RP	RIGHT RENAL PELVIS
LT RP	LEFT RENAL PELVIS
MD OF RT / LT PU	MAXIMUM DIAMETER OF RIGHT /LEFT PROXIMAL URETER
MD OF RT / LT DU	MAXIMUM DIAMETER OF RIGHT /LEFT DISTAL URETER
RK / LK CT	RIGHT KIDNEY / LEFT KIDNEY CORTICAL THICKNESS
RK / LK ct	RIGHT KIDNEY / LEFT KIDNEY CORTICAL THINNING
RT / LT VUR	RIGHT / LEFT VESICoureTERAL REFLUX
CFEK	CROSSED FUSED ECTOPIC KIDNEY
PUV	POSTERIOR URETHRAL VALVE
USG	ULTRASONOGRAPHY

Sno	Age (yrs)	Sex	Presenting Complaints	H/O Cong ano	MCU Findings	APD of RT RP (cm)	APD of LT RP (cm)	MD of RT PU (cm)	MD of LT PU (cm)	MD of RT DU (cm)	MD of LT DU (cm)	RT VUR ON USG	LT VUR ON USG	RK CT (cm)	LK CT (cm)	RK ct	LK ct	Grading of rt vur	Grading of lt vur	USG GRADING OF THE VUR
1	5	M	Burning Micturition	PUV	Bilateral grade IV VUR	1.8	2.1	0.9	1.2	1.1	1.3	Yes	Yes	0.7	0.6	yes	yes	grade IV	grade IV	Bilateral grade IV VUR
2	10	M	Poor Stream	nil	Bilateral grade III VUR	1.2	1.3	0.5	0.6	0.6	0.5	Yes	Yes	1	1.1	no	no	grade II / III	grade II / III	Bilateral grade II / III VUR
3	8	M	Poor Stream	anal atresia	Bilateral grade II VUR	0.8	0.7	0.6	0.5	0.6	0.5	Yes	Yes	1.5	1.6	no	no	grade II	grade II	Bilateral grade II VUR
4	11	M	Fever	nil	Bilateral grade II VUR	0.6	0.5	0.3	0.4	0.4	0.7	Yes	Yes	1.6	1.6	no	no	grade I / II	grade I / II	Bilateral grade I / II VUR
5	8	F	Poor Stream of Urine	nil	Bilateral grade V VUR	2.6	2.5	1.5	1.3	1.4	1.3	Yes	Yes	0.4	0.3	yes	yes	grade V	grade V	Bilateral grade V VUR
6	8	M	Pain Abdomen	phimosis	Bilateral grade V VUR	2.5	2.5	1.3	1.4	1.3	1.5	Yes	Yes	0.3	0.3	yes	yes	grade V	grade V	Bilateral grade V VUR
7	3	M	Increased Frequency of Micturition	PUV	Bilateral grade IV VUR	1.7	1.9	0.9	1.3	1.1	1.2	Yes	Yes	0.7	0.8	no	no	grade IV	grade IV	Bilateral grade IV VUR
8	11	M	Burning Micturition	nil	Bilateral grade IV VUR	1.6	2	1.1	1.1	1	0.9	Yes	Yes	0.8	0.8	no	no	grade IV	grade IV	Bilateral grade IV VUR
9	8	M	Poor Stream	phimosis	Bilateral grade III VUR	1.1	1.3	0.6	0.5	0.6	0.6	Yes	Yes	1	1.1	no	no	grade II / III	grade II / III	Bilateral grade II / III VUR
10	9	M	Poor Stream	anal atresia	Bilateral grade III VUR	1.6	1.5	0.7	0.8	0.8	0.7	Yes	Yes	1.2	1.2	no	no	grade III	grade III	Bilateral grade III VUR
11	8	M	Fever	phimosis	Right grade II VUR	0.8	0.6	0.5	0.2	0.4	0.2	Yes	no	1.5	1.6	no	no	grade II	nil	Right grade II VUR
12	2	M	Poor Stream of Urine	nil	Bilateral grade I VUR	0.6	0.6	-	-	-	-	no	no	1.7	1.8	no	no	nil	nil	nil
13	12	M	Pain Abdomen	CFEK	Bilateral grade IV VUR	2.2	1.8	0.9	1.1	0.8	1	Yes	Yes	0.5	0.6	yes	yes	grade IV	grade IV	Bilateral grade IV VUR
14	11	M	Increased Frequency of Micturition	phimosis	Bilateral grade IV VUR	2.3	2.1	1.1	1.2	1	1.1	Yes	Yes	0.7	0.6	yes	yes	grade IV	grade IV	Bilateral grade IV VUR
15	6	M	Burning Micturition	nil	Bilateral grade III VUR	1.5	1.7	0.6	0.8	0.7	0.8	Yes	Yes	1	1.2	no	no	grade III	grade III	Bilateral grade III VUR
16	9	M	Poor urinary Stream	phimosis	Right grade IV VUR	2.4	0.7	1.3	0.3	1.3	0.2	Yes	no	0.8	1.3	no	no	grade IV	nil	Right grade IV VUR
17	12	M	Poor urinary Stream	phimosis	Bilateral grade II VUR	0.8	0.8	0.4	0.5	0.4	0.5	Yes	Yes	1.5	1.5	no	no	grade I / II	grade I / II	Bilateral grade I / II VUR
18	8	F	Fever	anal atresia	Bilateral grade V VUR	2.4	2.5	1.3	1.4	1.5	1.4	Yes	Yes	0.3	0.3	yes	yes	grade V	grade V	Bilateral grade V VUR
19	10	M	Poor Stream of Urine	CFEK	Bilateral grade V VUR	2.2	2.3	1.4	1.3	1.5	1.2	Yes	Yes	0.4	0.5	yes	yes	grade V	grade V	Bilateral grade V VUR
20	9	M	Pain Abdomen	PUV	Right grade IV VUR	1.3	0.6	0.6	0.2	0.5	0.2	Yes	no	0.6	1.4	yes	no	grade III / IV	nil	Right grade III / IV VUR
21	11	M	Poor Urinary stream	nil	Bilateral grade IV VUR	1.8	2.1	0.6	0.8	0.7	0.8	Yes	Yes	0.9	0.7	no	yes	grade III / IV	grade III / IV	Bilateral grade III / IV VUR
22	7	F	Burning Micturition	nil	Bilateral grade I VUR	0.5	0.4	0.3	0.2	0.5	0.6	Yes	Yes	1.4	1.5	no	no	grade I / II	grade I / II	Bilateral grade I / II VUR
23	10	M	Poor Stream	PUV	Bilateral grade II VUR	0.8	0.5	0.3	0.2	0.2	0.2	no	no	1.5	1.5	no	no	nil	nil	nil
24	6	M	Poor Stream	phimosis	Bilateral grade III VUR	1.5	1.7	0.6	0.8	0.7	0.8	Yes	Yes	1.3	1.2	no	no	grade III	grade III	Bilateral grade III VUR
25	11	M	Fever	nil	Bilateral grade IV VUR	1.9	2.2	1.1	1	1	1	Yes	Yes	0.8	0.7	no	yes	grade IV	grade IV	Bilateral grade IV VUR
26	7	M	Poor urinary Stream	CFEK	Bilateral grade IV VUR	2.2	2	0.6	0.8	0.7	0.8	Yes	Yes	0.7	0.7	yes	yes	grade III / IV	grade III / IV	Bilateral grade III / IV VUR
27	2	M	Pain Abdomen	anal atresia	Bilateral grade V VUR	2.4	2.2	1.3	1.2	1.4	1.5	Yes	Yes	0.3	0.4	yes	yes	grade V	grade V	Bilateral grade V VUR
28	11	F	Increased Frequency of Micturition	nil	Bilateral grade III VUR	1	0.9	0.3	0.2	0.3	0.2	no	no	1.1	1	yes	yes	nil	nil	nil
29	9	M	Burning Micturition	nil	Bilateral grade V VUR	2.6	2.4	1.5	1.6	1.5	1.7	Yes	Yes	0.4	0.4	yes	yes	grade V	grade V	Bilateral grade IV VUR
30	12	M	Poor Stream	PUV	Bilateral grade V VUR	2.3	2.3	1.5	1.7	1.6	1.7	Yes	Yes	0.5	0.4	yes	yes	grade V	grade V	Bilateral grade V VUR
31	6	M	Poor Stream	nil	Bilateral grade II VUR	0.5	0.5	0.3	0.2	0.2	0.2	no	no	1.3	1.4	no	no	nil	nil	nil
32	12	M	Fever	nil	Right grade IV VUR	2.1	0.8	1.1	0.2	1.1	0.2	Yes	no	0.8	1.2	no	no	grade IV	nil	Right grade IV VUR
33	3	M	Poor Stream of Urine	PUV	Bilateral grade V VUR	2.4	2.4	1.6	1.4	1.5	1.7	Yes	Yes	0.4	0.5	yes	yes	grade V	grade V	Bilateral grade V VUR
34	7	F	Pain Abdomen	PUV	Bilateral grade V VUR	2.3	2.4	1.7	1.6	1.5	1.4	Yes	Yes	0.5	0.5	yes	yes	grade V	grade V	Bilateral grade V VUR
35	11	M	Increased Frequency of Micturition	nil	Bilateral grade II VUR	0.6	0.8	0.5	0.5	0.6	0.6	Yes	Yes	1.4	1.3	no	no	grade I / II	grade I / II	Bilateral grade I / II VUR
36	9	M	Burning Micturition	nil	Bilateral grade III VUR	1.2	1.2	0.6	0.5	0.5	0.5	Yes	Yes	1.2	1.1	no	no	grade II / III	grade II / III	Bilateral grade II / III VUR
37	6	M	Poor Stream	PUV	Bilateral grade IV VUR	2.3	1.9	1.2	1.1	1	1.1	Yes	Yes	0.5	0.6	yes	yes	grade IV	grade IV	Bilateral grade IV VUR
38	5	M	Poor Stream	nil	Right grade II VUR	0.5	0.5	0.3	0.2	0.5	0.2	Yes	no	1.2	1.3	no	no	grade I / II	nil	Right grade I / II VUR
39	2	F	Fever	nil	Bilateral grade V VUR	2.4	2.4	1.6	1.4	1.5	1.7	Yes	Yes	0.4	0.5	yes	yes	grade V	grade V	Bilateral grade V VUR
40	12	M	Poor Stream of Urine	nil	Bilateral grade IV VUR	1.5	1.4	0.7	0.8	0.8	0.8	Yes	Yes	1.3	1.4	no	no	grade III / IV	grade III / IV	Bilateral grade III / IV VUR
41	9	M	Pain Abdomen	nil	Bilateral grade II VUR	0.8	0.7	0.6	0.6	0.7	0.6	Yes	Yes	1.4	1.6	no	no	grade II	grade II	Bilateral grade II VUR
42	11	M	Pain Abdomen	PUV	Bilateral grade I VUR	0.3	0.3	-	-	0.6	0.5	Yes	Yes	1.5	1.4	no	no	grade I	grade I	Bilateral grade I VUR