CORRELATION OF SONOGRAPHIC PATTERNS AND RENAL FUNCTION TESTS IN PATIENTS WITH SUSPECTED URINE OBSTRUCTION AT MOI TEACHING AND REFERRAL HOSPITAL –ELDORET, KENYA.

BY

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DECLARATION

I declare that this is my original work and has not been presented in any other university or institution for an award of a degree or any academic credit. No part of this work may be reproduced or transmitted in any form without prior permission from the author or Moi University.

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DEDICATION

This thesis is dedicated to my family – Hubesi's and friends for believing in me and giving me the strength to carry on.

“If you fell down yesterday, stand up today.”

— H.G. Wells

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I give my greatest gratitude to the almighty, Allah.

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TABLE OF CONTENT

ABBREVIATIONS

$\hat{\beta}_0$	Beta Hat coefficient
AKI	Acute kidney injury
BOO	Bladder outlet obstruction
BPH	Benign prostate hyperplasia
CDUS	Color Doppler Ultrasound
CKD	Chronic kidney disease
DDUSG	Duplex Doppler ultrasound
HOD	Head of Department
IVP	Intravenous pyelogram
LUTS	Lower urinary tract symptoms
MTRH	Moi Teaching and Referral Hospital
NAPRTCS	North American Pediatric Renal Transplant Cooperative Study
NPV	Negative predictive value
PPV	Positive predictive value
PUV	Posterior urethral valve
PVR	Post void urine residual volume
RI	Resistive index
SFU	Society of Fetal Ultrasound
TAUS	Trans abdominal ultrasound
TRUS	Trans rectal ultrasound
VUJ	Vesico-ureteral junction

DEFINITIONS

Caliectasis	Dilatation of the calyceal system.
Children	Participants under 18 years old.
Echogenicity	It is the amount of sound reflected from a probe and therefore it is how bright or dark an image of a tissue appears on gray scale imaging. It depends on the amplitude of incident sound, amount of sound absorbed, sound reflected and the angle of reflection
Gray scale ultrasonography	It is the use of high frequency sound waves to generate real time (brightness) B mode imaging, where the reflected ultrasound signals is converted into a gray scale image.
Hydronephrosis	Dilation of the collecting system of the kidney caused by an accumulation of urine resulting from obstruction of normal outflow.
Impedance index	Similar term used to refer to resistive index
Megacystis	An unusually large bladder.
Megaureter	An abnormally large ureter
Obstructive nephropathy	Kidney disease caused by obstruction of the urinary tract characterized by hydronephrosis, slowing of the glomerular filtration rate, and tubular abnormalities.

Obstructive uropathy	Obstructive uropathy is a condition in which the flow of urine is blocked.
Pyelohydronephrosis	Dilatation the pelvi-calyceal system.
Pyonephrosis	Pus collection in the renal pelvis
Resistive index	Sonographic index used to assess vascular resistance
Urine retention	Inability to completely empty the bladder
Urinoma	Peri-renal encapsulation of urine extravasations caused by disruption of the urinary collecting system.

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ABSTRACT

Background: Obstructive uropathy is known to result in urinary tract infections, renal injury and eventually end stage renal failure. The prevalence of this disease has not been established locally due to limited studies in this area.

Ultrasound is the imaging modality of choice in the initial investigation of urine obstruction. This study sought to establish local baseline ultrasound imaging profile and determine the utility in detection of early kidney changes.

Objective: The purpose of this study was to evaluate gray-scale and Doppler ultrasonographic patterns of patients referred with clinical suspicion of urine obstruction in correlation to creatinine and urea levels.

Methods: A cross sectional study was carried out at the Radiology and Imaging Department, Moi Teaching and Referral Hospital in Eldoret between October 2014 and October 2015. Participants with clinical suspicion of urine obstruction were enrolled into the study by consecutive sampling. Clinical, sonographic data, creatinine and urea levels were collected using a structured questionnaire. Data analysis was done using SPSS version 21.0. Data was summarized into mean, median and percentage. ANOVA, chi square, linear regression models and Krukal-Wallis test were used to assess correlation. Level of statistical significance was 5%.

Results: A total of 84 participants were evaluated. The median duration of symptoms was 12.0 (IQR: 2.0-30.0) months. The mean age was 61.5 ± 24.7 years with an age range of 0.25 – 105.7years. There was a male predominance n = 73 (86.9%). Prostate enlargement was seen in n = 47 (70.1%) male >17years. Urine retention was diagnosed in n = 33 (56.9%) participants without Foleys catheter. Normal ultrasonographic patterns were seen in n = 4 (4.8%). The children n = 9 (10.7%) were the minority with variable findings according to age. The average length of an adult kidney was 9.7 ± 1.7cm & 10 ± 1.8 cm for the right and left kidneys respectively. Grade 0 hydronephrosis was common n = 54 (64.3%) and 52 (62.7%) for the right and left kidney respectively. Loss of corticomedullary differentiation and echogenic renal cortex were seen in 79 (94%), 80 (95.2%) and 44 (52%), 45 (54 %) for the right and left kidney respectively. The mean RI was (0.689 ± 0.086), (0.687 ± 0.097) and (0.671 ± 0.080), (0.654 ± 0.0880) for right and left renal and interlobar arteries respectively. There was no correlation in distribution of mRI across the grades of hydronephrosis p=0.047, 0.099 and 0.032, 0.156 for the right and left renal and interlobar arteries respectively. There was a weak positive correlation between RI with levels of both creatinine and urea (p=0.003-0.026) except for the RI of the left renal artery in relation to urea (p=0.058).There was no statistical significant relation between creatinine and urea with renal cortical echotexture (p= 0.127, 0.146, 0.051) except for urea and right kidney echotexture (p=0037).

Conclusion: Participants presented with longstanding symptoms of chronic urine obstruction. Patterns of chronic renal injury were mostly seen. There was no correlation in distribution of mRI across the grades of hydronephrosis. There was a weak positive correlation between RI with levels of both creatinine and urea except for the RI of the left renal artery in relation to urea. There was no association between renal cortical echotexture and renal function test except for urea and right kidney echogenicity.

Recommendation: A combination of clinical presentation, renal function tests and ultrasound should be utilized for the initial assessment of renal injury

CHAPTER ONE

INTRODUCTION

1.1 Background

Obstructive uropathy is one of the causes of post-renal renal failure. Whereas longstanding urinary tract obstruction is known to lead to obstructive nephropathy (Abrams et al., 2012), early surgical interventions have been found to reverse renal injury (El Imam, 2006). Few studies have been done in East Africa hence the actual data on the prevalence and incidence of obstructive uropathy and the burden it poses on renal replacement therapy is lacking.

Unpublished study on 'The Diagnostic Value of Ultrasound in Renal Diseases in Adult Patients at Kenyatta National Hospital' showed 6.7% of 105 patients who underwent renal ultrasound had an indication of obstructive uropathy (Thinwa, 1995). A study on obstructive uropathy in Sudan showed 345 (66%) among 520 patients presented with chronic obstruction while 175 (34%) had acute obstruction. Two hundred and ten (40%) had significant renal impairment among which 50 (23%) required emergent dialysis (El Imam, 2006). Records at Lagos University Teaching Hospital in Nigeria showed that 40.2% of Uroradiologic request in all age groups in the department of Radiodiagnosis from a period of March 1990 – February 1995 had a diagnosis of obstructive uropathy (Soyebi & Awosanya, 1996).

Approximately 2/1000 people are hospitalized with obstructive uropathy in the USA. Varied prevalence based on different etiologies in specific age groups ranging from 5/10000 to 5/1000 have been reported (Preminger, 2016). A survey on elderly men showed a prevalence of 20 – 35% of obstructive uropathy. Post mortem examinations showed 3.8% of adults and 2.0% of children had hydronephrosis (Alter, 1997; Curhan & Zeidel, 1996; Nayyar, 2005). Overall, obstructive uropathy was responsible for about

4% of end-stage renal failure (Preminger, 2016). According to the annual report of the North American Pediatric Renal Transplant Cooperative Study (NAPRTCS), obstructive uropathy is the cause of renal failure in 16.2% of pediatric patients who underwent renal transplant, 12.9% of those on dialysis, and 23.1% of those with chronic renal insufficiency. It was also found that obstructive uropathy associated with congenital malformations accounted for 30 – 50% of all end stage renal failure (Nayyar, 2005) (Huang, 2000).

1.2 Problem Statement

Though the prevalence of obstructive uropathy is not known, in MTRH it is a frequently encountered condition with the majority of patients presenting in the late stages with signs of renal injury. Early features are also nonspecific and may present with normal imaging findings.

Delayed diagnosis is commonly associated with sequelae of obstructive nephropathy. Few studies done on the causes of renal replacement therapy have shown obstructive uropathy to be an uncommon cause of renal failure, accounting for approximately 6.7% in patients with renal disease who underwent ultrasound at KNH (Thinwa, 1995). In Sudan 210 (40%) among those with obstructive uropathy had significant renal impairment, 50 (23%) of them required emergency dialysis (El Imam, 2006) and in another study 9.6 % accounted for causes of ESRD among 1583 patients (Banaga et al., 2015). However lack of adequate population studies to back the speculated low incidence of obstructive uropathy cannot rule out a significant burden on the health sector. Most causes of obstructive uropathy can be successfully managed with early intervention thus preventing the associated complications. El Imam’s study showed 100% complete recovery of renal function with early management in acute obstruction and 90% stabilization in chronic obstruction (El Imam, 2006). Halle’s study in

Cameroon demonstrated the degree of renal recovery was dependent on the duration of the obstruction with 28% total renal recovery and 4% partial recovery among 229 patients (Halle, 2016).

1.3 Justification

Locally, studies on obstructive uropathy are lacking. Contradictory results on the use of Doppler renal ultrasound to diagnose early signs of renal injury and to distinguish complete from partial, acute from chronic and obstructive from non obstructive urine obstruction have been documented. This study looked into a reversible cause of renal failure to establish a local baseline data of ultrasound imaging and determine if Doppler renal ultrasound could detect early signs of kidney injury as some studies have proposed. Whose application could enable early diagnosis and therefore reduce morbidity and mortality resulting from it.

Though ultrasound cannot diagnose all the causes of obstructive uropathy, it is the first imaging modality of choice because it carries no known side effect and contraindications, it is non radiative, cheap, feasible and can depict changes in the urinary system caused by obstructive uropathy. Gray scale coupled with Doppler ultrasound has been shown to pick early renal changes as opposed to Gray-scale ultrasound alone.

1.4 Research Questions

What is the profile of ultrasonographic features in patients referred with clinical suspicion of urine obstruction at Moi Teaching and Referral Hospital?

What is the correlation between renal sonographic patterns and renal function tests?

1.5 Research Objectives

1.5.1 Main objective

To describe the sonographic patterns and evaluate the sonographic patterns of renal changes in relation to renal function test in patients referred with clinical suspicion of urine obstruction at Moi Teaching and Referral Hospital (MTRH).

1.5.2 Specific objectives

- To describe the patterns of gray scale and Doppler ultrasonography in patients referred with a clinical suspicion or diagnosis of urine obstruction or urine retention at Moi Teaching and Referral Hospital.
- To correlate sonographic patterns of renal changes with renal function tests.

CHAPTER TWO

LITERATURE REVIEW

2.1 Epidemiology

There is paucity of studies for the prevalence and incidence of urine obstruction (Nayyar, 2005). Though studies on the different causes in specific age groups have been done, the prevalence and incidence of urine obstruction as a whole subject cannot be clearly stated. A prospective multicenter community-based study in Madrid done on 748 participants with acute renal injury showed 10% of the causes were due to obstructive acute kidney injury (Liaño, 1996).

Urinary tract obstruction occurs most commonly in the young and the elderly (Fitzpatrick, 2006). Hydronephrosis, the hallmark of urine obstruction is relatively common in pediatrics due to congenital abnormalities. Prenatally, 1 in 100 fetuses are found to have hydronephrosis on ultrasound. Congenital urethral tract obstructions are more common in boys, owing to posterior urethral valves. An analysis of children presenting after renal tract trauma found an incidence of congenital renal tract abnormalities of 8.3%. Most common site of obstruction was at the pelvi-ureteric junction (McAleer, 2002).

In adults, urinary tract obstruction is common in men with benign prostate hyperplasia (BPH) and urethral strictures being the most common causes. In women, pelvic tumors, prolapse of pelvic structures or pregnancy are the most common causes (Naderi, Mochtar, & de la Rosette, 2004). The incidence of lower urinary tract obstruction is approximately 15 /1,000 man-years. In the age group of 45-49, it is 3 /1,000 man-years but increases to 38/1,000 man-years by age 75-79 (Naderi et al., 2004). Acute urinary retention is relatively uncommon, with a cumulative incidence of 2% over five years in men with symptomatic BPH (Fitzpatrick, 2006).

2.2 Definition

Urine obstruction is a structural or functional blockage of the normal urine flow at any point of the urinary tract (El Imam, 2006).

Urine obstruction can be classified according to various factors. Unilateral or bilateral based on the number of kidneys involved. Partial or complete based on the degree of obstruction. Acute or chronic based on the duration of symptoms. Where the former occurs within hours to weeks with abrupt cessation of urine flow, while chronic obstruction occurs within months and years with insidious onset of symptoms (Schrier, 2010; Windus, 2008). Some authors have included a subacute phase ranging from days to weeks (Greenberg, 2005). It can also be classified based on the site or level of obstruction as upper and lower urinary tract obstruction with reference to the vesical urethral junction (VUJ) (Schrier, 2010; Windus, 2008).

2.3 Ultrasonographic Patterns

Ultrasonography is the preferred first imaging modality of choice in urinary system imaging, owing to it's a non-invasive, painless and non-radiative property (Adam, 2014).

2.3.1 Gray scale renal sonographic patterns

Gray scale ultrasound has been reported to have a high sensitivity of >90% in detecting renal obstruction but with a varied specificity of 65-84% (Ashraf, 2009; Moghazi, 2005; Oktar, 2004; Platt, 1992). The kidney usually grows rapidly in the first few years of life, reaches its maximum size in the third decade, plateaus at the fifth and sixth decade then decreases in size thereafter (Adam, 2014). With aging renal parenchyma is replaced by adipose tissue and the mass also decreases in size by over 20 % (Adam, 2014).

Kidney size

The kidney length is approximately three lumbar vertebrae in adults and four in children. The size is dependent on gender, age and body size (Adam, 2014; Jackson, 2003). Studies have shown that renal volume is the most accurate measurement of renal size, but it is highly affected by interobserver variability. Therefore renal length is the most practical and reliable measurement as it is less affected by inter-observer variability and can easily be reproduced. The maximum renal length is more reliable than other measurements as it correlates well with chronic renal disease (Bakker, 1999; Emamian, 1993; Moghazi, 2005; O’Neill, 2014). The left kidney is usually larger than the right by 0.3cm due to anatomic confinement of the right kidney where it is compressed by the liver (Maaji, 2015). A size difference of 2cm or more between the two kidneys is a sign of unilateral disease (Adam, 2014; Moghazi, 2005).

Ultrasound may distinguish some of the features of acute and chronic kidney injury. Acute kidney injury may have nonspecific ultrasound patterns ranging from normal to increased kidney mass. However chronic kidney injury may also present with a preserved renal size (Ozmen, 2010) though it’s commonly known to present with a smaller kidney size. A prospective study by Ozmen where 127 participants with creatinine levels above 3mg/dl were assessed, it was found that participants with CKD had a shorter kidney size of 9.0 ± 1.5cm. Studies have also shown that kidney sizes decreases with age after 60 years (Emamian, 1993).

Assessment of cortical thickness is usually subjective and also affected by inter observer variability (Moghazi, 2005; O’Neill, 2014). It is also difficult to determine in cases where corticomedullary differentiation is lost (Moghazi, 2005). Though studies have shown that cortical thinning is highly suggestive of chronic kidney injury, a normal cortical thickness can be seen in both acute and chronic kidney injury (Ozmen, 2010). O'Neill suggested that a combination of small renal size, thin cortex and renal cysts highly favour features of chronic kidney injury (O'Neill, 2014).

Echogenicity

On ultrasound normal renal cortex appears slightly hypoechoic to a normal liver and spleen. The medulla is usually less echogenic than the cortex due to increased number of collecting tubules with high fluid content (S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014; Grenier, 2016). Invaginations called the columns of Bertin between medullary pyramids appear hyperechoic compared to the cortex in the first 6 months of life, then become less hyperechoic with ageing and some diseases (Adam, 2014; Jackson, 2003).

Neonates usually have an echogenic renal cortex due to immaturity and also the renal sinus fat is less than in older children, thus sonographic corticomedullary differentiation is usually depicted well in this age group (Daneman, 2010; Jackson, 2003; Moghazi, 2005). Thereafter echogenicity of the cortex decreases till 4-6 months of age, where it becomes hypoechoic relative to the liver (Daneman, 2010).

Renal echotexture alone is insufficient to distinguish among different causes of kidney injuries (S. Faubel, Patel, Nayana U, Lockhart, Mark E, Cadnapaphornchai, Melissa A, 2013; S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014; Moghazi, 2005; O'Neill, 2014). But a combination of a small kidney size and increased echogenicity favors chronic kidney disease (CKD) with high specificity (Moghazi, 2005). Though CKD may also present with normal kidney size and increased echogenicity, it is a non-specific finding occurring in association with multiple histopathologic renal diseases and has also been seen with inadequate hydration (S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014; Moghazi, 2005; O'Neill, 2014).

Studies comparing renal echotexture to histopathology have yielded non-specific results. An increase in echogenicity is less specific and has been correlated with various histologic renal abnormalities i.e. interstitial fibrosis, tubular atrophy, inflammation, and glomerulosclerosis (Hricak et al., 1982; Moghazi, 2005). A decrease in echogenicity usually results from interstitial inflammation (S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014; O'Neill, 2014).

Corticomedullary differentiation decreases with age; therefore its absence is usually a normal finding. However prominence of corticomedullary differentiation may indicate increased echogenicity of the renal cortex (O'Neill, 2014).

A study by Siddappa et al showed that renal cortex echogenicity correlated well with serum creatinine in CKD than other sonographic parameters like renal length, parenchyma thickness and cortical thickness. He argued that renal echogenicity was a better parameter than serum creatinine when estimating renal function because of its irreversibility with renal replacement therapy unlike serum creatinine (Siddappa, Singla, Al Ameen, Rakshith, & Kumar, 2013).

Hydronephrosis

Ultrasound has a sensitivity of approximately 98% and a specificity of 78% in detecting hydronephrosis. Pyonephrosis is shown by echoes in the collecting system while thickness of renal parenchyma indicates duration and severity of obstruction (Jackson, 2003).

Hydronephrosis is the hallmark for urine obstruction, though studies have shown that absence of it does not rule out obstruction especially in acute obstruction (Tseng, 2004).

Ashraf's study on comparison of diagnostic accuracy of DDUSG showed that ultrasound had a high sensitivity of 97.5% with a false negative ratio of 2.5% in detecting hydronephrosis (Ashraf, 2009). Similarly, Ellenbogen study found an overall sensitivity of 98% in detecting hydronephrosis. Though, the sensitivity decreased from severe to mild hydronephrosis with 100% sensitivity for severe to moderate and false positive and negative rates of 26% and 2% for mild hydronephrosis respectively. These indicate that ultrasound is a poor tool in detecting mild hydronephrosis (Ellenbogen, 1978).

2.3.2 Renal Doppler ultrasound patterns

Though gray scale ultrasound has high sensitivity in depicting urine obstruction, studies have shown that late onset hydronephrosis usually presents with normal gray scale ultrasonographic patterns. Thus may lead to a missed diagnosis of urine obstruction (Oktar, 2004). Therefore Doppler renal ultrasonography enables early detection of changes in the intrarenal blood flow and collecting system that occur with urinary tract obstruction. During urine obstruction the pressures in the collecting system increases. This will lead to a reduction in the renal vascular compliance. Hence this will result in an increase in the vascular resistance and a reduction in the diastolic flow more than the systolic flow. Measurements of RI/impedance index indirectly indicate the intrarenal vascular resistance: ((peak systolic velocity – end diastolic velocity)/ peak systolic velocity). This usually occurs in phases. The 1st phase occurs in the first two hours, where the venous flow increases due to vasodilatation. 2nd phase occurs between 2-4 hours and renal blood flow decreases due to vasoconstriction. The 3rd or chronic phase is between 3-5 hours and the blood level returns to baseline then a steady decline ensues. (Shokeir, Provoost, & Nijman, 1997).

However, high RI >0.7 may be seen in children under four years of age and in elderly patients without renal insufficiency due to higher active renin levels and compromised vascular compliance respectively (Apoku, 2015; Bude, 1992; Murat, 2005; Platt, 1993; J. F. Platt, 1992; Tublin, Bude, & Platt, 2003).

Increased RI can occur in both acute and chronic kidney injury (Sugiura & Wada, 2011). A study by Piazzese et al showed that RI was excellent at diagnosing acute dilatation of hydronephrosis with high sensitivity (100%), specificity (80%), accuracy (92.6%), positive predictive value (PPV) (87.9), negative predictive value (NPV) (100%) and efficiency (84%). Sensitivity was higher in complete obstruction rather than partial obstruction (Piazzese, 2012). De Toledo and Saboo also reported high sensitivity (91.8-96%) and specificity (84%) in detecting complete obstruction and low a sensitivity (48.1-73.3%) in partial obstruction with specificity of 100%. They also reported high RI levels in patients presenting < 12-24 hours. Though this studies were done on participants with acute obstruction (De Toledo, 1996; Saboo, 2007). Similarly, Platt and Opdenakker demonstrated that RI decreases substantially after 24 hours of onset symptoms (Opdenakker, 1998; J. F. Platt, 1992).

However, Amirthalingam documented that intrarenal RI was less sensitive in predicting acute ureteric obstruction and therefore should not be interpreted in isolation. He proposed the use of RI Ratio instead, as it was a better parameter (Amirthalingam, 2014). These findings were echoed by Taj-Aldean where no significant relationship was found between the RI and acute obstruction or degree of obstruction (Taj-Aldean, 2015).

Studies have shown that RI >0.7 is a good discriminatory between obstructive and non-obstructive uropathy with a high sensitivity (82.5-100%), specificity (88-90%) and accuracy (90%) (Apoku, 2015; Ashraf, 2009; Gottlieb, 1997; Platt, 1993; Saboo, 2007). Ashraf compared Doppler ultrasonography and IVP in obstructive uropathy, and found an excellent sensitivity and specificity in detecting obstructed kidneys by use of RI cut off of >0.7. He found a high RI in obstructed kidneys on IVP with a range and mean of 0.71-1.42, 0.76 respectively, while non-obstructed kidneys had a relatively low RI range and mean of 0.49-0.70, 0.61 (Ashraf, 2009). Similar findings were reported by Saboo and Oktar (Oktar, 2004; Saboo, 2007).

In contrast, Chen and Azam et al study documented a lower sensitivity (53-76.2%) in discriminating obstructive and nonobstructive urine obstruction with specificity; 88.13%, NPV; 68.2%, PPV: 68.2% and an accuracy of 80%. They attributed the difference to decreased blood flow in chronic obstructed grade 4 hydronephrosis or due to absence of vasoconstriction in early presentation less than 24 hours and use of NSAID which had been shown to reduce RI sensitivity from 70% to 50% within 6 hours (Azam & Beg, 2013; Chen, 1993). Naleini et al also found no relation between RI and hydronephrosis in acute renal colic as there was no difference of RI values in obstructed kidneys with and without hydronephrosis. He concluded that Doppler ultrasound alone is not sufficient in diagnosing unilateral obstructive uropathy (Naleini & Maryam Javheri 2015).

Studies have shown discordance in the use of mRI to depict chronic urinary obstruction. Ashraf argued that Duplex Doppler ultrasonography (DDUSG) is not only able to detect acute obstruction but also chronic established urinary obstruction (Ashraf, 2009). Comparable findings where RI >0.7 or asymmetry difference of >0.1 between kidneys differentiated obstruction from urinary tract ectasia were also documented (Von Schultess & Zollikofer, 2012). Similarly, Dwivedi et al found RI could detect change in renal perfusion in chronic urinary obstruction with 100% specificity and 88% sensitivity (Dwivedi, Shrivastava, & Dubey, 1998).

Nevertheless, Oktar found no significant difference in mRI in chronic obstruction vs. non obstructed kidneys (Oktar, 2004). Normal RI values have been seen in late chronic obstruction due to modest increase in RI or partial obstruction that hasn't compromised the renal vascular supply (Platt, 1993; Tseng, 2004). Resistive Index normalized after relief of obstruction despite persistent dilatation of the collecting system (Platt, 1993).

Analysis of mRI across grades of hydronephrosis; N Apoku and Platt's study documented a steeply increasing mRI across the grades of hydronephrosis from grade I to grade III but fell rapidly in grade IV (Apoku, 2015; J. F. Platt, 1992)). Chen found that RI correlated well with the degree of obstruction and RI of >0.7 warranted surgical intervention in obstructive uropathy. He argued that cases with RI< 0.7 probably had minimal altered renal blood flow and the renal function was probably unchanged (Chen, 1993). Platt's study also echoed Chen's findings by proposing that a normal RI indicates minimal obstruction without associated increase in vascular resistance (Platt (Platt, 1993).

In contrast, studies by Lee and Tseng revealed that, though RI increases significantly with severity of obstructive uropathy, it was not a good indicator for chronic and partial obstruction, therefore sensitivity of identifying severe obstructive uropathy that needs intervention was low at 39%(11/39) (Lee, 1996; Tseng, 2004). Comparable findings were seen in the minority group in Tseng's study where 2 participants had severe hydronephrosis and impaired renal function evidenced by radioisotopic renography, but with RI levels of <0.7. This implies that long-term gradual increase in pressure in the collecting system results in modest increase in RI. Therefore a normal RI does not always mean absence of change in the renal vascular system and a normal renal function. Similarly, Piazzese also found no correlation between degree of hydronephrosis and RI levels (Piazzese, 2012).

2.3.3 Bladder ultrasound

Urine retention is the inability to completely empty the bladder of urine (Oefelein, 2008). It can be classified as complete or partial and acute or chronic. Acute urinary retention is abrupt onset of inability to voluntarily urinate while chronic urine retention is persistent inability to completely evacuate the bladder resulting in elevated post void residual urine volumes (PVR) that develops insidiously over months to years. It is usually characterized by a non-tender palpable bladder after voiding. This predisposes to increased risk for urinary tract infections (Oefelein, 2008).

Several causes have been found in association with urine retention, ranging from obstructive, infectious, inflammatory, pharmacologic, neurologic etc (Selius & Subedi, 2008).

Bladder outlet obstruction (BOO) is usually accompanied by detrusor smooth muscle hypertrophy and collagen deposition, which decrease after relieve of obstruction (Manieri, 1998). Therefore Bladder wall thickness (BWT) measurements have high predictive value for BOO (Oelke, 2007). BWT is dependent on multiple factors; the age, sex and the bladder capacity (Peedikayil, Shyamkumar, & Kekre, 2004). Manieri et al, who studied 174 participants with lower urinary tract symptoms (LUTS), found that a cut off of 5mm at 150ml bladder volume was the best to diagnose bladder outlet obstruction (BOO) (Manieri, 1998). Similarly, Peedikavil's et al study showed that BWT was a good indicator for BOO compared to free uroflowmetry. He also found cut off value of >4.5mm predicted urinary obstruction with a sensitivity and specificity of

80% and 92% respectively (Peedikayil et al., 2004). This findings were echoed by Oelke who showed that detrusor wall thickness (DWT) was a good indicator for BOO better than free uroflowmetry, post void residual urine or prostate volume and therefore he advocated for its use in clinical practice (Oelke, 2007).

Contrary, Oelke's study demonstrated that at bladder capacity of <250 ml, DWT was dependent on the bladder filling, but remained stable with a bladder capacity >250ml, therefore he advocated for DWT to be measured with a bladder volume >250ml. He also argued that measurement of the bladder wall thickness is prone to errors, such as due to inclusion of the perivesical tissue, the bladder mucosa and adventitia which may be thickened due to other causes such as infection and cancer. Thus DWT is the most reliable measurement with positive predictive value of 94% and specificity 95% (Oelke, 2007).

Post void residual urine volume (PVR) is either due to weakness of detrusor muscle contraction with inability to generate enough pressure to enable complete bladder evacuation or due to detrusor muscle dysfunction. Ultrasound is a non invasive imaging modality that can accurately measure post void residual volume on a daily basis. Ultrasound errors increase with decrease in residual volume (Maruschke, Protzel, & Hakenberg, 2009).

Post void residual volumes (PVR) >50 ml is significant for a diagnosis of urine retention (Madersbacher, 2004). Studies have shown that higher volumes are associated with increased incidence of urinary tract infection (UTI). PVR of more than 300ml have been associated with upper urinary tract dilatation and renal insufficiency (Kelly, 2004; Manieri, 1998). Madersbacher's et al study showed that persistent PVR >100 ml requires invasive intervention to relieve obstruction. However, large PVR >200–300 ml usually indicates marked bladder dysfunction and therefore invasive intervention usually causes unsatisfactory results (Madersbacher, 2004).

Kolman's study demonstrated men with prostate volume >30ml were 2.5 more likely to have post-void residual greater than 50 ml (Kolman, 1999).

2.3.4 Prostate

Prostate enlargement is one of the common causes of obstructive uropathy in middle aged men while prostate cancer is prevalent in elderly men patients. In 80% of cases prostatic carcinoma arises in the peripheral zone. They generally appear hypoechoic but echogenicity varies with increasing tumour size and (Kilic, 2014; Ogwuche, 2013).

Kilic's study found that both trans-abdominal ultrasound (TAUS) and trans-rectal ultrasound (TRUS) measured prostate volume correlated well with actual prostate weight, though TRUS was more accurate method for measuring prostate volume (Kilic, 2014). Similarly, Maruschke et al agreed on TRUS being an accurate method of estimating prostate volume and better assesses the transitional zone separately, but differed on the routine use for TRUS as it was not helpful in benign prostate enlargement (Maruschke et al., 2009).

Other studies found comparable estimated transitional zone volume with TRUS and TAUS with no significant difference in correlation ($r=0.594$, $p<0.001$), although TRUS offered superior clarity in defining zonal anatomy and had higher sensitivity and specificity than TAUS (Ajayi, 2013).

Peedikayil et al found modest correlation between prostate volumes as measured by suprapubic ultrasonography and BOO (Peedikayil et al., 2004). However Bosch et al did not find any correlation between extent of prostate size and benign prostatic obstruction (Bosch, Bangma, Groeneveld, & Bohnen, 2008).

Presence of calcifications in the prostate parenchyma indicated chronic inflammation, and it’s commonly seen with benign prostate enlargement (Maruschke et al., 2009).

2.4 Correlation between Sonographic Renal Changes and Renal Function Tests.

Most studies have compared RI to sonographic changes of obstructive nephropathy or to patients known to have evidence of renal injury evidenced by deranged renal function tests or IVP. Higher levels of RI have been associated with worse renal parenchyma damage and worse outcome (Sugiura & Wada, 2009, 2011).

Apoku study documented that RI> 0.7 had a sensitivity of 86.7% and specificity of 90% in predicting obstructive nephropathy (Apoku, 2015). Siddappa et al found that renal echogenicity correlated well with serum creatinine in CKD. He also recommended the use of echogenicity to estimate renal function as opposed to serum creatinine. He argued that serum creatinine levels reduced with renal replacement therapy therefore could not assess renal injury status (Siddappa et al., 2013).

Nonetheless, the minority group in Tseng study showed 2 participants with severe hydronephrosis and impaired renal function evidenced by radioisotopic renography, had RI levels of <0.7 (Tseng, 2004).

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Study Design

This was a cross sectional study. Data was collected by reviewing ultrasound scans of patients referred with suspicion of urine obstruction within a period of one year from October 2014 to October 2015.

3.2 Study Site

The study was conducted at the Radiology and Imaging Department, participants being patients from outpatient, urology and renal clinic at Moi Teaching and Referral Hospital and its environs.

The Hospital is located in Eldoret town, which is 312 kilometers northwest of the Capital Nairobi. MTRH is a tertiary (level 6) health facility serving as a teaching hospital for Moi University School of Medicine, Public health and Dentistry. Other training institutions using this facility as a teaching hospital include Kenya Medical Training Center (KMTC), Eldoret and University of Eastern Africa Baraton School of Nursing. MTRH is also a training center for medical, clinical and nursing officer interns. It is the referral hospital for the Western part of Kenya and North rift and has a catchment population of approximately 16 million people corresponding to 40% of Kenya’s population.

3.3 Study Population

The study population included all patients referred with clinical suspicion of urine obstruction at the Ultrasound Department, Moi Teaching and Referral Hospital.

3.4 Sampling Technique

3.4.1 Sampling method

Consecutive sampling was used in this study, where every patient referred for ultrasound with suspected urine obstruction and had complete renal function test was included. Informed consent was obtained from adults. Consent was also obtained from guardian for children under 18 years and additional assent from children between the age of eight and seventeen years.

3.5 Study procedure

Patients referred from outpatient, Urology and Renal clinics with clinical suspicion or diagnosis of urine obstruction who met the study criteria, were identified at the ultrasound room Radiology and Imaging department. Informed consent was obtained from the study participants chosen. For participants between 8 and 17 years consent was obtained from the guardian then additional assent from the participants. Consent was obtained from the guardians for children under 8years of age. A complete KUB scan was done according to MTRH protocol and additional Doppler renal ultrasound was performed. The findings were verified by 2 Radiologists oblivious to the study. The ultrasonographic patterns in conjunction with clinical and renal function tests obtained from patients and MTRH laboratory respectively were used for the study.

3.5.1 Procedure for KUB ultrasound scan

The ultrasound machines used were Aloka's Prosound Alpha 7 and Phillips HD 11xe. Ultrasound of the genitourinary tract was performed after the patient had been adequately prepared. Some patients were asked to fast to reduce bowel gas and to enable bladder visualization and one liter of water was taken one hour prior to examination to distend the bladder.

Gray scale renal ultrasound

The kidneys were examined with the patient either in supine, prone or turned 45degrees on the side under examination. Using 3.5-5MHz sector transducer placed on the para-sagittal or coronal at the intercostal or subcostal region at the mid axillary line, mid longitudinal and transverse images of the kidney were acquired by rotating the transducer through transverse and sagittal plane. A normal renal cortical parenchymal was similar in echogenicity to a normal liver and spleen on the right and left side respectively. The renal sinus appeared higher in echogenicity to the cortex. Corticomedullary differentiation was also assessed. The kidney size was measured using length and width from a mid-sagittal image across the hilum. The ureters were not visualized unless they were dilated.

Hydronephrosis was graded according to Society of Fetal Ultrasound (SFU) system (table 1), which was initially designed for grading hydronephrosis in neonates and infants but currently it is most widely used even in adults (Fernbach, 1993; Keays et al., 2008). Hydronephrosis was graded after micturition.

Table 1: Hydronephrosis grading

Grade of hydronephrosis	Ultrasound features
Grade 0	No dilatation.
Grade 1	Dilated renal pelvis without dilatation of the calyces No parenchyma atrophy
Grade 2	Mild dilatation of the renal pelvis and calyces. No parenchyma atrophy.
Grade 3	Moderate dilatation of the renal pelvicalyceal system. Blunt fornices and flattened papillae. Mild cortical thinning.
Grade 4	Gross dilatation (ballooned) of the pelvicalyceal system. Cortical thinning.

Doppler ultrasound protocol

Using low frequency probe (3-5MHz) renal arterial supply was assessed using both direct and indirect technique by assessing both the renal and interlobar artery. Patients were examined either in oblique coronal, prone or decubitus position. The probe was moved from the spine laterally to locate and renal hilum using color Doppler. The interlobar artery was sampled adjacent to medullary pyramids (Coombs, 2004; Rumwell & McPharlin, 2000).

The Doppler angle used was 45-55 degrees and color was adjusted to avoid aliasing. One millimeter sampling gate was used. The Resistive Index was measured by placing a caliper on the peak systolic velocity and the other caliper on the lowest diastole. A normal waveform demonstrated a low resistance monophasic waveform with a rapid upstroke in systole (Coombs, 2004).

Bladder ultrasound

Bladder ultrasound was assessed after adequate bladder filling or the maximum bladder capacity tolerated by the patient. Using a low frequency probe (3-5MHz) and patient in supine position a suprapubic approach was undertaken. The bladder was examined in both sagittal and transverse plane. The anterior wall of bladder was measured at a premicturition volume, additional premicturition and post micturition bladder volumes were also measured by obtaining 3 orthogonal dimensions from transverse and sagittal images. Documentation of the bladder outline and pathology was also done. Examination of the surrounding pelvic structures was done.

The male participant above 18 years underwent a trans-abdominal prostate examination while in supine position. The use of TRUS was not possible in our set up due to lack of a prostatic ultrasound probe. The prostate was also examines in both transverse and sagittal planes. The contour, echotexture and presence of calcification were documented. Prostate volume was measured by taking the coronal diameter from the transverse image and the depth and sagittal diameter from the sagittal image.

Acquired data was entered into a structured questionnaire. The questionnaires were kept under lock and key during the study period to ensure access to authorized persons only.

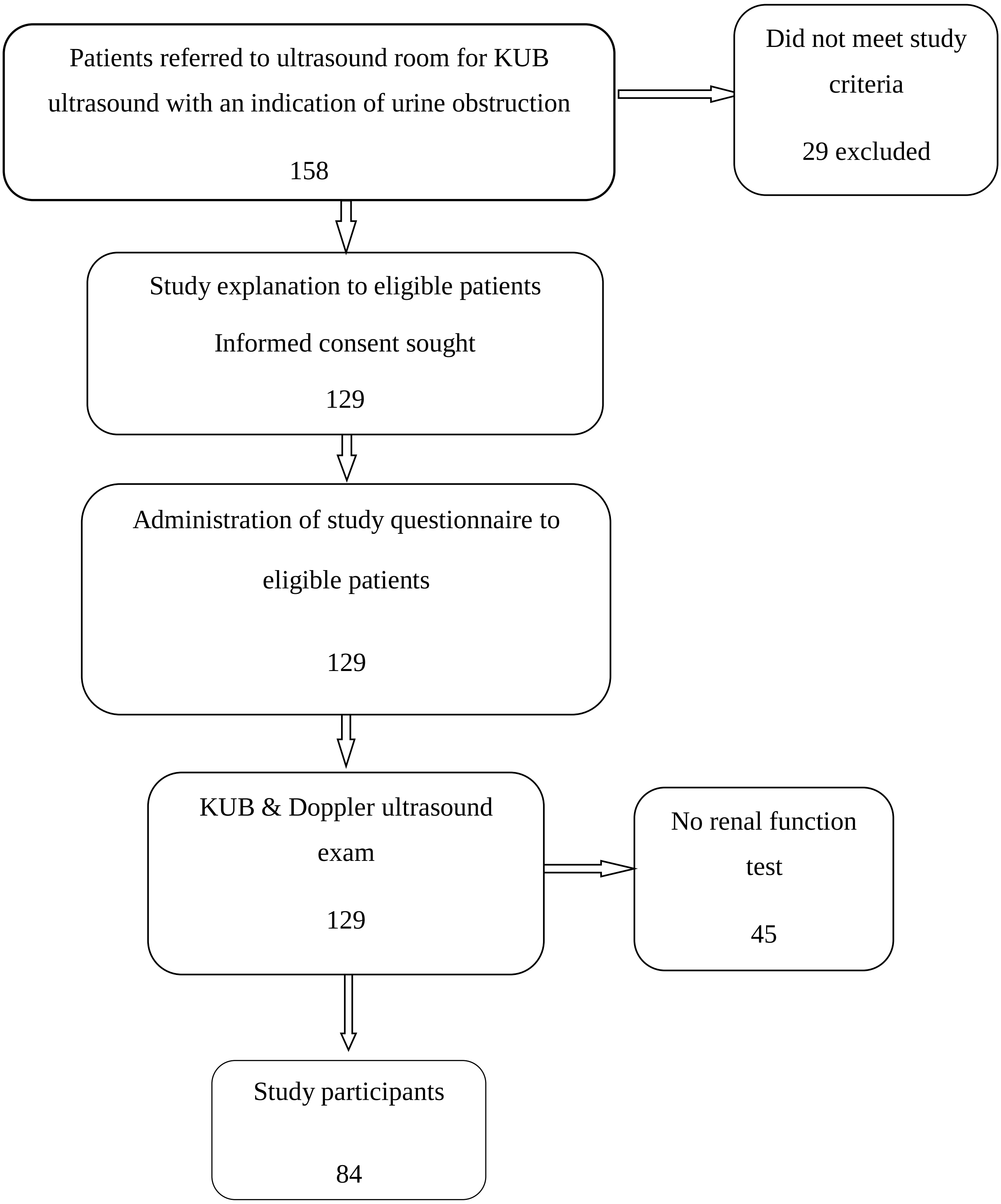


Figure 1: Flow chart for recruitment of study participants

3.6 Data Collection and Management

3.6.1 Data collection

Collection of data occurred between October 2014 and October 2015. Entry was made in the questionnaires and later transferred to a computer database. Double entry was used to ensure accuracy of the data. All patients' details were kept confidential and data was only available to the investigator and the supervisors via password protection. Patients had a copy of their results and had autonomy over who else could view their scan result(s). Serial numbers were used in order to protect patients' identity. At the end of each day data collection forms were verified for completeness and then coded.

3.6.2 Quality control

The ultrasound scans were performed by the investigator at MTRH Radiology Imaging Department according to the hospital's protocol, and were verified independently by two Radiologists oblivious to the study.

3.6.3 Data analysis and presentation

Statistical data analysis

Data analysis was done using SPSS version 21.0 statistical software. Study population was described using demographic and clinical characteristics summarized into mean, median and percentages for categorical and continuous variables respectively. Mean resistive index (mRI) was compared across grades of hydronephrosis using ANOVA test. Besides, mRI was categorized as normal (<0.7) and raised (>0.7) and associated with degree of hydronephrosis using chi square test. Median creatinine and urea was calculated and compared across the grades of hydronephrosis using Krukal-Wallis test. Relationship between resistive index and renal function tests was assessed using linear regression models. All statistical tests were interpreted at 5% level of significance. The findings of this study were presented in tables and graphs.

Some variables were categorized using clinically acceptable limits. Creatinine (umol/l) was considered as low, normal or high if it was <62.0, 62.0 – 106.0, or >106.0, respectively. Normal levels of urea (mmol/l) were in the range of 0.0-8.30 else it was high. Resistive index was considered to be normal if it was <0.7 otherwise it was high. This was applicable to resistive index of the renal and interlobar artery. This study measured anterior bladder wall thickness at a bladder volume of >150ml, since most patient had detrusor instability and could not tolerate further bladder distention (Kelly, 2004; Manieri, 1998). Bladder outlet obstruction was considered if the bladder distention was >150.0 ml and the bladder wall thickness was >0.5cm. Normal residual volume was regarded as <50.0 ml otherwise a diagnosis of urine retention was made. Prostate volume <30.0 ml was regarded as normal otherwise it was enlarged. Creatinine and urea were scaled down by 250 and 10 units respectively for reasons of interpretability in the model. Participants aged below 18 years were regarded as children.

3.7 Ethical Considerations

Permission to carry out the study was sought from Institutional Research and Ethics Committee (IREC) and the CEO of Moi Teaching and Referral Hospital. Privacy and safety of the participants was the core of the study. Informed consent was obtained and total confidentiality was maintained. To obtain the consent of the selected participants, all important information of the study, including the objectives, purpose, possible risks and benefits was explained in a comprehensible language. The study did not affect or change management of patients whether they participated in study or not. The respondents were allowed to withdraw from the study at any point. No coercion or incentives were used to attract patients to join the study. Confidentiality of the participants was observed by usage of coded identity and personal information was stored under lock and key to limit access to authorized personnel only.

3.8 Eligibility Criteria

3.8.1 Inclusion criteria

All patients referred for KUB ultrasound with clinical suspicion of urine obstruction.

Patients with KUB and renal Doppler ultrasound and renal function test.

3.8.2 Exclusion criteria

Patients who had undergone surgical intervention to relieve obstruction.

Patients with non obstructive causes of renal failure.

Patients with comorbid illnesses which could also cause renal failure.

CHAPTER FOUR

RESULTS

4.1 Introduction

A total of 84 participants referred with clinical suspicion or diagnosis of urine obstruction or urine retention were recruited into the study between October 2014 and October 2015 from urology, outpatient and renal clinics. The median duration of symptoms was 12.0 (IQR: 2.0-30.0) months.

4.2 Demographic Characteristics of the Participants:

The mean age was 61 ± 24.7 years with an age range of 0.25 (10weeks) - 105.7 years (figure 2). Among which 73 (86.9%) were male and 11 (13.1%) were female. The overall male to female ratio was 6.6:1. Children to adult ratio were 1:8.3 (table 2).

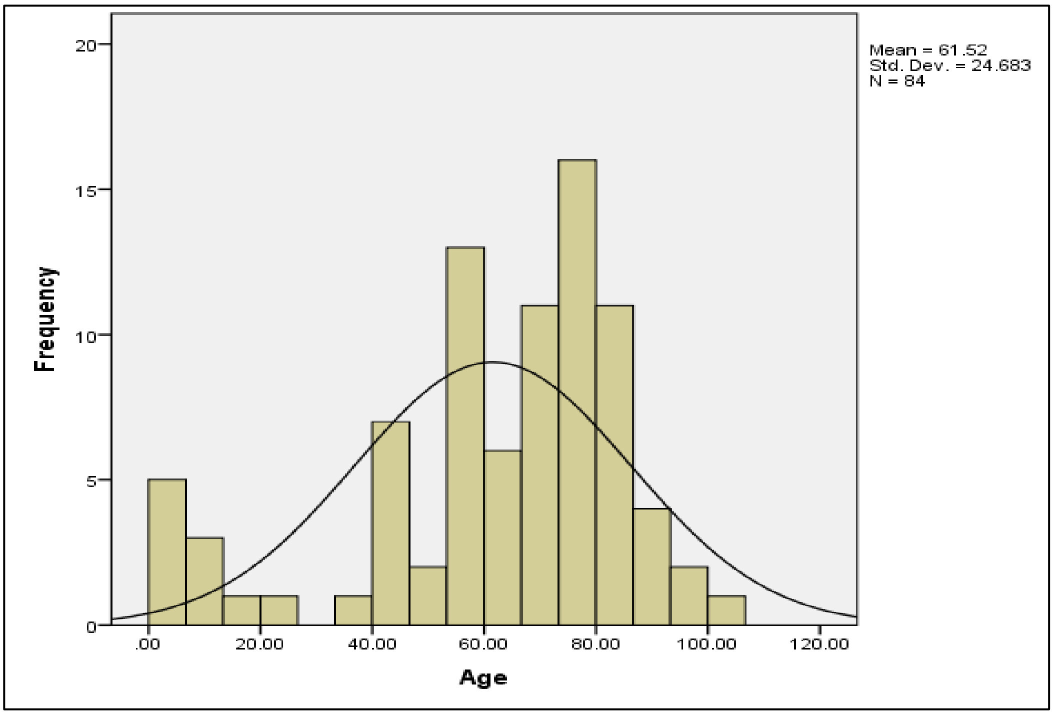


Figure 2: Distribution of the participants' age.

Table 2: Demographic characteristics

Variable	Frequency (%)
Age in years	
Mean (SD)	61.5± 24.7
Min-Max	0.25 – 105.7
Gender	
Male	73 (86.9%)
Female	11 (13.1%)
Male : Female ratio	6.6 : 1
Children (≤17 years) : Adult ratio	1 : 8.3

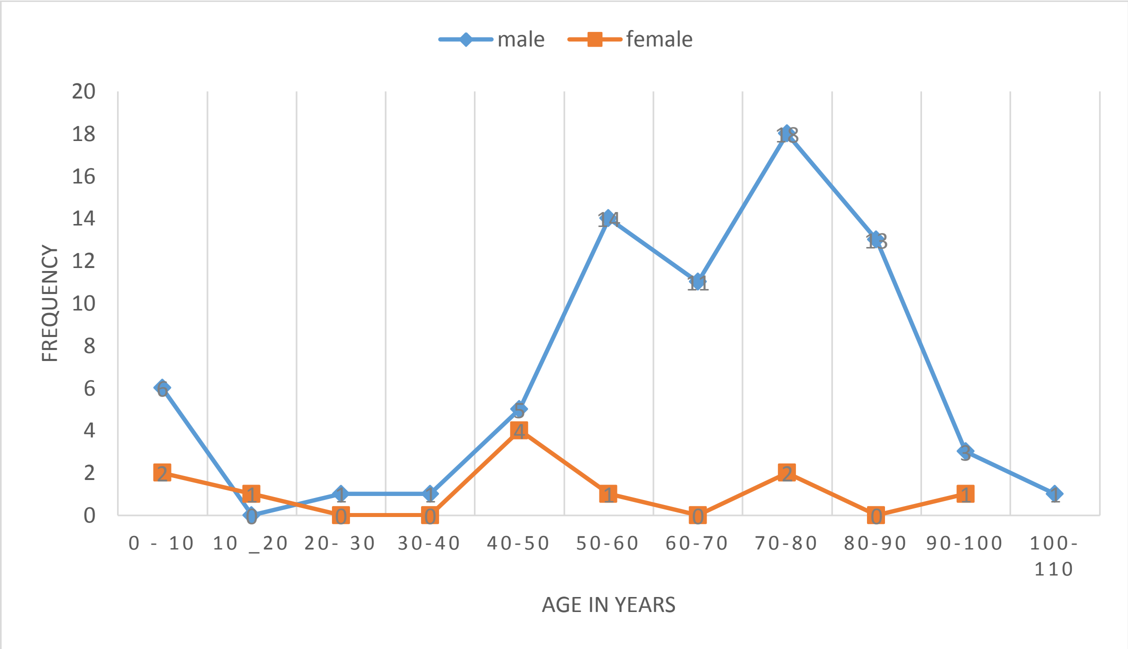


Figure 3: Age gender distribution line graph.

Table 3: Symptoms, signs and duration of symptoms

Variable (n=84)	Frequency (%)
Symptoms	
Urine retention	67 (79.8%)
Decreased flow	57 (67.9%)
Terminal dribbling	56 (66.7%)
Suprapubic pain	52 (61.9%)
Frequency	46 (54.8%)
Dysuria	42 (50.0%)
Hesitancy	25 (29.8%)
Flank pain	25 (29.8%)
Urge incontinence	17 (20.2%)
Incontinence	14 (16.7%)
Hematuria	10 (11.9%)
Pyuria	04 (4.8%)
Signs	
Suprapubic tenderness	55 (65.5%)
Distended bladder	42 (50.0%)
Flank tenderness	24 (28.6%)
Duration of symptoms	
Median duration of symptoms (months)	12.0 (IQR: 2.0-30.0)

4.3 Clinical Profile

Sixty seven (79.8%) of the participants presented with urine retention which was the most frequent symptom seen. Other common symptoms were decreased urine flow 57 (67.9%), terminal dribbling 56 (66.7%), Suprapubic pain 52 (61.9%) and frequency 46 (54.8%). Pyuria 04 (4.8%), hematuria 10 (11.9%) and urge incontinence 14 (16.7%) were among the least common symptoms seen (table 3).

The most common sign on examination was suprapubic tenderness which accounted for 55 (65.5%), distended bladder and flank tenderness were seen in 42 (50.0%) and 24 (28.6%) of the participants respectively (table 3).

The median duration of the symptoms was 12.0 (IQR: 2.0-30.0) months.

4.3 Renal Function Tests

The median creatinine level was 84.50 (IQR: 60.0-326.5) µmol/L. Thirty two (38.1%) of the participants had high creatinine levels above 106µmol/L, 30 (35.7%), however, 30 (35.7%) and 22 (26.2%) had normal and lower levels of creatinine respectively (table 4).

The median level of urea was 5.60 (IQR: 3.8-16.2) mmol/L with 34 (40.5%) having urea levels within the normal range. 50 (59.5%) had high levels of urea (Table 4).

Table 4: Renal function test

Renal function test			Median (IQR), n (%)
Creatinine (µmol/L)		84	84.50 (IQR: 60.0 - 326.5)
	Low (<62)		22 (26.2%)
	Normal (62 - 106)		30 (35.7%)
	High (>106)		32 (38.1%)
Urea (mmol/L)		84	5.60 (IQR: 3.8 - 16.2)
	Normal (0.0 – 8.3)		34 (40.5%)
	High (>8.3)		50 (59.5%)

4.4 Ultrasonographic Patterns

4.4.1 The kidney size

The average length of an adult kidney was 9.7 ± 1.7cm and 10.0 ± 1.8cm for the right and left respectively. The average width was 5.1 ± 1.0cm and 5.0 ± 1.3cm for the right and the left kidneys respectively.

The average lengths for the right and the left kidneys in children were 6.9 ± 1.7 and 6.3 ± 3.1cm; while the average widths for the right and the left kidneys were 3.3 ± 0.8 and 2.8 ± 1.4cm respectively (table 5).

Table 5: Mean kidney sizes

		Right kidney	Left kidney
Characteristic	Sample size	Mean ± SD	Mean ± SD
Adults (>17 years)			
Length (cm)	75	9.7± 1.7	10.0 ± 1.8
Width (cm)	75	5.1 ± 1.0	5.0 ± 1.3
Children (≤17 years)			
Length (cm)	9	6.9 ± 1.7	6.3 ± 3.1
Width (cm)	9	3.3 ± 0.8	2.8 ± 1.4

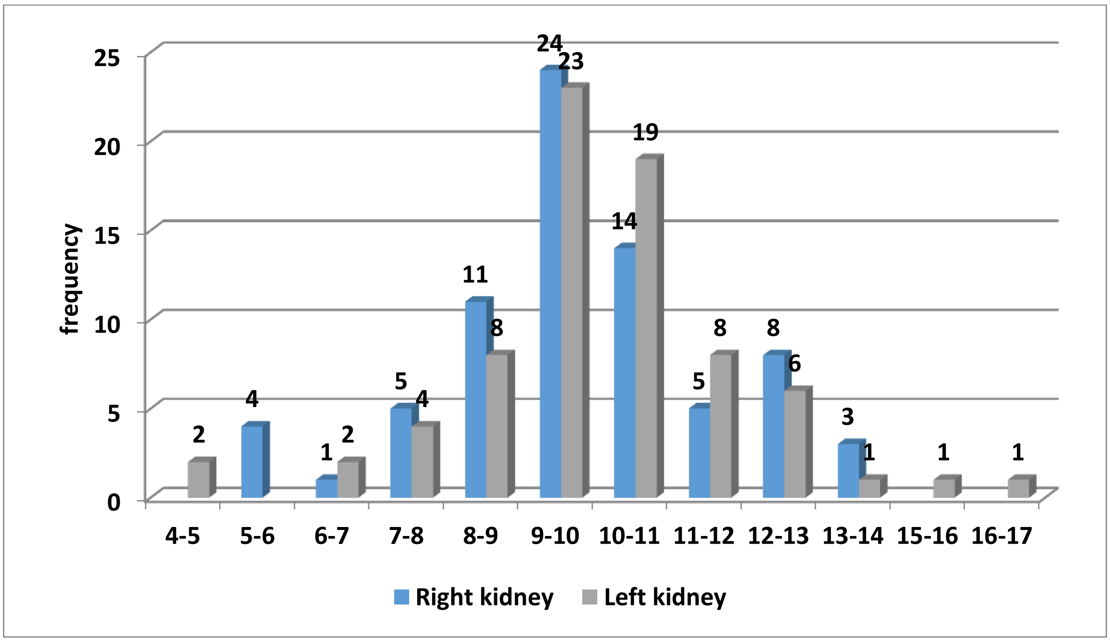


Figure 4: Distribution of kidney lengths in adults.

There was a peak of kidney length between 9-10cm interval for both right and left kidneys (figure 4).

Table 6: Kidney sizes and causes of urine obstruction in children.

AGE (years)	**SEX**	**RIGHT KIDNEY (cm)**		**LEFT KIDNEY (cm)**		**CAUSE/ HISTORY**
		LENGTH	WIDTH	LENGTH	WIDTH	
0.25	M	10.2	5.2	11	5.5	Unknown
1.6	M	4.4	2	3.88	1.7	Spina bifida
1.6	M	5.26	3	5.04	2.16	3rd degree burn
3	M	6.86	3.01	7.89	3.64	Unknown
9	M	6.4	3.3	6.21	3.4	Spina bifida
9	M	6.99	3.15	6.6	2.56	Spina bifida
9	M	7.4	3.3	8.2	3	Appendicitis
15	M	8.5	3.5	8.6	3.6	Unknown
17	M	8.7	3.9	9.8	4.9	Trauma

Most of the children had kidney sizes within normal range, with only one child having bilateral enlarged kidneys caused by hydronephrosis secondary to an unknown etiology based on ultrasound findings alone. Children with spina bifida were the majority with urine obstruction.

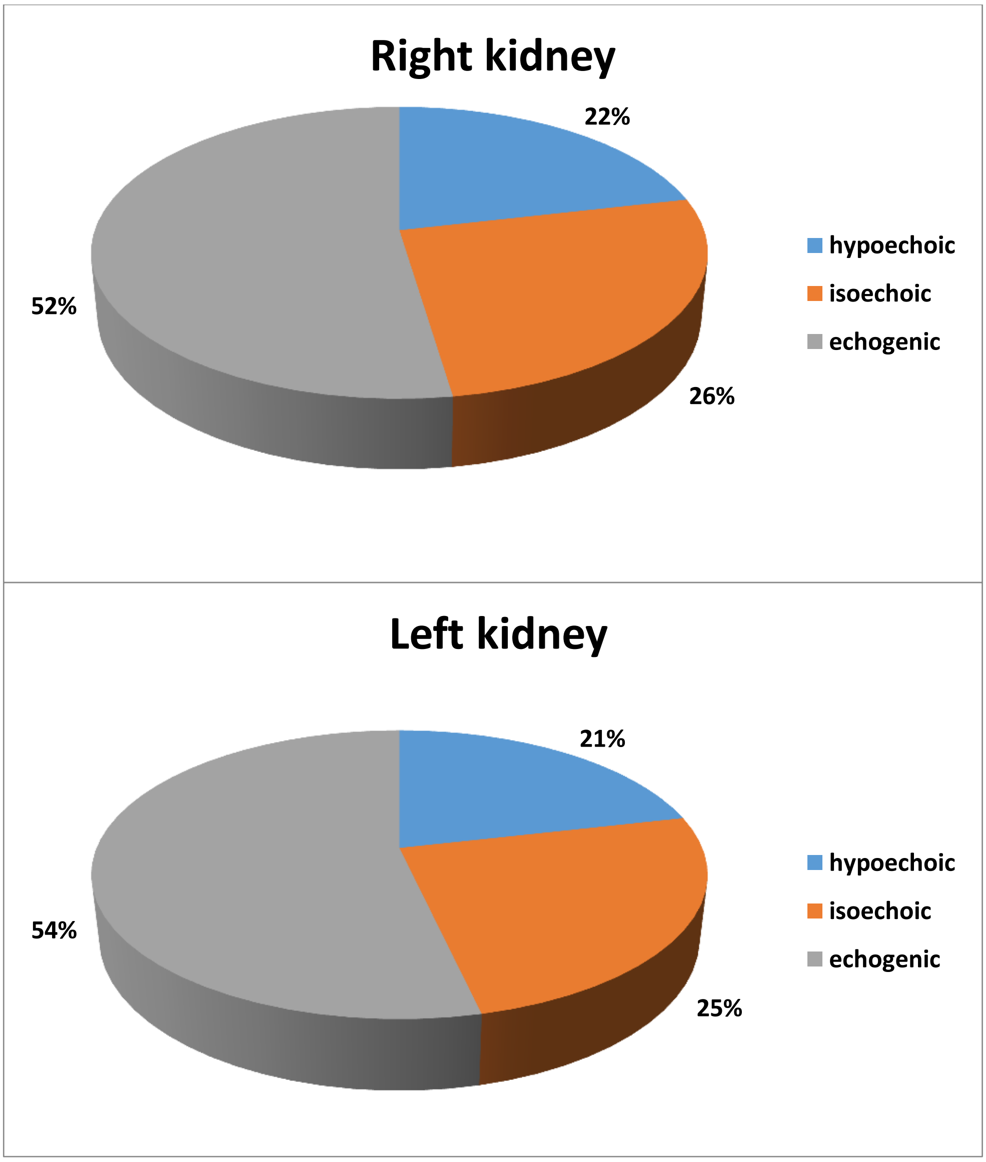


Figure 5: kidney echotexture.

4.4.2 Kidney echopattern

The renal cortex was echogenic in 44 (52%) and 45 (54 %) on the right and left respectively. Whereas in 18 (22%) and 18 (21%) hypoechoic and 22 (26%) and 21 (25%) were isoechoic for the right and left kidneys respectively (figure 5).

4.4.3 Other kidney patterns

Corticomedullary differentiation was preserved in 5 (6.0%) right kidneys and 4 (4.8%) left kidneys. Renal cysts were seen in 6 (7.1%) right kidneys and 4 (4.8%) left kidneys. None presented with solid or mixed renal masses (table 7).

Table 7: Other kidney patterns

			Right kidney	**Left kidney**
Characteristic		**Sample size**	**n (%) or mean ± SD**	**n (%) or mean ± SD**
Preserved corticomedullary differentiation		84	5 (6.0%)	4 (4.8%)
	Renal cysts		6 (7.1%)	4 (4.8%)
Masses	Solid	84	0 (0.0%)	0 (0.0%)
	Mixed		0 (0.0%)	0 (0.0%)
Calculi		84	1 (0.8%)	1 (0.8%)

4.4.4 Distribution of grades of hydronephrosis

Approximately two thirds of the participants had Grade 0 hydronephrosis accounting for 54 (64.3%) and 52 (62.7%) on the right and left kidneys respectively (figure 5). Grade 2 hydronephrosis had the least frequency 6 (7.1%) and 8 (9.5%) on right and left kidney respectively (figure 6).

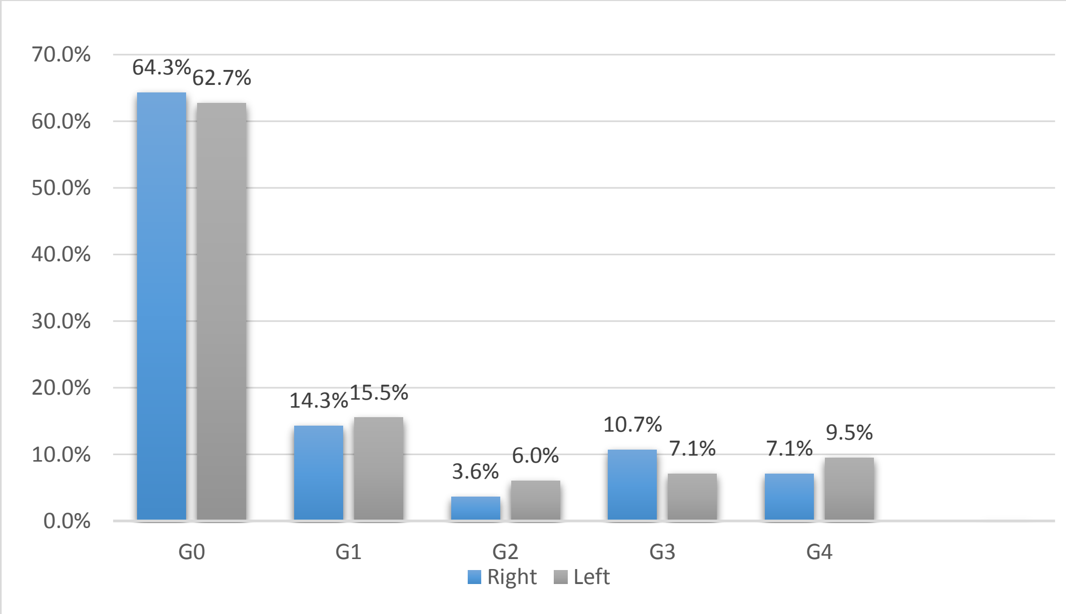


Figure 6: Distribution of grades of hydronephrosis.

3.4.5 Doppler ultrasound

Doppler ultrasound showed that the mean resistive index (mRI) was 0.689 ± 0.089 and 0.687 ± 0.097 for the right and left renal artery respectively. Similarly, the mRI for the right and left interlobar arteries were 0.671 ± 0.080 and 0.654 ± 0.088 respectively (Table 8). More than half 46 (54.8%) and 58 (69%) had normal mRI for the right and left renal artery respectively. Normal mRI for the right and left interlobar artery was 51 (60.7%) and 59 (70.2%) respectively (table 8).

Table 8: Doppler ultrasound results

		Right	**Left**
Doppler flow ultrasound	Sample size	n (%) or mean ± SD	n (%) or mean ± SD
Renal artery RI		0.689 ± 0.089	0.687 ± 0.097
Normal (≤0.7)	84	46(54.8%)	58 (69%)
High (>0.7)		38 (45.2%)	26 (31%)
Inter lobar artery RI		0.671 ± 0.080)	0.654 ± 0.088)
Normal (≤0.7)	84	51 (60.7%)	59 (70.2%)
High (>0.7)		33 (39.3%)	25 (29.8%)

3.4.6 Analysis of RI and gray scale renal patterns

Table 9: Frequency distribution of RI across the grades of hydronephrosis.

Variable	Renal artery RI			Interlobar artery RI		
	Normal n (%)	Raised n (%)	P value	Normal n (%)	Raised n (%)	P value
Right kidney						
G0	35 (76.1%)	19 (50.0)	0.056	43(74.1%)	11(42.3%)	0.022
G1	6 (13.0%)	7 (18.4%)		6 (10.3%)	7 (26.9%)	
G2	0 (0.0%)	2 (5.3%)		1 (1.7%)	1 (3.8%)	
G3	4 (8.7%)	5 (13.2%)		6 (10.3%)	3 (11.5%)	
G4	1 (2.2%)	5 (13.2%)		2 (3.4%)	4 (15.4%)	
Left kidney						
G0	35(68.6%)	17(51.5%)	0.465	40(67.8%)	12(8.0%)	0.319
G1	7 (13.7%)	6 (18.2%)		7 (11.9%)	6 (24.0%)	
G2	3 (5.9%)	2 (6.1%)		4 (6.8%)	1 (4.0%)	
G3	2 (3.9%)	4 (12.1%)		3 (5.1%)	3 (12.0%)	
G4	4 (7.8%)	4(12.1%)		5 (8.5%)	3(12.0%)	

Results of frequency distribution of RI across the grades of hydronephrosis (table 9). Hydronephrosis was significantly related with raised right interlobar RI (p=0.022). Grade 4 hydronephrosis was significantly higher in patients with raised interlobar artery RI 4 (15.4%) compared to those with normal RI 2 (3.4%). Conversely, G0 was significantly higher in patients with normal interlobar RI 43 (74.1%) compared to those with raised 11(42.3%). Similar trend was observed in the RI of the renal artery though not significant (p=0.056). Higher proportion of patients with G4 hydronephrosis was found in those with raised right renal artery RI compared to 1 (2.2%) in the normal RI. On the other hand, 35 (76.1%) of the participants with normal right renal artery RI had G0 hydronephrosis compared to 19 (50%) with raised renal artery RI (table 9).

Similar to the right kidney, the left kidney showed a trend of higher grades of hydronephrosis detected in patients with raised RI. However, there was no statistically significant relation between grades of hydronephrosis and RI in the left kidney for both renal artery (p=0.465) and interlobar artery (p=0.319) (table 9).

Table 10: Correlation of right kidney mRI across the grades hydronephrosis

Right kidney	**Grades of hydronephrosis**					**P value**
	G0	**G1**	**G2**	**G3**	**G4**	
Renal artery						
Mean ±SD	0.67 ±0.07	0.73 ±0.09	0.74 ±0.06	0.72 ±0.15	0.74 ±0.04	0.047
95% CI	0.65-0.69	0.67-0.78	0.32-1.15	0.61-0.84	0.70-0.78	
Interlobar artery						
Mean ±SD	0.65 ±0.07	0.71 ±0.08	0.72 ±0.07	0.68 ±0.14	0.70 ±0.07	0.099
95% CI	0.64-0.67	0.67-076	0.11-1.33	0.57-0.78	0.63-0.77	

mRI for the right renal artery was found to be significantly lower in patients with G0 hydronephrosis 0.67 ± 0.07, compared to the G1 to G4 hydronephrosis (p=0.047). However, there was no significant difference in the right interlobar artery mRI across the grades of hydronephrosis, 0.65 ±0.07 (p=0.099) (table 10).

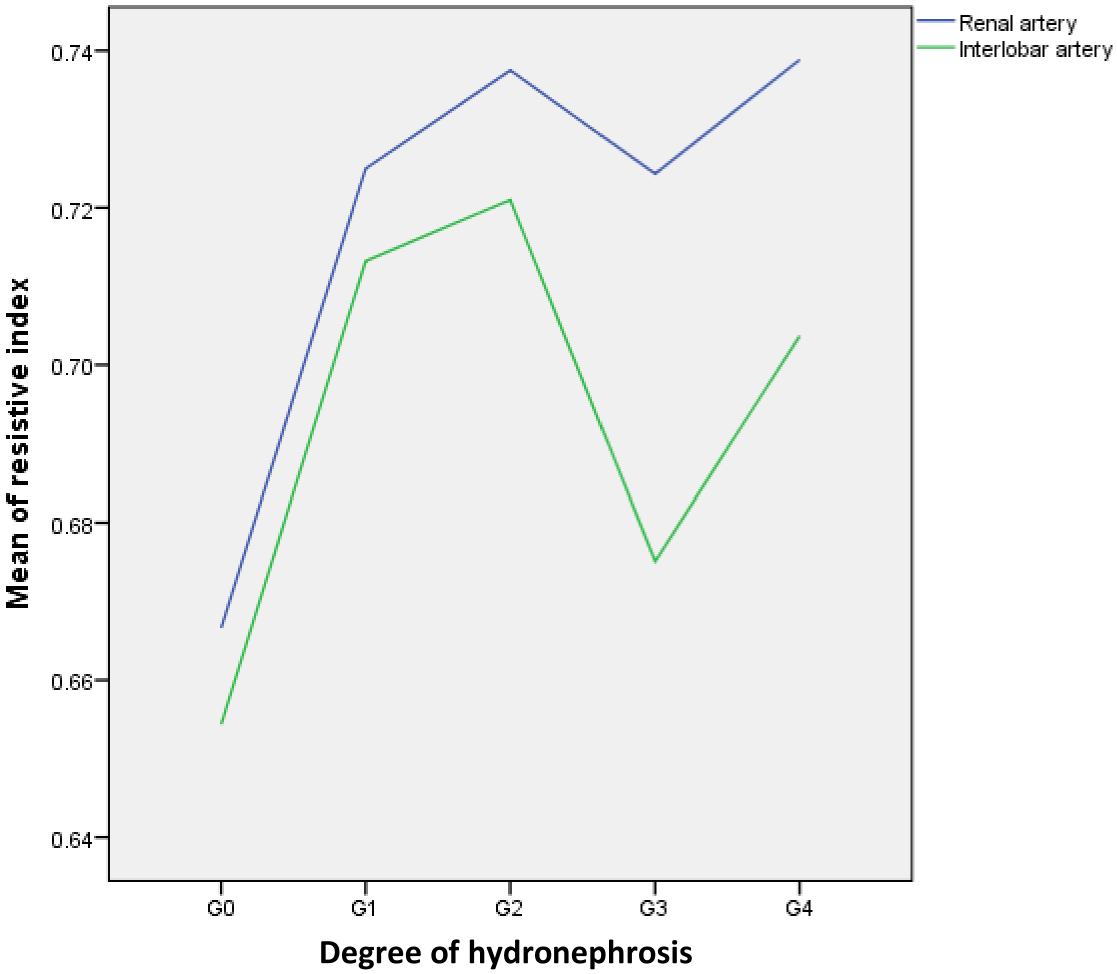


Figure 7: Graph of mean resistive index (mRI) versus degree of hydronephrosis in the right kidney.

Analysis of the relationship between mRI across grades of hydronephrosis showed mRI for right renal and interlobar artery rose with increasing severity of obstruction up to grade 2, with an abrupt fall at grade 3 then rose again in grade 4. The relation was only statistical significant to the renal artery RI, p=0.047 (figure 7).

Table 11: Correlation of left kidney mRI across the grades hydronephrosis

Left kidney	**Grades of hydronephrosis**					**P value**
	G0	**G1**	**G2**	**G3**	**G4**	
Renal artery						
Mean ±SD	0.66 ±0.08	0.71 ±0.08	0.77 ±0.14	0.76 ±0.16)	0.69 ±0.09	
95% CI	0.64-0.69	0.66-0.76	0.59-0.94	0.58-0.93	0.61-0.76	0.032
Interlobar artery						
Mean ±SD	0.64 ±0.09	0.68 ±0.08	0.65 ±0.12	0.69 ±0.11)	0.70±0.06)	
95% CI	0.61-0.66	0.63-0.73	0.51-0.80	0.57-0.81	0.65-0.75	0.156

Significantly higher mRI's for the renal artery was reported in patients with G2 (0.77) and G3 (0.76) hydronephrosis compared to G0 (0.66), p=0.032. The mRI's for interlobar artery were not significantly different across the grades of hydronephrosis in the left kidney (p=0.156) (table 11).

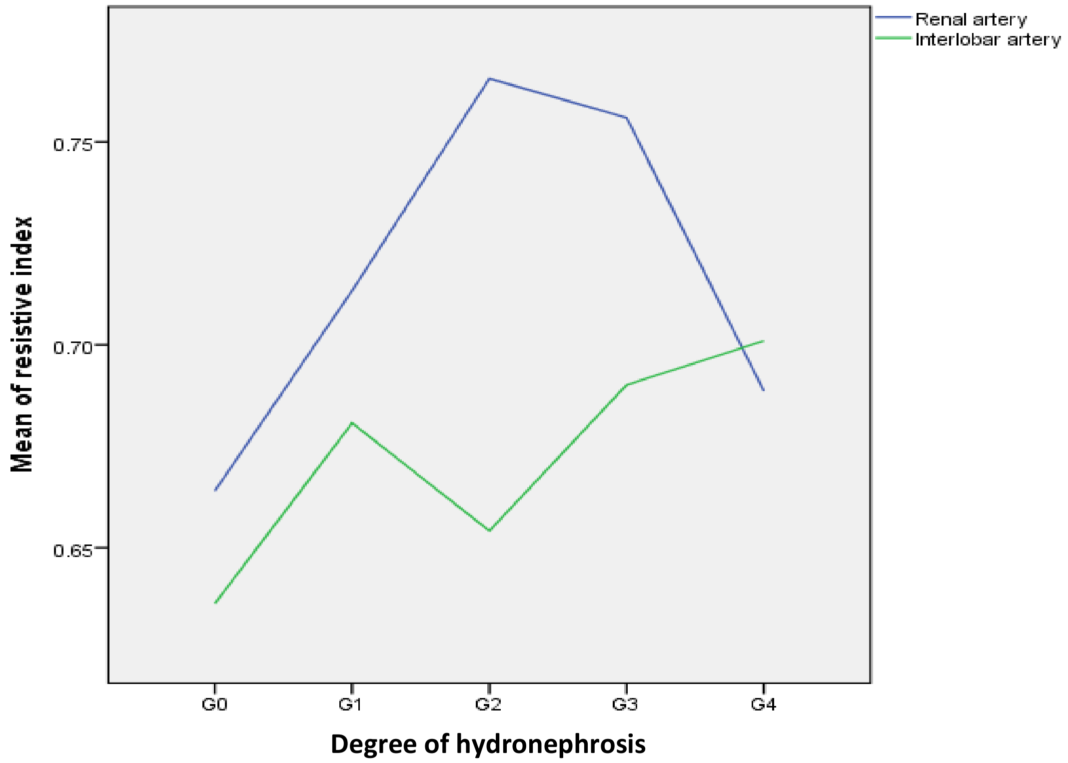


Figure 8: Graph of mean resistive index (mRI) versus degree of hydronephrosis in the left kidney.

Similarly to the right kidney, mRI of left renal artery rose from G0 to G2 then it dropped thereafter. The mRI of the interlobar artery also rose with increasing severity of obstruction up to grade 1, with an abrupt fall at grade 2 then rose again in grade 3 and 4. The relation was only statistical significant to the left renal artery RI, p=0.032 (figure 8).

4.4.7 Bladder patterns

The average bladder wall thickness (BWT) was 0.56 ± 0.26cm and the median premicturition bladder volume was 167 (IQR: 102, 311.5) cm^3. Among the 45 participants who had premicturition bladder volume >150ml, 27(32%) had BWT of >0.5cm while 18 (21.4%) had BWT <0.5cm. The median post-micturition bladder volume was 60 (IQR: 31.0, 265.0) cm^3. A total of 42 (54.5%) exhibited urine retention with a residual volume of >50ml.

More than 80% of the participants had regular bladder margins however, 15 (17.9%) had irregular bladder margins. A total of 11 (13.1%) had sediments in urine while none had calculi. Pedunculated bladder mass was seen 1 (1.2%) while bladder diverticular were seen in only 6 (7.1%). Twenty six (31%) of the participants had Foley’s catheters during examination (table 12).

Table 12: Ultrasonographic bladder patterns.

Characteristic		Sample size	n (%) or mean ± SD or median (IQR)
Wall thickness (cm)		84	0.56 ± 0.26
	<0.5cm(>150ml)	84	18 (21.4%)
	<0.5cm(<150ml)		20 (23.8%)
	>0.5cm (>150 ml)		27 (32%)
	>0.5cm (<150 ml)		16 (19%)
Margin	Regular	84	69 (82.1%)
	Irregular		15 (17.9%)
Sediments		84	11 (13.1%)
Calculi		84	00 (0.0%)
Masses	Pedunculated		01 (1.2%)
	Intramural	84	00 (0.0%)
	Intraluminal		00 (0.0%)
Bladder volume (cm^3)			
Pre-micturition	Bladder volume	84	167 (102, 311.5)
	≤150 ml)		39 (46.4%)
	>150 ml)		45 (53.6%)
Post-micturition		58	60 (31.0, 265.0)
	≤50 ml)		25 (43.1%)
	>50 ml)		33 (56.9%)
Diverticular		84	6 (7.1%)
Catheter		84	26 (31%)

4.4.8 Prostate patterns

Table 13: Ultrasonographic prostate patterns.

Characteristic (>17 years)		Sample size	n (%) or Median (IQR)
Prostate size (cm^3)			55.5 (29.0, 110)
	Prostate Normal (≤30 cm^3)	67	19(29.4%)
	Prostate enlarged (>30 cm^3)		48(71.6%)
Echopattern	Homogeneous		20 (29.9%)
	Heterogeneous	67	47 (70.1%)
Calcification			45 (67.2%)
Margin	Regular	67	59 (88.1%)
	Irregular		08 (11.9%))

The median prostate size was 55.5 (IQR: 29.0, 110) cm^3 with close to two thirds 48 (71.6%), having an enlarged prostate. Twenty (29.9%) of the adult male participants had a homogenous prostate, with 47(70.1%) having a heterogeneous prostate. Forty five (67.2%) of the prostates had calcification. Approximately 59 (88.1%) of the male participants had regular prostate margin while the rest had irregular margins (table 13).

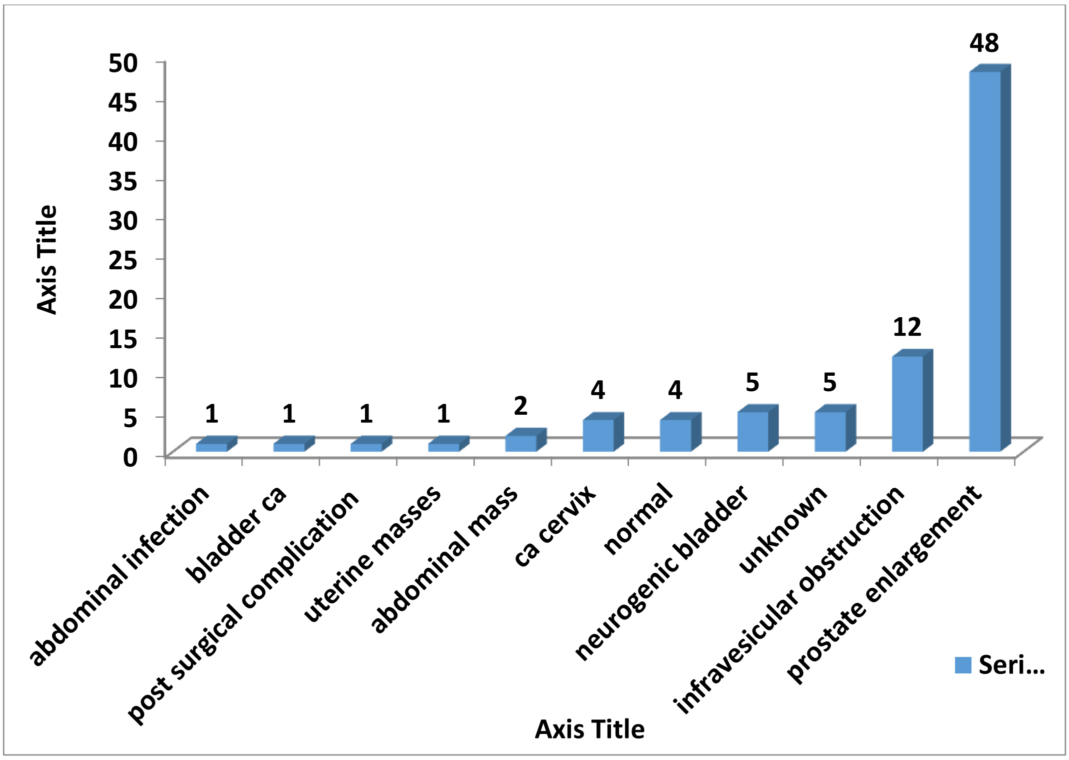


Figure 9: ultrasound and clinical history based causes of urine obstruction.

Based on ultrasound patterns in combination with the clinical findings, the most common cause of urine obstruction was prostate enlargement accounting for 48(71.6%) among adult male participants and 57.1% overall cause of obstruction. Distal urethral tract obstruction 12/84 (14.3%) was also common but the definitive cause could not be established with ultrasound alone. The least causes were abdominal infections, bladder cancer and post-surgical complications 1/84 (1.2%) each. Normal ultrasound patterns were seen in 4/84 (4.8%) and in 5/84 (6%) unknown cases had abnormal KUB scans without evidence of urine retention (figure 8).

4.5 Correlation between Sonographic Patterns and Renal Function Tests

Table 14: Correlation between renal cortex echotexture and renal function

Right kidney				
	Hypoechoic	**Isoechoic**	**Echogenic**	**P value**
Creatinine (µmol/L)	70.2 (56-88)	87.5 (72-137)	130.5 (60-535.5)	0.127
Urea (mmol/L)	3.9 (3.4-5.8)	5.2 (4.5-8.4)	9.0 (3.9-26.3)	0.037
Left kidney				
	Hypoechoic	**Isoechoic**	**Echogenic**	**P value**
Creatinine (µmol/L)	70.2 (56-88)	89 (73-138)	94 (61-492)	0.146
Urea (mmol/L)	3.9 (3.4-5.8)	5.3 (4.5-8.4)	8.6 (3.9-24.8)	0.051

Though statistically not significant (p=0.127), the median creatinine value was higher in patients with echogenic compared to hypoechoic and isoechoic renal cortex. Urea was significantly higher in echogenic renal cortex (9.0 mmol/L) compared to hypoechoic (3.9 mmol/L) and isoechoic (5.2 mmol/L) renal cortex (p=0.037).

Similar trend was found in the left kidney with no significant difference in median creatinine levels across the cortical echotexture (p=0.146). Also, patients with echogenic cortex had a median urea level of 8.6 mmol/L compared to hypoechoic (3.9 mmo/L) and isoechoic renal cortex (5.3 mmol/L), p=0.051 (table 14).

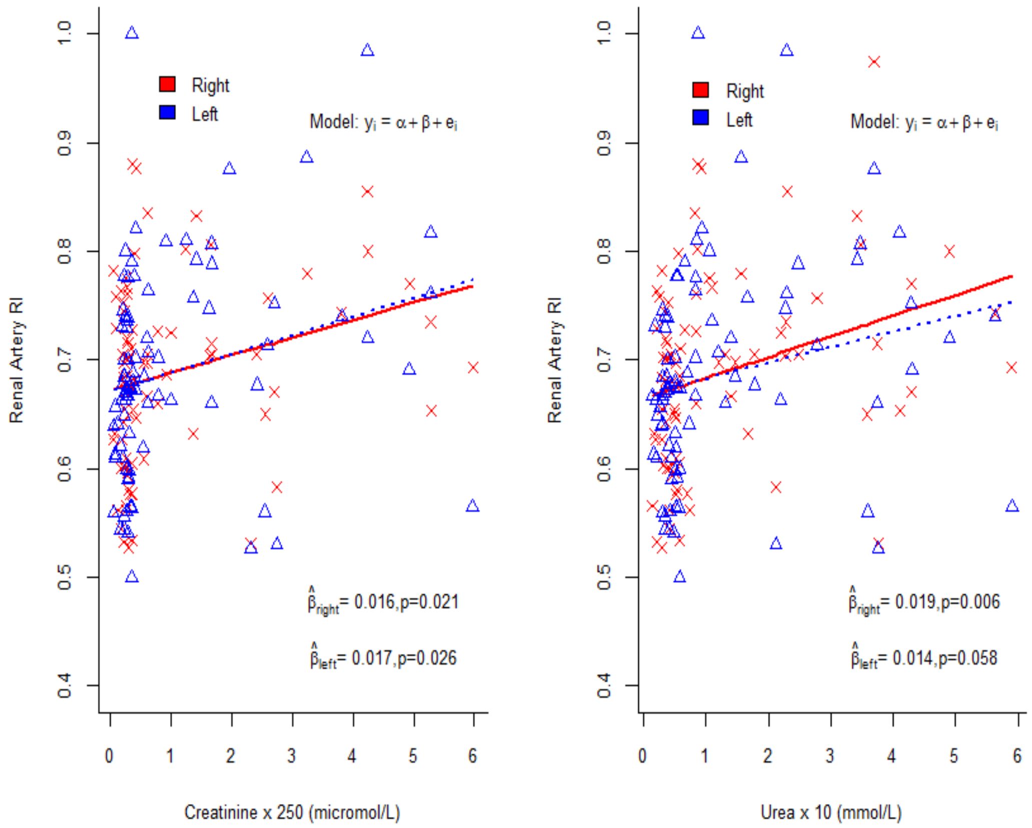


Figure 10: Correlation of renal artery RI with creatinine and urea.

There was a significant weak positive correlation between right and left renal artery RI's with both creatinine and urea (p=0.021, 0.026, 0.006) except for the left renal artery and urea, p=0.058 (Figure 9). From the figure, the slope denoted by $\hat{\beta}_1$ coefficient represents the average change in RI of the renal artery per 250 micromoles/L change in creatinine or per 10 micromoles/L change in urea. Comparing two participants that differ from each by 250 micromoles/L of creatinine shows that the one who has 250 micromoles/L more is associated with higher RI for the right and the left renal artery by 0.016 units, p=0.021, and 0.017 units, p=0.025 respectively. Higher levels of urea were associated with high RI for the right renal artery, $\hat{\beta}_1$: 0.019units, p=0.006. Although high levels of urea were indicative of higher RI in the left renal artery, there was no sufficient evidence from the data to justify this association, $\hat{\beta}_1$: 0.014, p=0.058.

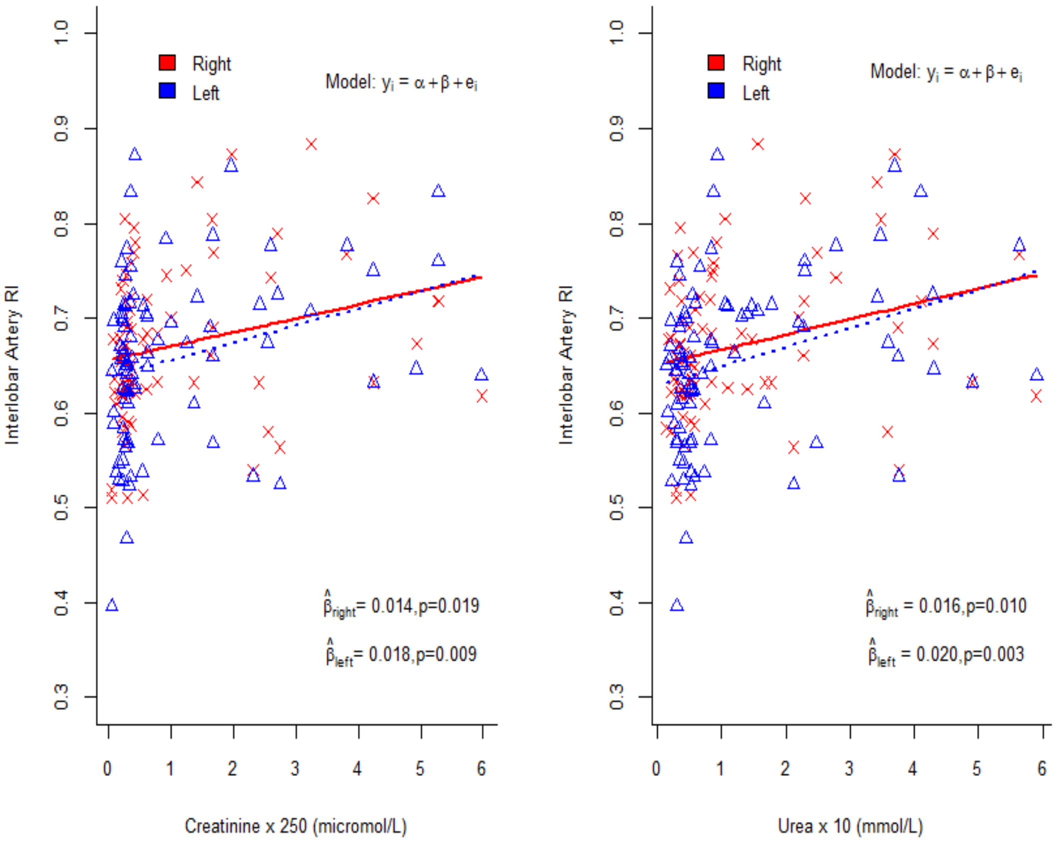


Figure 11: Correlation between inter lobar artery RI and creatinine, and urea.

The results show a weak positive relationship between creatinine and the RI of the right and left interlobar artery, $\hat{\beta}_1$: 0.014, p=0.019, and $\hat{\beta}_1$: 0.018, p=0.009 respectively. Similarly, there was a weak positive correlation between urea and the RI for the right and left interlobar artery, $\hat{\beta}_1$: 0.016, p=0.010, and $\hat{\beta}_1$: 0.020, p=0.003 respectively.

4.6 Sample Ultrasound Images

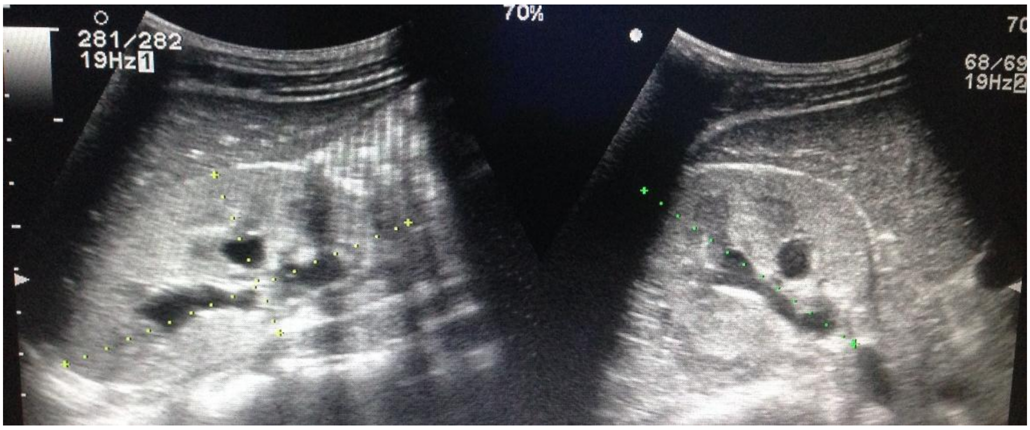


Figure 12: A right renal ultrasound scan of a 10 year old with a 4year history of urine retention, showing echogenic renal cortex, preserved corticomedullary differentiation and mild dilatation of calyceal system.

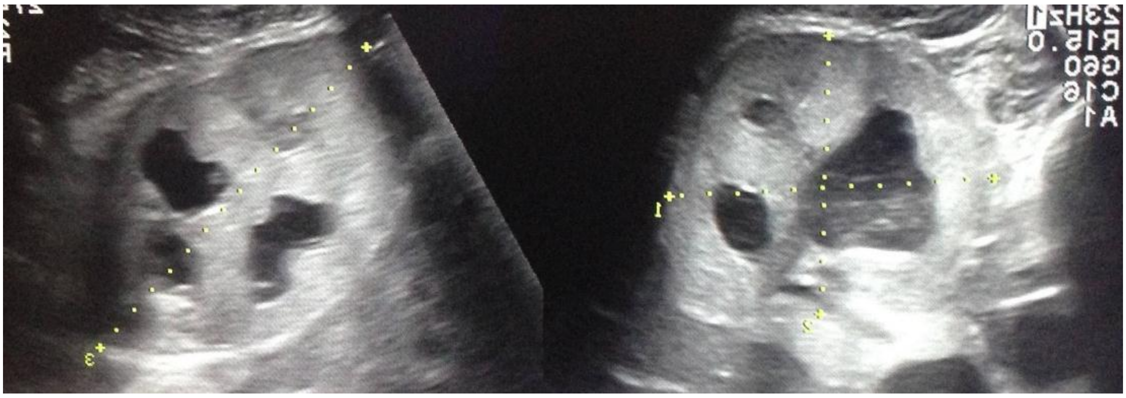


Figure 13: ultrasound scan of a kidney in a 72 year old male patient with 3years history of obstructive uropathy due to enlarged prostate. There is loss of corticomedullary differentiation, echogenic cortex, moderate thinning of the renal cortex and dilated calyceal system.

Figure 14: Right renal ultrasound image of a 40 year old woman with cervical cancer. Shows urinoma.

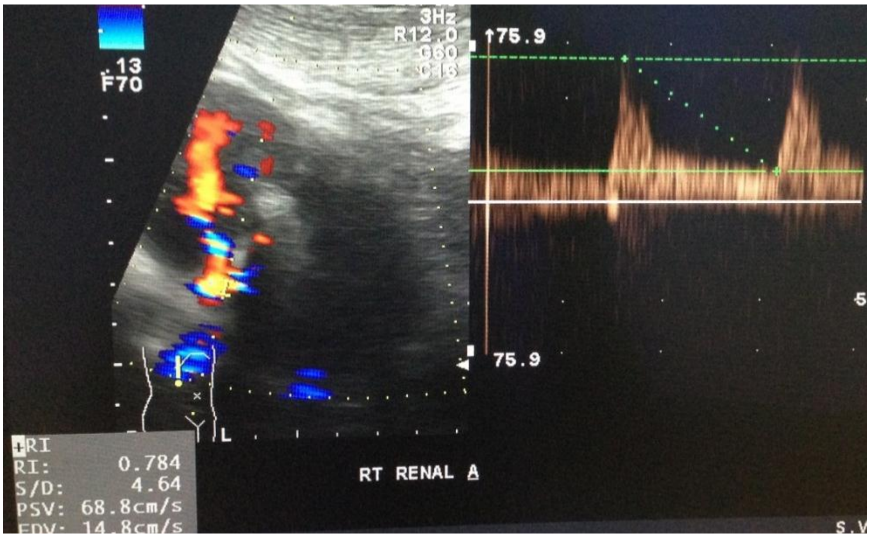


Figure 15: Doppler ultrasound of the right renal artery showing a preserved waveform pattern but the RI is raised.(normal RI <0.7

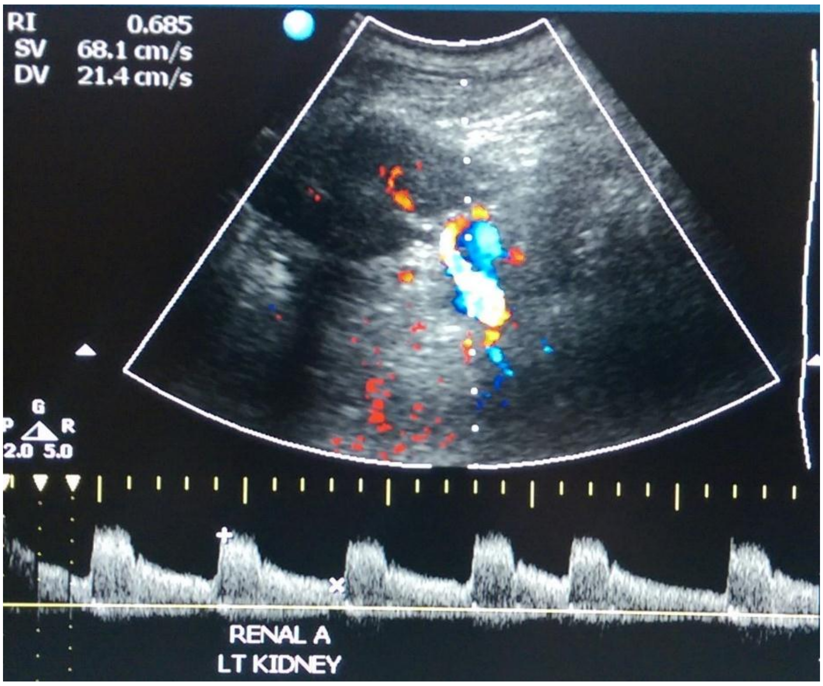


Figure 16: Doppler ultrasound image of the right renal artery showing blunting of the upstroke but a normal RI.

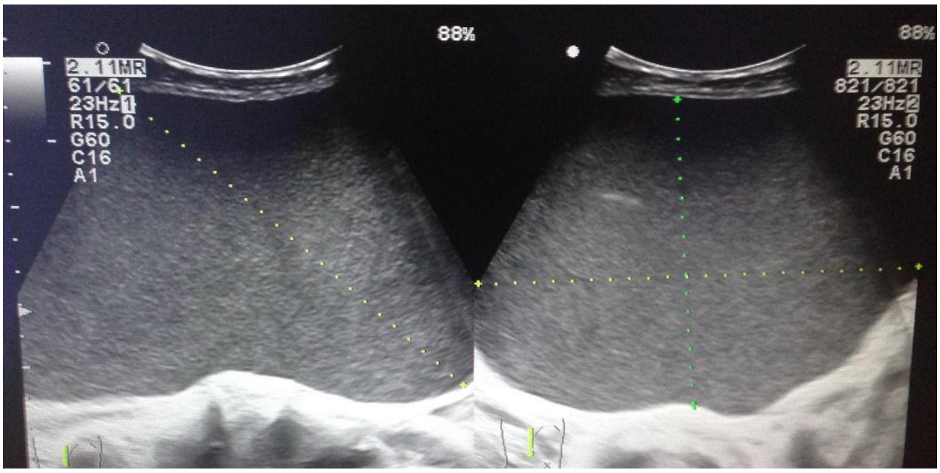


Figure 17: Residual turbid bladder volume in a patient with markedly enlarged prostate.

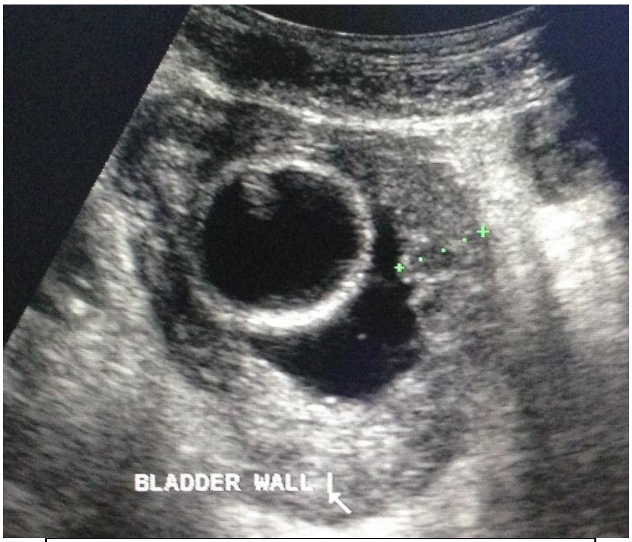


Figure 18: Thickened bladder wall in a 59 year old man with prostate enlargement.

Figure19: bladder diverticular

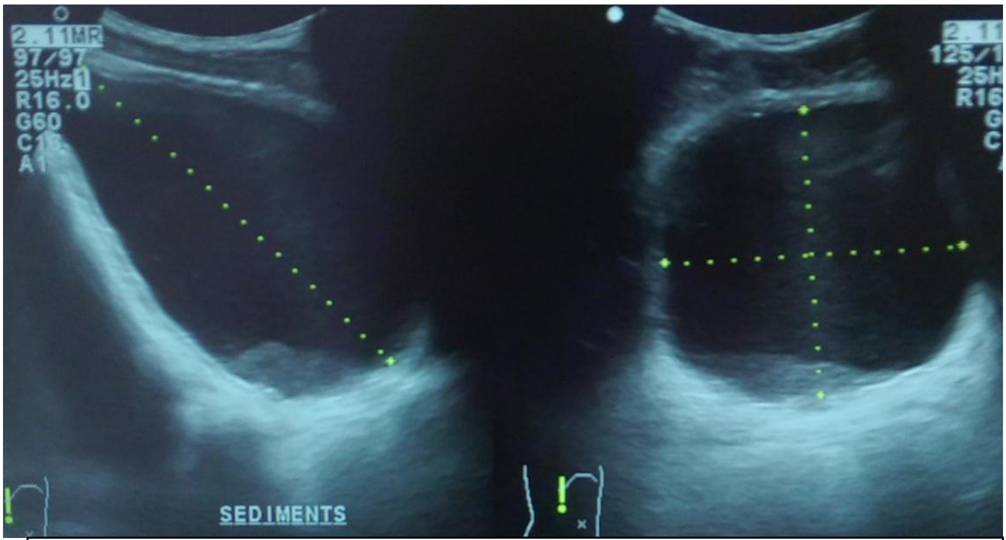
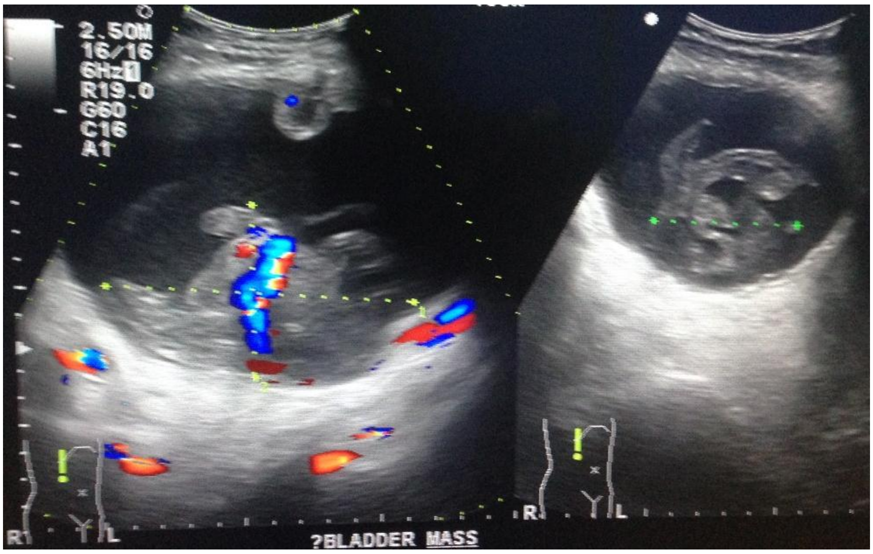


Figure 20: sediments in urine in a 69 year old male patient with a history of paralysis and normal prostate size.



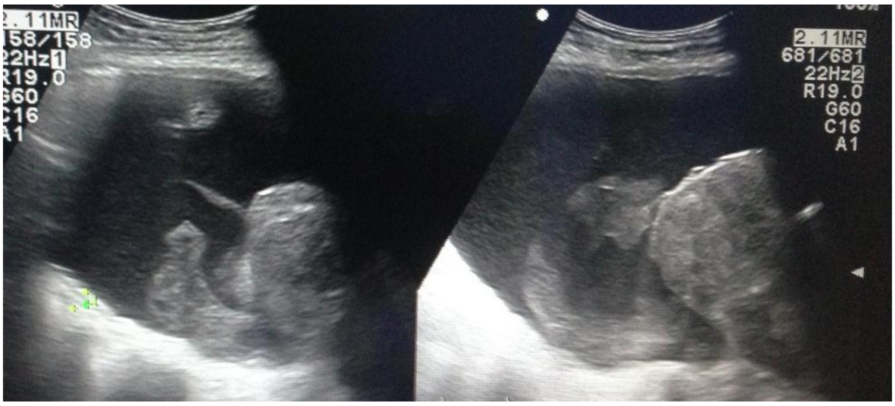


Figure 20 & 21: bladder ultrasound image of a 75 year old man. The prostate is markedly enlarged and protrudes into the bladder lumen. There is an additional pedunculated immobile vascularized bladder mass.

CHAPTER FIVE

DISCUSSION

5.1 Ultrasound Patterns

5.1.1 The patterns of gray scale ultrasonography

The average length of an adult kidney was between 9-10cm interval (table 5), which was also the peak of kidney size (figure 3). This kidney dimension should be evaluated with caution as an isolated finding as it may be a normal feature (O'Neill, 2014). Though it may also be attributed to chronic kidney disease caused by the urine obstruction or age related renal atrophy as there was a predominance of elderly participants above the age of 50 years (Emamian, 1993).

This mean kidney length was within normal limits compared to normal lengths of Sudanese population (Abdoelrahman et al,2014). This could be attributed to features of a preserved renal length which may also occur with chronic renal injury or may be attributed to overall raised mean by participants with increased renal length secondary to hydronephrosis.

These values were lower than the normal average kidney length found in a study in Northwestern Nigeria. Where 104 volunteers of 50 female and 50 male were scanned and a mean kidney length of 11.3± 8.8cm and 11.6± 9.8cm for the right and left kidney respectively was found. The difference could be due to features of chronic renal injury or age related renal atrophy in the predominantly elderly participants. Nevertheless, kidney size has been shown to differ by gender, age, weight and body mass index. Other factors i.e. environmental, genetic, ethnicity and nutrition have also been proposed to affect the kidney size (Maaji, 2015; Muthusami, Ananthakrishnan, &

Santosh, 2014). There are no large studies done for adult kidney nomogram, therefore these findings might not be comparable to our population.

Nevertheless there was an agreement with previous studies where the left kidney was found to be larger than the right by 0.3cm due to anatomic confinement of the right kidney where the right kidney is compressed by the liver (Maaji, 2015; Moghazi, 2005). These findings imply that there was equal right and left kidney involvement.

Approximately 14.7% and 12% of the 75 pair of kidneys assessed were enlarged for the right and left kidney respectively (table 5). This could be attributed to higher grades of hydronephrosis. Some of the patients with lower grade of hydronephrosis had normal or smaller kidney sizes. Around 28% and 21.3% had smaller kidneys below 9cm for the right and left kidneys respectively. These values are in agreement with ultrasonographic features of chronic renal injury from a prospective study by Ozmen where 127 participants with creatinine levels above 3mg/dl were assessed and found that participants with CKD had a shorter kidney size of 9.0 ± 1.5cm. However, participants with CKD may also have normal size kidneys (Ozmen, 2010). Similar findings were reported by O'Neill and Moghazi. Studies have also shown that kidney sizes decreases with age after 60 years. This study had a predominance of participants above 50 years with a median of 67 years; therefore the peak kidney sizes of 9-10cm interval could also be normal due to age related renal atrophy (Emamian, 1993; S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014; O'Neill, 2014).

This study found echogenic renal cortex to be significantly high followed by isoechoic then hypoechoic echotexture (figure 4). Renal echotexture alone is insufficient to distinguish among different causes of kidney injury as it may also occur with poor hydration other than renal parenchyma diseases (S. Faubel, Patel, Nayana U, Lockhart, Mark E, Cadnapaphornchai, Melissa A, 2013; S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014). Various studies have linked echogenicity to be nonspecific, occurring in various renal parenchyma diseases (Hricak et al., 1982; O'Neill, 2014). But a combination of a small kidney size and increased echogenicity favors chronic kidney disease (CKD) as was the case in some of the participants in our study, though CKD may also present with normal size kidney (Moghazi, 2005).

This study showed corticomedullary differentiation was preserved in a minority, most of which were children (table 7). The large number of loss of corticomedullary differentiation especially in adults can be attributed to urine obstruction changes or normal loss of corticomedullary differentiation with age (Daneman, 2010; Emamian, 1993).

These findings are similar to O'Neil's who argued that absence of corticomedullary differentiation is not an abnormal finding. However prominence of it may be due to increased echogenicity in the renal cortex (O'Neill, 2014).

Most study participants had grade 0 hydronephrosis (figure 5). This could be explained by the large number of participants having been relieved of obstruction by use of a Foleys catheter. Also there is a possibility that some of the participants did not have complete obstruction, as these features were not ascertained by another imaging modality before recruitment into the study.

In contrast, most studies reported presence of hydronephrosis (Apoku, 2015; Halle, 2016; Naleini & Maryam Javheri 2015). The disparity can be explained by the inclusion criteria, where this study recruited participants who were suspected to have urine obstruction or urine retention based on the indication provided by the clinician.

While other studies recruited based on multimodality imaging findings of patients confirmed to have urine obstruction.

The median duration of symptoms was 12 months (IQR; 2 - 30 months) (table 3). This duration was within the range of chronic urinary obstructive symptoms, and therefore confirms our earlier concern that patients presented late with longstanding symptoms. Therefore this study could not assess participants with acute urinary obstructive symptoms. Probably the late presentation could be attributed to cultural stigma attributed to the genito-urinary system, preference of alternative medicine or naivety to the symptoms and the consequential urine obstruction.

A study in Nigeria had similar finding of longstanding duration of symptoms, 8 months (IQR; 1 week to 5 years) (Apoku, 2015) Similar presentation was seen by Ashraf, 1.5(IQR; 0.25-5) years (Ashraf, 2009).

Naleini et al however found shorter duration of 15.6 ± 12.5 hours but he targeted participants with only unilateral obstruction secondary to renal colic with multimodality imaging approach (Naleini & Maryam Javheri 2015). Most of the studies did not provide duration of symptoms.

5.1.2 Renal Doppler ultrasound patterns

This study recorded normal values of mean RI's for renal and interlobar arteries for both kidneys with more than half of the participants having normal RI values (table 8). These findings could be attributed to the late chronic obstructive presentation with modest increase in RI or due to partial obstruction that hasn't compromised the renal vascular supply rendering mRI to be within normal limits (Platt, 1992; Platt, 1993; Tseng, 2004). Decreased renal blood flow due to chronic renal injury may also have contributed to the normal mRI levels (Apoku, 2015).

Naleini et al found mRI of 0.68 ± 0.07 in acute obstructed kidneys which was less than the proposed cut-off >0.7. However this was higher than the mRI of non-obstructed kidneys 0.62 ± 0.07 (Naleini & Maryam Javheri 2015). These findings still documented a raise in mRI though it was under the proposed cut-off.

Analysis of the frequency distribution of normal (<0.7) and raised (>0.7) mRI across the grades of hydronephrosis showed no statistical significant relation (p=0.056, 0.465, 0.319) except for mRI of right interlobar artery (p=0.022) (table 9). This implies that, though participants with mRI >0.7 were likely to have hydronephrosis, the findings were not statistical significant except for the mRI of the right interlobar artery across grades of hydronephrosis. This discrepancy in findings could be attributed to the small sample size used. Also long-term gradual increase in pressure in the collecting system result in modest increase in RI as explained above. Therefore a normal RI does not always mean absence of change in the renal vascular system and a normal renal function (Chen, 1993; Platt, 1992).

Numerous studies have shown that RI correlates poorly with chronic obstruction; therefore lower values are expected after 24 hours of onset of symptoms (De Toledo, 1996; Opdenakker, 1998; Saboo, 2007). Similarly, this study constituted participants with chronic urinary obstructive symptoms. As some studies have shown, RI is not a good parameter for assessing chronic urinary obstruction, as it tends to decrease after 24 hours of onset of symptoms.

In contrast, Studies have shown that cut off RI >0.7 is a good discriminatory between obstructive and non-urine obstruction with a sensitivity of 82.5 - 100%, specificity 88-90% and accuracy of 90% (Apoku, 2015; Ashraf, 2009; Gottlieb, 1997; Saboo, 2007). Similar findings were reported by oktar (Oktar, 2004). Other studies have also shown that increased RI can occur in both acute and chronic kidney obstruction (Sugiura & Wada, 2011). Ashraf documented that duplex Doppler ultrasonography had a sensitivity and specificity comparable to IVP in detection of renal obstruction in both chronic and acute obstruction without hydronephrosis (Ashraf, 2009).

Correlation of mRI across the grades of hydronephrosis showed that the mRI for renal artery increased steeply from grade I to grade II but fell abruptly at grade III with a rise in grade IV on the right but a gradual fall was seen on the left (p=0.047, 0.032) (table10, figure 6). However both right and left interlobar artery mRI did not demonstrate a statistical significant relation (p=0.09, 0.156) (table11, figure 7). This means that there was a relation between degree of hydronephrosis and high values of mRI for the renal artery but not for the interlobar artery.

This discrepancy could also be attributed to the small sample size used, high probability of participants not having complete urine obstruction and due to chronic urinary symptoms as explained above. Studies have shown discordance in results in correlation of RI with degree of hydronephrosis. Some, documenting a rise in RI with severity of hydronephrosis except for grade 4, while others documenting that RI is not a good parameter for assessing degree of hydronephrosis in chronic urinary obstruction as discussed above.

Comparable findings have been documented by the minority group in Tseng's study, who demonstrated 2 participants with severe hydronephrosis and impaired renal function evidenced by radioisotopic renography, but with RI levels of <0.7 (Tseng, 2004). Similarly, Piazzese and Naleini et al found no relation between RI and hydronephrosis in obstructed kidneys with and without hydronephrosis (Naleini & Maryam Javheri 2015; Piazzese, 2012). However, Naleini et al's studied a population with acute renal colic. Lee and Tseng revealed that, though RI increases significantly with severity of urine obstruction, it was not a good indicator for chronic and partial obstruction (Lee, 1996; Tseng, 2004).

In contrast, Chen found that RI correlates well with the degree of obstruction. He argued that cases with RI< 0.7 probably had minimal altered renal blood flow and the renal function was probably unchanged (Chen, 1993). Apoku and Platt's study also showed that the mRI increased steeply over the grades of hydronephrosis (Apoku, 2015; Platt, 1992). The disparity could be attributed to the studied population where the participants were not confirmed to have urine obstruction, but were clinically suspected to have urine obstruction as described above.

5.1.3 Bladder patterns

The average bladder wall thickness was above 5mm and among participants who had premicturition bladder volume >150ml, 1/3 had thickened bladder wall (table 12). The cut off BWT of 5mm at a bladder capacity of 150ml was used because high numbers of participants had Foleys catheter with resultant detrusor instability, therefore could not tolerate further bladder filling. The bladder wall thickening could have been due to detrusor smooth muscle hypertrophy and collagen deposition which occurs with persistent urine retention in BOO and could also be due to cystitis which is a common complication in BOO or bladder cancer (Manieri, 1998).

This results are in agreement with Manieri, and Peedikayil‘s et al who found that a cut off of >4.5-5mm at 150ml bladder volume was the best to diagnose bladder outlet obstruction (BOO) (Manieri, 1998; Peedikayil et al., 2004).

Although Oelke agreed that BWT had high sensitivity and specificity in diagnosing BOO, he demonstrated that at bladder capacity of <250 ml detrusor wall thickness

(DWT) was dependent on the bladder filling but remained stable with a bladder capacity >250ml. Therefore he advocated for DWT to be measured with a bladder volume >250ml in diagnosing BOO. This study contradicts our study where the BWT was measured at a bladder capacity of 150ml because most patients could not tolerate further bladder distention and therefore the etiology of a thickened bladder wall ranged from BOO, cystitis and bladder cancer. Since Oelke's study measured detrusor wall thickness which is sensitive in diagnosis of BOO, his results cannot compare with our findings. He also argued that measurement of the bladder wall thickness is prone to errors, such as due to inclusion of the perivesical tissue, the bladder mucosa and adventitia which may be thickened due to other causes (Oelke, 2007).

The median post-micturition bladder volume was above 50ml with slightly over half participants exhibiting urine retention (table 12). This could be due to weakness of detrusor muscle contraction or detrusor muscle dysfunction (Maruschke et al., 2009). Approximately a third of the participants had urinary catheter and PVR was only measured in participants without Foleys catheter. This explains the lower number of participants with urine retention.

Madersbacher and Kolman's findings were in agreement with our findings of using post void residual volumes >50 ml for diagnosis of urine retention (Kolman, 1999; Madersbacher, 2004), as larger PVR are associated with complications ie UTI, hydronephrosis and obstructive nephropathy.

The least in presentation were irregular bladder margin and sediments in urine which could be attributed to changes due to BOO, cystitis and complications due to indwelling Foleys catheter. The incidence of bladder diverticula was 7.1 % (table 12), a complication arising from BOO. Comparable to our study is Ogwuche's, who found an incidence of 3.2 % (Ogwuche, 2013). However Quirinia et al found a higher incidence of approximately half. The difference could be attributed to the multiple imaging modality used; cystography and urography (Quirinia & Hoffmann, 1992). Also the higher number of participants with urinary catheter and resultant detrusor instability may have prevented development of diverticula disease.

5.1.4 Prostate patterns

The median prostate size was approximately 50.0 cm^3 with close to two thirds having enlarged prostate (table 13). These findings were expected as there was predominance of male participants above the age of 50years in whom prostate enlargement has an increased incidence (Kilic, 2014).

These findings were lower than the ones found in Nigeria where 117 participants with BPH were enrolled with mean age of 67 ± 9.25 years (41-98) the prostate volume range was 22.5 - 387ml with a mean of 214 ± 8.49 (Maaji, 2015). This difference could be attributed to the age difference in the sample group where we included men of 18 years and above with a prostate volume range of 5-360ml. The younger participants with a normal prostate size might have lowered the mean, but majority of the male patients were above 50years of age.

Two thirds of the male participants had heterogeneous prostate and calcification. These findings are common with aging and chronic inflammation commonly seen with prostate enlargement (Maruschke et al., 2009).

5.2 Correlation between Sonographic Patterns of Renal Changes with Renal Function Tests

There was no statistically significant relation between creatinine and urea with renal echotexture (p=0.127, 0.146, 0.051), except for relation of urea and right kidney echogenicity (p=0.037). The discrepancy could be attributed to the small sample size and the characteristics and composition of study participants who were suspected but not confirmed to have urine obstruction and the study population only captured participants with chronic symptoms of urine obstruction..

Studies have shown that renal echotexture is non-specific finding occurring in several renal parenchyma diseases (S. Faubel, Patel, Nayana U., Lockhart, Mark E., Cadnapaphornchai, Melissa A., 2014; Moghazi, 2005).

Contrary to our findings, Siddappa et al found that renal echogenicity correlated well with serum creatinine in CKD. He also recommended the use of echogenicity to estimate renal function as opposed to serum creatinine. He argued that serum creatinine levels reduced with renal replacement therapy therefore could not assess renal injury status (Siddappa et al., 2013). The discordance could be attributed to the study population, where Siddappa recruited all patients with CKD while we only had patients suspected to have urine obstruction or urine retention. Probably in some of the participants renal injury had not yet occurred.

There was a weak positive correlation between RI values for the right and the left renal artery and the right and left interlobar arteries with creatinine and urea except for the RI of the left renal artery in relation to urea, p=0.058 (figure 9,10). These findings could be attributed to RI not being a good indicator for renal injury as it portrays changes of resistance and compliance in the renovascular supply rather than renal function.

Similar findings have been documented by the minority group in Tseng's study, where 2 participants with severe hydronephrosis and impaired renal function evidenced by radioisotopic renography yet had RI levels of <0.7.

In contrast, higher levels of RI have been associated with worse renal parenchyma damage and worse outcome (Sugiura & Wada, 2009). Apoku documented that RI> 0.7 had a sensitivity of 86.7% and specificity of 90% in predicting obstructive nephropathy (Apoku, 2015). The discordance could be tied to RI not being a good indicator for renal parenchyma injury as it mainly shows changes in the renovascular system.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The commonest gray scale and Doppler sonographic pattern seen were; normal mean kidney length, echogenic renal cortex, loss of corticomedullary differentiation, Grade 0 hydronephrosis, normal mRI.

Enlarged prostate volume was common in elderly male participants associated with significant urine retention.

Longstanding symptoms of urine obstruction were common in presentation.

There was no correlation in distribution of mRI across the grades of hydronephrosis. There was a weak positive correlation between RI with levels of both creatinine and urea except for the RI of the left renal artery in relation to urea. There was no association between renal cortical echotexture and renal function test except for urea and right kidney echogenicity.

6.2 Recommendation

A combination of clinical presentation, renal function tests and ultrasound imaging should be utilized for the initial assessment of renal injury in patient with urine obstruction.

A larger study to determine the utility of renal ultrasound in the diagnosis of acute and chronic urine obstruction is recommended.

6.3 Study Limitations

Only referred participants were studied.

Participants with acute urine obstruction were not captured.

Late referrals for ultrasound after relief of obstruction.

Lengthy renal Doppler ultrasound examinations, which could not be tolerated by invalids.

Based on inclusion criteria unilateral renal obstruction was not captured.

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APPENDICES

Appendix I: Time Schedule

ACTIVITY	START	COMPLETE
Proposal concept Development	March 2014	April 2013
Proposal Writing	April 2014	May 2014
IREC Approval	July 2014	July 2014
Research	October 2014	October 2015
Data Analysis	October 2015	January 2016
Thesis Writing	January 2016	March 2016

Appendix II: Estimated Project Budget

The estimated budget for this project is as illustrated below. The financial resources required to fund this research project shall be the researcher's own.

ITEM	QUANTITY	UNIT PRICE(ksh)	TOTAL(Ksh)
Laptop computer	1	70,000	70,000
Printer and photocopier	1	10000	10000
Stationary	-	6000	6000
Digital camera	1	15000	15000
CDs(ultrasound images storage)	60	20	1200
Statistical consultation	-	-	15000
Internet services and communication	-	-	10000
Publication	-	-	50000
Miscellaneous	-	-	17720
GRAND TOTAL	-	-	194920

Appendix III: Consent Form

English Version

Investigator: My name is Dr. Hubesi K. Asumin. I am a qualified doctor, registered by the Kenya Medical Practitioners and Dentists Board. I am currently pursuing a Master's degree in Radiology and Imaging at Moi University. With your permission I would like to recruit you into my research at Moi Teaching and Referral Hospital.

Purpose: This study will describe ultrasonographic pattern of Genito- urinary system in patients presenting with blockage of urinary tract in all age groups.

Procedure: All patients presenting with a clinical diagnosis of obstructive uropathy without a history of previous surgery and from who consent has been acquired will be examined using ultrasound. The patient's nominal data such as age, sex will be acquired. Data will be collected on data collection forms. Data collecting material will be kept in a locked cabinet in the office of the principal investigator during the study period.

Benefits: There will be no benefits of participating in this study. Study subjects will be accorded same quality of management as non-study subjects

Risks: There are no anticipated risks to the participants attributable to this study.

Confidentiality: All information obtained in this study will be treated with confidentiality and shall not be shared to any unauthorized person.

Rights to Refuse: Participation in this study is voluntary, there is freedom to decline to participate or withdraw at any time from the study. This study has been approved by the Institutional Research and Ethics Committee (IREC) of Moi University/Moi Teaching and Referral Hospital.

Sign or make a mark if you agree to take part in the study

Parent/Guardian: ……………… Investigator: ………………….. Date:

Kiswahili Version

Mpelelezi: Jina langu ni Dr Asumin K. Hubesi. Mimi ni daktari niliohitimu kusajiliwa na bodi ya Madaktari ya Kenya. Kwa sasa natafuta shahada ya uzamili katika Radiology na Imaging katika Chuo Kikuu cha Moi. Ningependa kukusajili katika utafiti wangu ambao ni wa kupima mfumo wa mkojo kwa wagonjwa walio na kizuizi ya njia ya mkojo katika hospitali ya mafundisho na ya rufaa ya moi.

Kusudi: Utafiti huu utaeleza matokea ya ultrasound wa wagonjwa walio na kizuizi ya njia ya mkojo.

Utaratibu: Wangonjwa wote ambao wana kasoro ya kizuizi ya njia ya mkojo bila historia ya upasuaji wa awaliwatafanyiwa utafiti kutumia ultrasound. Ruhusa itachukuliwa na maswali wa umri na jinsia yataulizwa. Data zitakusanywa kwenye fomu za ukusanyaji data. Hifadhi zitakazo tumika katika ukusanyaji wa data zitawekwa katika kabati iliyofungwa katika nyumba ya mpelelezi mkuu katika kipindi cha utafiti.

Faida: Hakutakuwa na faida yeyote ya kushiriki katika utafiti huu. Wanaofanyiwa utafiti watakuwa nahaki sawa ya kupatiwa matibabu bora na wale ambao hawatofanyiwa utafiti huo.

Hatari: Utafiti huu haukusudiwi kuwa na hatari yeyote.

Usiri: habari zozote zitakazopatikana katika utafiti huu zitawekwa kwa siri na wala hazitatolewa kwa mtu yeyote asiye husika na utafiti.

Haki ya kukataa: Kushiriki katika utafiti huu ni kwa hiari yako, kuna uhuru wa kukubali, kukataa au kutoka kwenye utafiti wakati wowote. Utafiti huu imepitishwa na Utafiti wa Taasisi na Kamati ya Maadili (IREC) ya Chuo Kikuu cha kufundishia Moi na Hospitali ya Rufaa.

Kusaini au kufanya alama kama unakubali kushiriki katika utafiti

Mzazi / Mlezi: .... Mpelelezi: ....

Tarehe: ....

Appendix IV: Data Collection Form

DEMOGRAPHICS

Date: …………………………… Medical Record Number: …………………………

Date of birth…………………….

Serial Number………………….. ………………………….

Sex: ☐ Male ☐ Female:

Residence....................................

Concurrent illness: ………………………..…………………………..:

Current medications: … …………………………………………………

Symptoms		Duration	Symptoms		Duration	Signs	
Urine retention			Terminal			Globe vesicale	
Dysuria			Decreased flow			Suprapubic	
Hesitancy			Hematuria			Flank tenderness	
Frequency			Pyuria			Fever	
Urge			Suprapubic pain				
Incontinence			Flank pain				

RENAL FUNCTION TEST RESULTS:

Renal function test	Creatinine		Urea	

ULRASONOGRAPHY RESULTS

Kidney:

		Right		Left	
Size (cm)					
Echotexture (echoic to [illegible])	Hypoechoic	Yes	No	Yes	No
	Isoechoic	Yes	No	Yes	No
	Echogenic	Yes	No	Yes	No
Corticomedullary		Yes	No	Yes	No
Masses	Cystic	Yes	No	Yes	No
	solid	Yes	No	Yes	No
	mixed	Yes	No	Yes	No
Calculi		Yes	No	Yes	No

Doppler ultrasound: (N= NORMAL, R= RAISED)

	Resistive index (RI)	
	Right	Left
Renal artery		
Interlobar artery		

Hydronephrosis : (G = grade)

	Right					Left				
Grade hydronephrosis	G0	G1	G2	G3	G4	G0	G1	G2	G3	G4

Bladder:

Wall thickness (cm)				NORMAL	THICKENED
Margin	Regular	Yes		No	
	Irregular	Yes		No	
Sediments		Yes		No	
Calculi		Yes		No	
Masses		Cystic		Solid	
	Pedunculate	Yes	No	Yes	No
	Intramural	Yes	No	Yes	No
	Intraluminal	Yes	No	Yes	No
Bladder volume (cm3)		Pre- mic…		Post- mic	

Prostate in male:

Size (cm3)		NORMAL	ENLARGED
Echopattern	Homogeneous	Yes	No
	Heterogeneous	Yes	No
	Calcification	Yes	No
Margin	Regular	Yes	No
	Irregular	Yes	No

Any additional findings:

……

……

……………

…………………………………………………………………………………………………

Appendix VII: MTRH Approval

MOI TEACHING AND REFERRAL HOSPITAL

Telephone: 2033471/2/3/4
Fax: 61749
Email: director@mtrh.or.ke

P. O. Box 3
ELDORET

Ref: ELD/MTRH/R.6/VOL.II/2008

18th November, 2014

Dr. Asumin K. Hubesi,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

RE: APPROVAL TO CONDUCT RESEARCH AT MTRH

Upon obtaining approval from the Institutional Research and Ethics Committee (IREC) to conduct your research proposal titled:-

"Ultrasound Patterns in Patients Presenting with Obstructive Uropathy at Moi Teaching and Referral Hospital".

You are hereby permitted to commence your investigation at Moi Teaching and Referral Hospital.

DR. JOHN KIBOSIA
DIRECTOR
MOI TEACHING AND REFERRAL HOSPITAL

CC - Deputy Director (CS)
- Chief Nurse
- HOD, HRISM

Appendix VIII: IREC Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET

24 th July, 2014

Reference: IREC/2014/121
Approval Number: 0001224

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
24 JUL 2014
APPROVED
P.O. Box 4606-30100 ELDORET

Dr. Asumin K.Hubesi,
Moi University,
College of Health Sciences,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Hubesi,

RE: FORMAL APPROVAL

The Institutional Research and Ethics Committee has reviewed your research proposal titled:-

"Ultrasound Patterns in Patients Presenting with Obstructive Uropathy at Moi Teaching and Referral Hospital".

Your proposal has been granted a Formal Approval Number: ***FAN: IREC 1224*** on 24th July, 2014. You are therefore permitted to begin your investigations.

Note that this approval is for 1 year; it will thus expire on 23rd July, 2015. If it is necessary to continue with this research beyond the expiry date, a request for continuation should be made in writing to IREC Secretariat two months prior to the expiry date.

You are required to submit progress report(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change (s) or amendment (s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	Director	-	MTRH	Dean	-	SOP	Dean	-	SOM
	Principal	-	CHS	Dean	-	SON	Dean	-	SOD

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
SCHOOL OF MEDICINE
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2014/121
Approval Number: 0001224

18th November, 2016

Dr. Asumin K.Hubesi,
Moi University,
College of Health Sciences,
P.O. Box 4606- 30100,
ELDORET.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
18 NOV 2016
APPROVED
P. O. Box 4606-30100 ELDORET

Dear Dr.Hubesi,

RE: APPROVAL OF AMENDMENT

The Institutional Research and Ethics Committee has reviewed the amendment made to your proposal titled:-

"Ultrasonographic Patterns of Patients Referred with Urine Obstruction in Correlation to Renal Function Tests at Moi Teaching and Referral Hospital."

We note that you are seeking to make amendments as follows:

1. To change the study title from "Ultrasonographic Patterns of Patients Referred with Obstructive Uropathy in Correlation to Renal Function Tests at Moi Teaching and Referral Hospital" to the title in bold above.
2. Reduction of Study Participants from 129 (sample size calculated was 118) to 84,

The amendments have been approved on 18th November, 2016 according to SOP's of IREC. You are therefore permitted to continue with your research.

You are required to submit progress(s) regularly as dictated by your proposal. Furthermore, you must notify the Committee of any proposal change(s) or amendment(s), serious or unexpected outcomes related to the conduct of the study, or study termination for any reason. The Committee expects to receive a final report at the end of the study.

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc:	CEO	-	MTRH	Dean	-	SPH	Dean	-	SOM
	Principal	-	CHS	Dean	-	SOD	Dean	-	SON