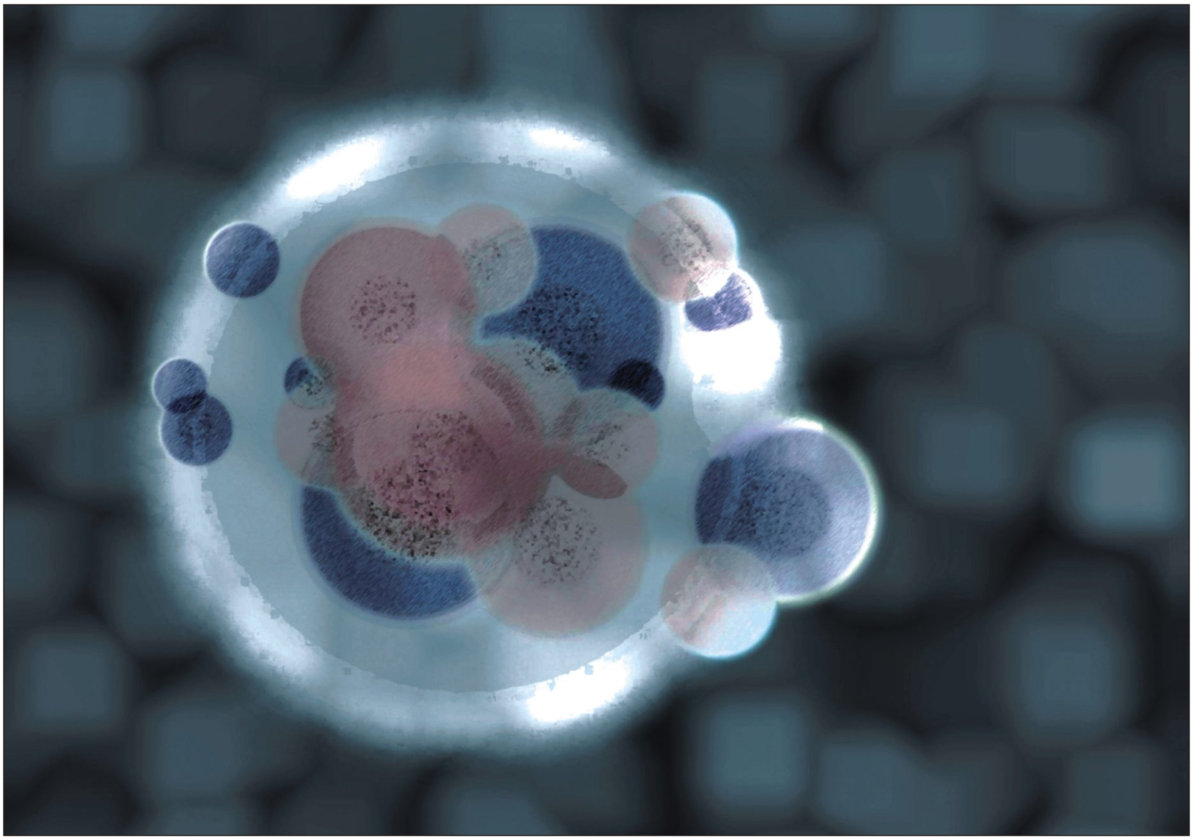

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Research Article

Real Time Brightness Mode Ultrasound in Determining the Causes and Complications of Obstructive Uropathy

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Abstract

Background and Objective: Obstructive uropathy (OU) refers to the structural or functional changes in the urinary tract that impede normal urine flow. This study was designed with an aim to detect the sensitivity, specificity and accuracy of using real-time brightness mode (B-mode) ultrasound (US) in determining the causes and complication of OU. **Materials and Methods:** A total of 100 patients with symptoms of OU were recruited for a period of 12 months between August, 2017 and August, 2018 in this prospective study. The renal and pelvic US examination was conducted using Mindray's DC-60 machine, equipped with a lower frequency (3.5 MHz) curvilinear probe that allowing a deep penetration and a wide depth of field, which was excellent for viewing intra-abdominal and pelvic structures. **Results:** Renal stones 25(40.3%), prostatic masses 9(14.5%), urinary tract infection (UTI) 2(3.2%) and urinary bladder (UB) diverticula1(1.6%) were the major causes of OU in male patients. While, in female patients, the most common causes of OU were renal stones 11(28.9%), ovarian masses 6(15.8%), UTI 1(2.6%) and ureterocele 1(2.6%). Hydronephrotic changes with grade II 16(25.8%), grade III 9(14.5%), grade I 2(3.2%) and grade IV 1(1.6%) were frequent in male patients. While, in female patients, the commonest hydronephrotic changes were with grade II 8(21.1%) and 7(18.4%), grade I 1(2.6%) and grade III 1(2.6%). **Conclusion:** Renal and pelvic US showed a sensitivity of 97.85%, specificity of 75% and accuracy of 95.24% in determining the causes and complication of OU.

Key words: Brightness mode ultrasound, intra-abdominal and pelvic structures, urinary tract infection, obstructive uropathy

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The term obstructive uropathy (OU) refers to a structural impedance to flow anywhere along the urinary tract from the renal pelvis to the tip of the urethra. This impedance increases pressure proximal to the obstruction. The term does not necessarily imply damage to the kidney[1]. However, obstruction can be thought of as a restriction of urine flow, which, if left uncorrected will lead to progressive renal deterioration or hamper normal renal development[1,2]. The obstructive process can occur at multiple levels of the urinary tract, including the urethra, the bladder outlet and the ureters[3].

The OU is classified according to the site, degree and duration of the obstruction. Acute or chronic obstruction can occur anywhere in the urinary tract and includes internal causes (casts, crystals) and external causes. Acute or chronic obstruction is further sub-divided into upper urinary tract obstruction (usually unilateral obstruction occurring above the vesicoureteral junction) and lower urinary tract obstruction (usually bilateral obstruction located below the vesicoureteral junction). Complete obstruction of the urinary tract is termed high grade, whereas partial or incomplete obstruction is termed low grade. In addition, the causes of OU affecting the upper and lower urinary tracts were summarized[4] in Table 1 and 2.

Prompt diagnosis of urinary tract obstruction is essential to allow treatment to limit any long-term adverse consequences. Symptoms such as renal colic may suggest the diagnosis and prompt appropriate investigation. Ultrasound (US) is the most widely used imaging modality, but the imaging approach for investigation of obstruction is changing. Computed tomography (CT) and magnetic resonance (MR) urography are useful in accurately diagnosing both the site and the cause of obstruction, but the availability and expertise in the use of different imaging techniques vary from center to center, an older imaging techniques, such as intravenous urography (IVU) can still be used effectively to evaluate patients with OU[4,5].

Renal and pelvic US is relatively inexpensive, widely available imaging modality that has the added advantage of not requiring ionizing radiation to identify structural changes of the urinary tract. It is the first diagnostic test that is ordered as part of the work-up for suspected obstruction. US allows for the excellent morphological assessment of both the lower and upper urinary tract systems, regardless of renal function. However, it is operator dependent and it can be difficult to obtain from patients who are not co-operative or who have a challenging body habitus[6]. Although US is sensitive for detection of hydronephrosis (Fig. 1), US will often not detect its cause. A pathologic change within the ureter is difficult to demonstrate and tiny stones will not generate acoustic

Table 1: Causes of upper urinary tract obstruction

Causes of upper urinary tract obstruction	
Intrinsic causes	Extrinsic causes
Intraluminal	**Reproductive system**
Intratubular deposition of crystals (uric acid, drugs)	Cervix: carcinoma
Stones	Uterus: pregnancy, tumors, prolapse, endometriosis and pelvic inflammatory disease
Papillary tissue blood clots	Ovary: abscess, tumor and cysts
Fungal ball	Prostate: carcinoma
Intramural	**Vascular system**
Functional: pelvic-ureteral or vesicoureteral junction dysfunction	Aneurysms: aorta and iliac vessels
Anatomic: tumors (benign or malignant), infections, granulomas, and strictures	Aberrant arteries: pelvi-ureteral junction
	Venous: ovarian veins and retrocaval ureter
	Gastrointestinal tract
	Crohn's disease
	Pancreatitis
	Appendicitis
	Diverticulitis
	Tumors
	Retroperitoneal space
	Lymph nodes
	Fibrosis: idiopathic, drugs or inflammatory
	Tumors: primary or metastatic
	Hematomas
	Radiation therapy
	Surgical disruption or ureteral ligation

Source: Harris and Hughes[4]

Table 2: Causes of lower urinary tract obstruction

Causes of lower urinary tract obstruction
Urethral causes
Urethral anatomic causes
Urethral strictures: trauma, post-instrumentation, infections such as gonococcal urethritis, non-gonococcal urethritis and tuberculosis
Posterior urethral valves
Stones
Blood clots
Periurethral abscess
Phimosis
Paraphimosis
Meatal stenosis
Urethral functional causes
Anti-cholinergic drugs, anti-depressants and levodopa
Prostatic causes
Prostate
Benign prostatic hypertrophy
Prostatic carcinoma
Prostatic calculi
Prostatic infection
Bladder causes
Bladder anatomic causes
Bladder cancer
Schistosomiasis (Schistosoma haematobium infection)
Bladder calculi
Bladder trauma and pelvic fracture
Bladder functional causes
Neurogenic bladder: spinal cord defects or trauma, diabetes, multiple sclerosis, Parkinson's disease and cerebro-vascular accidents

Source: Harris and Hughes[4]

Fig. 1: Hydronephrosis due to ureteropelvic junction obstruction in a pediatric patient
Source: Hansen *et al.*[7]

shadows. However, unilateral hydronephrosis suggests obstruction of the upper urinary tract by stones, blood clots, or tumors. Bilateral hydro-nephrosis is more likely to result from a pelvic problem obstructing either ureters or obstruction of the bladder outlet, in that case the bladder will also be enlarged[5-7].

To the best of author's knowledge, there were only a few studies conducted on the Saudi Arabia, which evaluated the role of real time B-mode US in determining the causes and complications of OU. Unfortunately, these published studies were not agreed upon as an approved medical framework for determining the causes and complications of OU using brightness mode (B-mode) US for their lack of sensitivity, specificity and accuracy. Thus, this study was designed with an aim to detect the sensitivity, specificity and accuracy of using realtime B-mode US in determining the causes and complication of OU.

MATERIALS AND METHODS

Selection and description of patients: After receiving approval from the local ethics committee, a group of 100 patients with symptoms and signs of OU, treated at King Fahad Medical City, Riyadh, Saudi Arabia, were recruited for a period of 12 months between August, 2017 and August, 2018 in this prospective study. Patients were recruited consecutively by the urologist and referred to the sonologist who was blinded to the clinical status of the subjects to minimize bias. A waiver of informed consent was granted in accordance with institutional guidelines.

Diagnostic work-up included the following: (i) Physical examination, (ii) Lab tests (urine analysis, urine culture and urea and creatinine), (iii) Plain abdominal X-ray films of the kidneys, ureters and urinary bladder (KUB), intravenous urography (IVU) and (iv) Renal and pelvic US exam. In addition, to ensure the credibility of the obtained results, a very strict inclusion and exclusion criteria were used. Inclusion criteria; were: (i) All adult patients, including males and females (age: $\geq$8 years) and (ii) With clinical signs (suprapubic and or renal angle tenderness) and symptoms (flank pain and or dysuria) suggestive of OU or urinary tract infection (UTI) were included. Exclusion criteria were patients who presented with either: (i) Pregnancy or gravidity, (ii) Sickle cell disease, (iii) Diabetes mellitus (DM), (iv) Smokers and (v) Who have hypertensive disorders. Patients who presented as emergency cases and comply with the inclusion and exclusion criteria were examined immediately, while others were examined after at least 8 h fasting to reduce intra-abdominal gas and enhance visualization of their kidneys and urinary bladder (UB).

Renal and pelvic US examination protocol: All renal and pelvic US examinations were performed in a supine position in a thermally controlled room of 26°C; 78°F by the same sonographer. The renal and pelvic US examination was conducted using Mindray's DC-60 US system (Mindray; Shenzhen Mindray Biomedical Electronics Co., Ltd., Seoul, Republic of Korea), equipped with a lower frequency (3.5 MHz) curvilinear probe that allowing a deep penetration and a wide depth of field, which is excellent for viewing intra-abdominal and pelvic structures. The initial US examination was performed under high gain (80-90 dB) and low gain (60-70 dB) sensitivity for more detailed inspection during ultrasonography. For efficient and accurate diagnosis of US images, the appropriate time gain compensation and dynamic range control of US echo signals were automatically set by the system and/or manually adjusted by the sonographer to obtain the desired image quality on the screen.

In this study, the routine renal US examination includes routine long-axis and transverse views of the upper poles, midportions and lower poles of the kidneys. The cortex and renal pelvises were assessed. A maximum measurement of renal length was also recorded for both kidneys. In addition, decubitus, prone or upright positioning was used to provide better images of the kidneys. When possible, renal echogenicity was compared to echogenicity of the adjacent liver or spleen. While, in the trans-abdominal pelvic sonogram, the patient's bladder was distended adequately to displace the small bowel from the field of view (FOV). Both kidneys and UB of each patient were initially examined by ultrasonography to rule out the potential causes of OU (Table 1, 2). The presence of hydro-nephrosis was documented for each subject on B-mode and graded as described by Apoku *et al.*[8] and Fernbach *et al.*[9], where a system to grade upper tract dilatation or hydro-nephrosis imaged by US has been developed as follows: In Grade 0 there was no hydronephrosis. At Grade I the renal pelvis only was visualized, Grade II hydro-nephrosis was present when a few, but not all calices were identified in addition to the renal pelvis. Grade III HN required that virtually all calices were seen. Grade IV hydro-nephrosis may had a similar appearance of the calices as Grade III but, when compared with the normal side, the involved kidney has parenchymal thinning[8,9]. It should be noted that, the used guidelines for performing renal and pelvic US examination were in line with the American Institute of Ultrasound in Medicine (AIUM) practice parameter for the performance of an US examination in the practice of urology and pelvic[9-11].

Analysis of renal and pelvic US images: In routine long-axis view the length of the adult kidney was normally 10-12 cm. The renal sinus was hyperechoic and was composed of calyces, the renal pelvis, fat and the major intra-renal vessels. The urinary collecting system in the renal sinus was not visible, but it created a hetero-echoic appearance with the interposed fat and vessels. The parenchyma was more hypoechoic and homogenous and was divided into the outermost cortex and the innermost slightly less echogenic medullary pyramids (Fig. 2). Normally, the full bladder on transverse US scan appeared as an anechoic thin-walled of 2-3 mm smooth

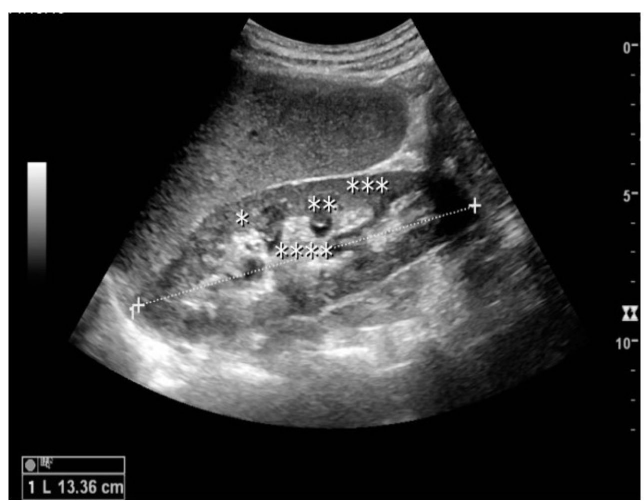

Fig. 2: Normal adult kidney

Measurement of kidney length on the US image was illustrated by '+' and a dashed line. *Column of Bertin, **Pyramid, ***Cortex and ****Sinus. Source: Hansen *et al.*[7]

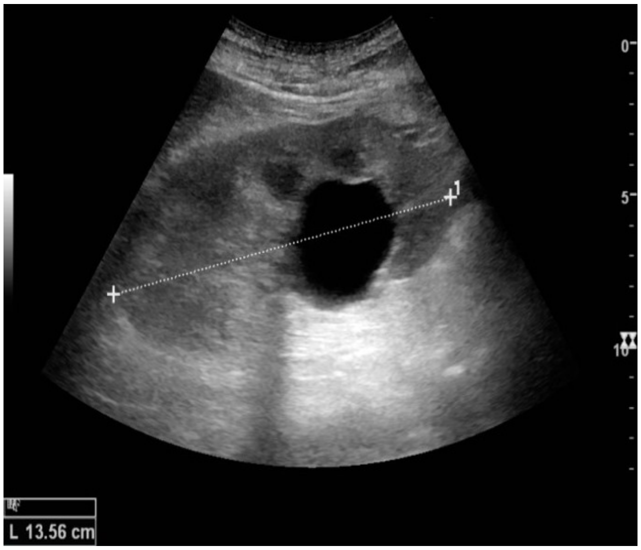

Fig. 3: Simple cyst with posterior enhancement in an adult kidney
Source: Hansen *et al.*[7]

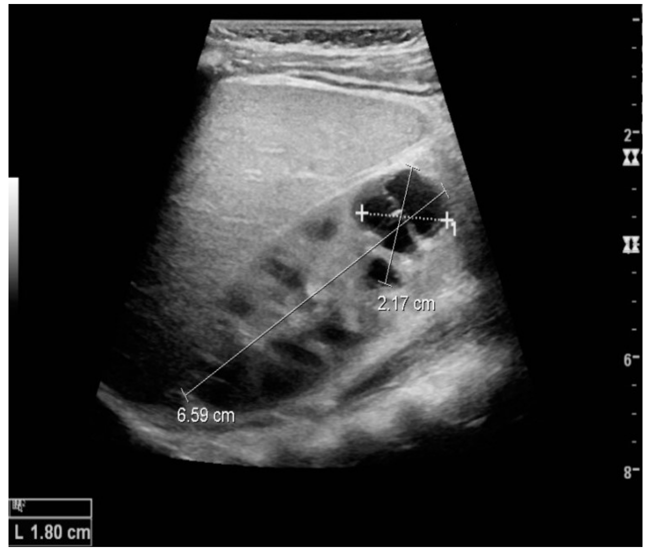

Fig. 5: Complex cyst with thickened walls and membranes in the lower pole of an adult kidney
Source: Hansen *et al.*[7]

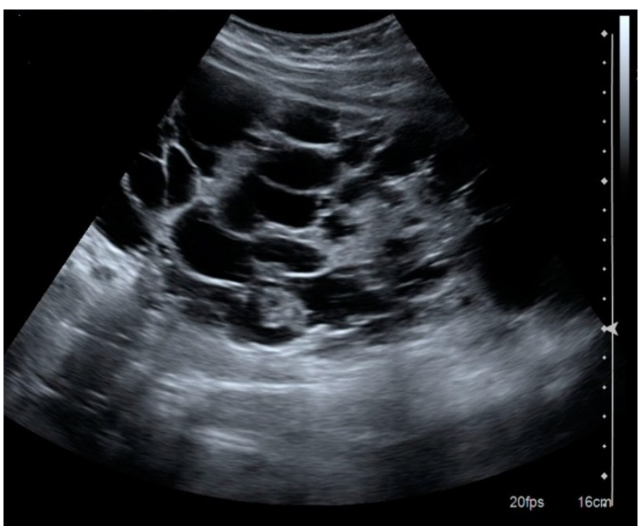

Fig. 4: Advanced polycystic kidney disease with multiple cysts
Source: Hansen *et al.*[7]

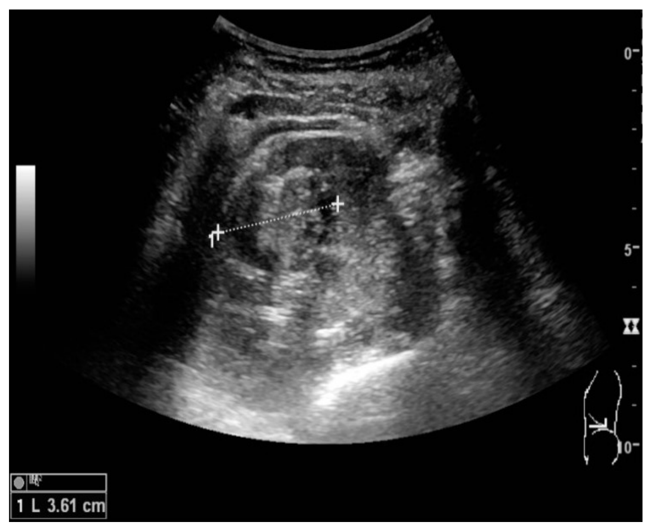

Fig. 6: Cortical solid mass of 3.61 cm, which later was shown to be renal cell carcinoma
Source: Hansen *et al.*[7]

structure, almost rectangular in configuration with a symmetrical shape. While in sagittal section, the bladder was triangular in shape. The ureteric orifices appeared as small focal thickenings of the bladder base[7].

Sonographically, cystic renal masses were seen as a distortion of the normal renal architecture. Simple cysts cause posterior enhancement as a consequence of reduced attenuation of the US within the cyst fluid (Fig. 3). Complex cysts had membranes dividing the fluid-filled center with internal echoes, calcifications or irregular thickened walls (Fig. 4). In polycystic kidney disease, multiple cysts of varying size in close contact with each other were seen filling virtually the entire region with lack of corticomedullary differentiation (Fig. 5). A solid renal mass appeared in the US exam with internal echoes, without the well-defined, smooth walls seen in cysts (Fig. 6)[7].

Hydro-nephrosis was seen as an anechoic fluid-filled interconnected space with enhancement within the renal

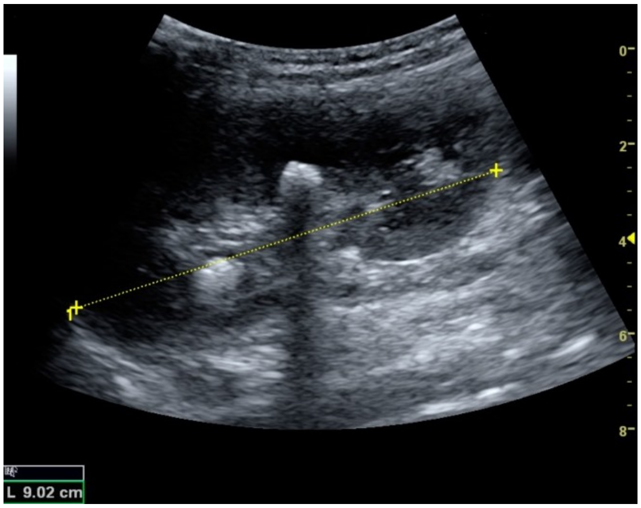

Fig. 7: Centrally-located stone with posterior shadowing. No hydronephrosis is present
Source: Hansen *et al.*[7]

Fig. 8: Bladder stones imaging with ultrasonography show an echogenic mass in the UB with posterior acoustic shadow
Source: Schwartz and Stoller[12]

sinus and normally, the dilated pelvis can be differentiated from the dilated calyces (Fig. 1). Hyper-echoic renal stones were seen with accompanying posterior shadowing (Fig. 7). The UB stones appeared as highly reflective masses within the bladder, move with altered posture and cast shadows (Fig. 8). Stones in the ureter are usually not visualized with US due to air-filled intestines obscuring the insonation window. However, ureteral stones near the ostium can be visualized with a scan position over the bladder[7,12].

In pelvic US, the superficial UB tumors project into the bladder lumen from the mucosa layer of the bladder. Broad

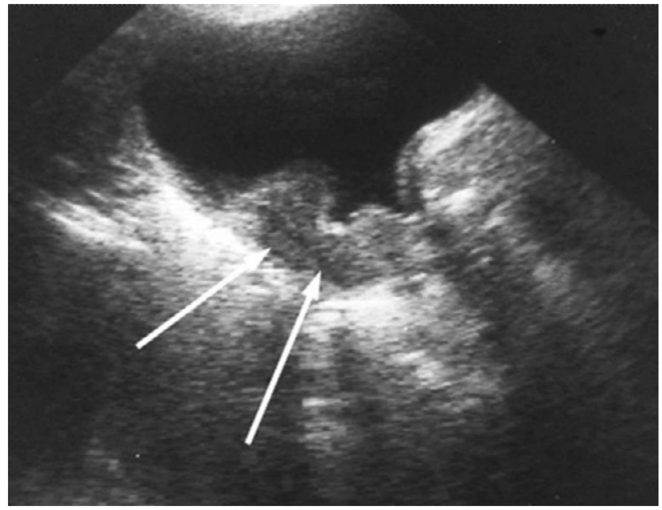

Fig. 9: Bladder adenocarcinoma. The tumor located in the bladder base (arrows) is associated with a superficial ulceration
Source: Bala and Chou[13]

based bladder tumors are larger sized and involve deep muscle layers (Fig. 9). In severe cases of acute cystitis, US will present the three-layer sign on the bladder wall and debris in the urine. While in recurrent cystitis and on ultrasonographic examination, the bladder inner wall was found to be irregular, urine may contain fine suspended echoes and a varying amount of post-void residual urine (Fig. 10). The UB diverticula were virtually associated with urinary outflow obstruction. Increased pressure inside the bladder tends to push mucosa between the superficial muscle bundles causing the formation of small pockets or cellules (Fig. 11). Ureteroceles appeared as a cyst within a cyst. Mostly, they are dynamic and gradually increase in size with accumulation of urine and then collapse (Fig. 12)[13].

Statistical analysis: All measurable data were initially summarized in a form of comparison tables. Range, mean and SD of patient's age, gender, causes and sites of obstruction and obstruction complications were recorded. The statistical diagnostic test was used to detect sensitivity, specificity and accuracy of the renal and pelvic US in determining the causes and complications of OU. Statistical analysis was performed using the Statistical Package for the Social Sciences version 20 for Windows (IBM Corporation, Armonk, NY, USA).

RESULTS

In this prospective study, a total of 100 patients with symptoms and signs of OU completed standard physical and

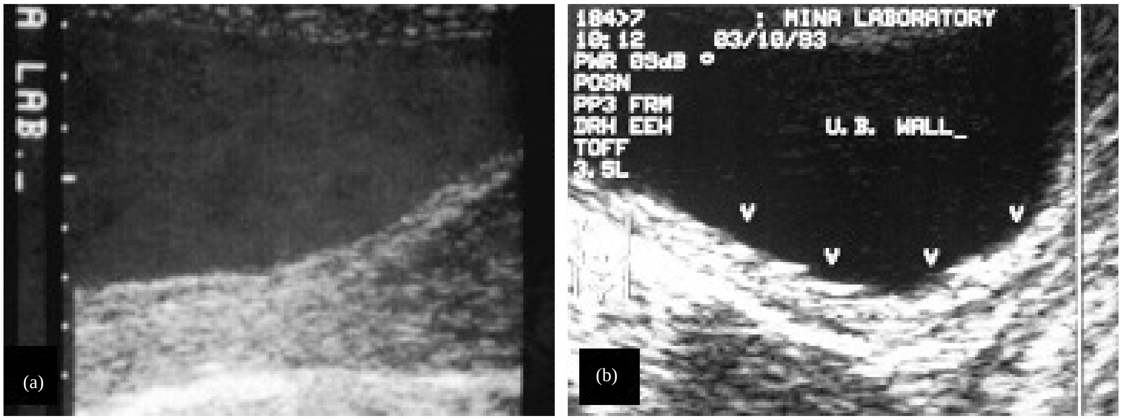

Fig. 10(a-b): (a) Acute cystitis, in severe cases, the three-layer sign of the bladder wall and debris in the urine are seen and (b) Recurrent cystitis. On ultrasonographic examination, the bladder inner wall is found to be irregular
Source: Bala and Chou[13]

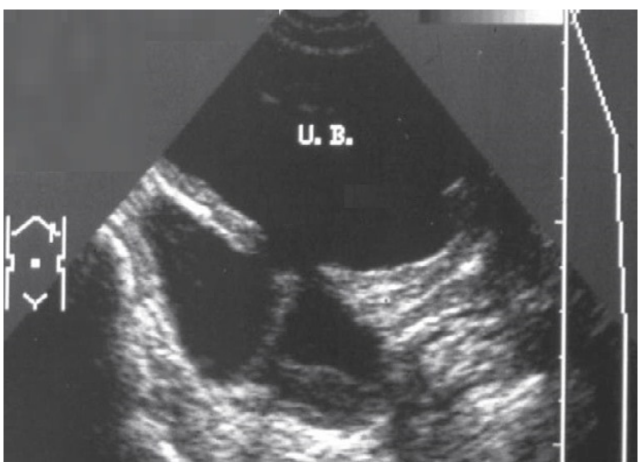

Fig. 11: Bladder diverticulum. There is a large diverticulum posteriorly and the ostium is easily identified. The wall of the diverticulum is smooth and contains debris
Source: Bala and Chou[13]

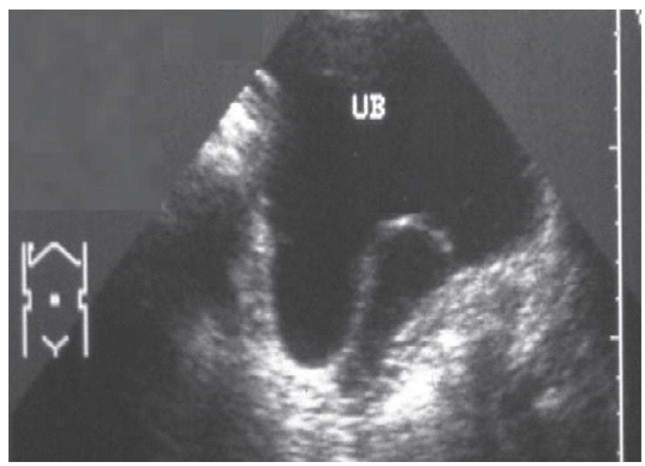

Fig. 12: Ureterocele. Sagittal section of the bladder showing a well-defined cystic lesion overlying the ureteric orifice. A dilated distal ureter is also seen
Source: Bala and Chou[13]

renal and pelvic real time grayscale ultrasonography examination. A total of 62(62%) patients were males and the rest 38(38%) were females (ratio of 1.6:1). The mean age$\pm$SD was 48.9$\pm$1.3 years (48.3$\pm$1.2 years for males and 49.5$\pm$1.3 years for females) with age ranges from 18 up to 83 years (Table 3).

All patients admitted for renal and pelvic US examination were screened for the presence of any OU associated clinical manifestations (Table 4). The median of symptoms and signs, duration in patients was 5 months with a range of 10 days to 2 years. Clinical manifestation of renal colic of 56(90.3%) and 34(89.5%) was the commonest findings in male and female patients, respectively.

Sonographically, in male patients, hydronephrotic changes with grade II 16(25.8%), grade III 9(14.5%), grade I 2(3.2%) and grade IV 1(1.6%) were frequent due to urinary system stones, masses, UTI and congenital disorders, respectively. While, in female patients, the commonest hydronephrotic changes were with grade II 8(21.1%) and 7(18.4%), grade I 1(2.6%) and grade III 1(2.6%). Also, these were due to urinary system stones, masses, UTI and congenital disorders, respectively (Table 5).

The diagnostic testing revealed a sensitivity of 97.85%, specificity of 75% and accuracy of 95.24% for the performance of renal and pelvic US in determining the causes and complication of OU. Furthermore, results showed positive

Table 3: Age distribution among OU patients in the study sample

Age ranges (years)	Frequency (n), age ranges in male patients (%)	Frequency (n), age ranges in female patients (%)	Mean age±SD (years) in male patients	Mean age±SD (years) in female patients	Mean age±SD (years) in the sample
18-28	2 (3.2%)	1 (2.6%)	23.0±1.7	20.0±1.2	21.5±1.45
29-39	5 (8.1%)	3 (7.9%)	31.0±0.9	34.0±1.9	32.5±1.4
40-50	27 (43.6%)	13 (34.2%)	43.0±1.6	48.0±0.5	45.5±1.05
51-61	11 (17.7%)	12 (31.6%)	53.0±1.1	56.0±1.3	54.5±1.2
62-72	14 (22.6%)	8 (21.1%)	63.0±1.3	64.0±1.6	63.5±1.45
73-83	3 (4.8%)	1 (2.6%)	77.0±0.8	75.0±1.4	76.0±1.1
Total	62 (100.0%)	38 (100.0%)	48.3±1.2	49.5±1.3	48.9±1.3

Table 4: Clinical manifestations in OU

	Clinical manifestations in male patients		Clinical manifestations in female patients	
Clinical manifestations in OU	Frequency	Percentage	Frequency	Percentage
Fever	53	85.5	33	86.8
Nausea and vomiting	44	71.0	30	79.0
Intermittent pain	55	88.7	31	81.6
Renal colic	56	90.3	34	89.5
Changes in urinary output				
Anuria or oliguria	45	72.6	22	57.9
Polyuria	11	17.7	7	18.4
Fluctuating urinary output	35	56.5	23	60.5
Hematuria	39	62.9	15	39.5
Palpable masses	16	25.8	11	29.0
New onset or poorly controlled hypertension	12	19.4	18	47.4
Repeated UTI	28	45.2	25	65.8
Lower urinary tract symptoms				
Hesitancy	27	43.6	24	63.2
Urgency	41	66.1	29	76.3
Incontinence	22	35.5	21	55.3
Post void dribbling	13	21.0	0	0.0
Decreased force and caliber of the urinary stream	21	33.9	17	44.7
Nocturia	9	14.5	6	15.8

predictive value (PPV) of 96.81% and negative predictive value (NPV) of 81.82% for the renal and pelvic US performance too (Table 6).

DISCUSSION

In this study and regarding changes in urinary output in male and female patients, polyuria was less frequent, with an incidence in 11(17.7%) and 7(18.4%) patients. Also, the lower urinary tract symptom of urgency was frequent in 41(66.1%) and 29(76.3%) male and female patients. The least frequent symptom of lower urinary tract was nocturia, with an incidence of 9(14.5%) in males and 6(15.8%) in females (Table 4). In addition, renal stones 25(40.3%), prostatic masses 9(14.5%), UTI 2(3.2%) and UB diverticula 1(1.6%) were the major causes of OU in male patients. While, in female patients, the most common causes of OU were renal stones 11(28.9%), ovarian masses 6(15.8%), UTI 1(2.6%) and ureterocele (Table 5). Such findings, could compared to the results of Apoku *et al.*[8], where 20 (33%) subjects had uterine fibroid, 16(27%) had enlarged prostate, 9(15%) had pelviureteral junction obstruction, 7(11%) had UB mass; 4(7%) subjects each had ovarian cysts, cervical carcinoma, rectal carcinoma, ureteral stricture and vesicoureteral obstruction, respectively.

Classically, dilation of collecting systems cores from grades 0 to IV, where in Grade 0 there was no hydro-nephrosis. At Grade I the renal pelvis only was visualized, Grade II hydro-nephrosis was present when a few, but not all calices were identified in addition to the renal pelvis. Grade III HN required that virtually all calices were seen. Grade IV hydro-nephrosis may have a similar appearance of the calices as Grade III but, when compared with the normal side, the involved kidney has parenchymal thinning[8,9]. Although, pathologic change within the ureter was difficult to demonstrate. However, unilateral hydro-nephrosis suggested obstruction of the upper urinary tract by stones, blood clots, or tumors. Bilateral hydro-nephrosis was more likely to result from a pelvic problem obstructing either ureters or obstruction of the bladder outlet, in which case the bladder will also be enlarged[5]. Current findings, in male patients represent hydronephrotic changes with grade II 16(25.8%), grade III 9(14.5%), grade I 2(3.2%) and grade IV 1(1.6%) were frequent due to urinary system stones,

Table 5: Causes and complication (hydronephrosis grades) in the study population as detected sono-graphically

Cause of OU	Frequency (n), percentage (%) of the incidence of OU causes in male patients	Frequency (n), percentage (%) of complication (hydronephrosis grades)				Frequency (n), percentage (%) of the incidence of OU causes in female patients	Frequency (n); percentage (%) of complication (hydronephrosis grades)			
		I	II	III	IV		I	II	III	IV
Stones	29(46.7%)	1(1.6%)	16(25.8%)	11(17.7%)	1(1.6%)	13(34.2%)	2(5.2%)	8(21.1%)	1(2.6%)	2(5.2%)
Renal	25(40.3%)	0(0.0%)	14(22.6%)	10(16.1%)	1(1.6%)	11(28.9%)	0 (0.0%)	8(21.1%)	1(2.6%)	2(5.2%)
UB	3(4.8%)	0(0.0%)	2(3.2%)	1(1.6%)	0(0.0%)	2(5.3%)	2(5.2%)	0(0.0%)	0(0.0%)	0(0.0%)
Prostatic	1(1.6%)	1(1.6%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)
Masses	15(24.1%)	1(1.6%)	5(8.0%)	9(14.5%)	0(0.0%)	16(42.1%)	5(13.1%)	7(18.4%)	3(7.8%)	1(2.6%)
Renal	2(3.2%)	1(1.6%)	1(1.6%)	0(0.0%)	0(0.0%)	1(2.6%)	0(0.0%)	0(0.0%)	1(2.6%)	0(0.0%)
UB	4(6.4%)	0(0.0%)	3(4.8%)	1(1.6%)	0(0.0%)	1(2.6%)	1(2.6%)	0(0.0%)	0 (0.0%)	0(0.0%)
Cervix	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	3(7.9%)	0(0.0%)	2(5.3%)	1(2.6%)	0(0.0%)
Uterus	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	5(13.2%)	0(0.0%)	4(10.5%)	1(2.6%)	0(0.0%)
Ovaries	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	6(15.8%)	4(10.5%)	1(2.6%)	0 (0.0%)	1(2.6%)
Prostate	9(14.5%)	0(0.0%)	1(1.6%)	8(12.9%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0 (0.0%)	0(0.0%)
UTI	2(3.2%)	2(3.2%)	0(0.0%)	0(0.0%)	0(0.0%)	1(2.6%)	1 (2.6%)	0(0.0%)	0 (0.0%)	0(0.0%)
Congenital disorders	1(1.6%)	0(0.0%)	0(0.0%)	0(0.0%)	1(1.6%)	1(2.6%)	0 (0.0%)	0(0.0%)	1(2.6%)	0(0.0%)
Ureterocele	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	1(2.6%)	0 (0.0%)	0(0.0%)	1(2.6%)	0(0.0%)
UB diverticula	1(1.6%)	0(0.0%)	0(0.0%)	0(0.0%)	1(1.6%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)

Table 6: Performance of the renal and pelvic in determining the causes and complication of OU

Renal and pelvic US in determining the causes and complication of OU	Number of cases (n)	
True positive	91	
True negative	9	
False positive	3	
False negative	2	
Performance of renal and pelvic US in determining the causes and complication of OU	Value	(95%) CI
Sensitivity (%)	(97.85)	(92.45-99.74%)
Specificity (%)	(75%)	(42.81-94.51%)
Positive likelihood ratio	3.91	1.47-10.43
Negative likelihood ratio	0.03	0.01-0.12
OU prevalence (%)	(88.57%)	(80.89-93.95%)
PPV (%)	(96.81%)	(91.92-98.78%)
NPV (%)	(81.82%)	(52.37-94.85%)
Accuracy (%)	(95.24%)	(89.24-98.44%)

masses, UTI and congenital disorders, respectively. While, in female patients, the commonest hydronephrotic changes were with grade II 8(21.1%) and 7(18.4%), grade I 1(2.6%) and grade III 1(2.6%). Also, these were due to urinary system stones, masses, UTI and congenital disorders, respectively (Table 5). Much more, the diagnostic testing revealed a sensitivity of 97.85%, specificity of 75% and accuracy of 95.24% for the performance of renal and pelvic US in determining the causes and complication of OU. Furthermore, results showed PPV of 96.81% and NPV of 81.81% for the renal and pelvic US performance too (Table 6). This was close to what Ather *et al.*[14] and Aslaksen and Gothilin[15] reported.

This study is limited by the unevenness of the population, which unfortunately might affect the accuracy of current measurement parameters and in fact, significantly reduce the power of current conclusions. Other limitations include a relatively small sample size that diagnosed in a single center origin, lack of information on the density and composition of renal stones, the short duration of follow-up and the using of US rather than CT to detect the stone free rate, although CT is more effective for this purpose.

CONCLUSION

The renal and pelvic US is the first imaging study for determining the causes and complications of OU. It showed a sensitivity of 97.85%, specificity of 75% and accuracy of 95.24% in determining the causes and complication of OU, with a PPV of 96.81% and NPV of 81.82% too. Due to small sample size, the findings of this study should be validated by other studies on a larger cohort of patients.

SIGNIFICANCE STATEMENT

This study shows that renal and pelvic US is the first imaging study for determining the causes and complications of OU. Renal and pelvic US showed a sensitivity of 97.85%, specificity of 75% and accuracy of 95.24% in determining the causes and complication of OU. Therefore, the importance of the current study lies upon it is one of the recent studies that detects the sensitivity, specificity and accuracy of using B-mode US in determining the causes and complication of OU, which is more likely to be modest in magnitude in this case since the study was a population based in its nature. In addition, this study is a significant contribution to the existing scanty literature on the subject. Also, this will help to uncover the critical areas of real time B-mode US in determining the causes and complications of OU that many researchers were not able to explore. Thus a new theory on the causes and complications of OU may be arrived at.

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