Bedside Ultrasound in the Emergency Department to Detect Hydronephrosis for the Evaluation of Suspected Ureteric Colic

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ABSTRACT

Background

Renal colic is a common emergency department presentation. Hydronephrosis is indirect sign of urinary obstruction which may be due to obstructing ureteric calculus and can be detected easily by bedside ultrasound with minimal training.

Objective

To compare the accuracy of detection of hydronephrosis performed by the emergency physician with that of radiologist's in suspected renal colic cases.

Method

This was a prospective observational study performed over a period of 6 months. Patients >8 years with provisional diagnosis of renal colic with both the bedside ultrasound and the formal ultrasound performed were included. Presence of hydronephrosis in both ultrasounds and size and location of ureteric stone if present in formal ultrasound was recorded. The accuracy of the emergency physician detection of hydronephrosis was determined using the scan reported by the radiologists as the "gold standard" as computed tomography was unavailable. Statistical analysis was executed using SPSS 17.0.

Result

Among the 111 included patients, 56.7% had ureteric stone detected in formal ultrasound. The overall sensitivity, specificity, positive predictive value and negative predictive value of bedside ultrasound performed by emergency physician for detection of hydronephrosis with that of formal ultrasound performed by radiologist was 90.8%., 78.3%, 85.5% and 85.7% respectively. Bedside ultrasound and formal ultrasound both detected hydronephrosis more often in patients with larger stones and the difference was statistically significant (p=.000).

Conclusion

Bedside ultrasound can be potentially used as an important tool in detecting clinically significant hydronephrosis in emergency to evaluate suspected ureteric colic. Focused training in ultrasound could greatly improve the emergency management of these patients.

KEY WORDS

Bedside ultrasound, hematuria, hydronephrosis, nephrolithiasis, renal colic, ureteric colic

INTRODUCTION

Renal colic is common in the emergency department (ED). Focused bedside ultrasound (BUS) is a rapid, safe, noninvasive and relatively cheap modality and is increasingly used in ED by treating emergency clinicians worldwide for assessment of various conditions including suspected renal colic.[1] The finding of hydronephrosis on BUS is indirect sign of urinary obstruction and has reported sensitivity of 76-97% when compared to computed tomography (CT) or intravenous pyelogram (IVP).[2-6] While CT and IVP are accurate diagnostic tests, there are numbers of factors that would discourage its use especially financial constrain in our setting.[7,8] In addition BUS helps exclude other lifethreatening pathologies like abdominal free fluid and abdominal aortic aneurysm.

BUS has several strengths: It can be performed safely and quickly at the patient bedside concurrently with other management with no risk to the patient.[2,9] Bedside ultrasound is increasingly being used in ED of Nepal by treating physician and the ultrasonography (USG) machine is available even at remote places. Detecting hydronephrosis on BUS is easily learnt and studies have observed favorable results after short training.[4,10,11] However the accuracy of detection of hydronephrosis by emergency physician is not proven in our context and if validated it could allow rapid diagnosis and disposition and might avert the need for formal USG which is usually not available during off hours. The goal of this study was to compare the accuracy of BUS performed in ED to detect hydronephrosis with that of formal USG done by radiologists in patients with suspected renal colic.

METHODS

This was prospective double blind observational study performed in the ED of a tertiary care hospital after the approval from institutional review committee with an annual attendance of approximately 10,000. All cases of suspected acute renal colic who presented to the ED from November 2015 - May 2016 (6 months), who underwent both BUS by treating emergency physician and formal USG by radiologist were included. The provisional diagnosis of renal colic was made by the treating doctor in ED on the basis of clinical history and examination. Patients <8 years, pregnancy, previous renal surgery, known case of congenital renal anomaly and chronic kidney disease were excluded from the study. Verbal consent was taken from the patient. There was no additional risk or cost to the patient. The demographic information, clinical information, medication administered, investigation performed, USG finding in ED and radiology was recorded in Microsoft excel 2010. Hematuria was defined as ≥3 red blood cells and pyuria ≥ 4 white blood cells per high-power field in urine. The Emergency physician and the radiologist were blinded to each other's USG finding. In the ED, BUS was performed by an emergency physician with a 2-5 MHz convex type transducer (FUKUDA DENSHI- FFsonic tellus UF-750 XT) who was trained in focused BUS during the 18 months fellowship program in Emergency medicine. Focused BUS differ from formal USG performed by radiologists and in essence, are meant to answer yes/no questions that are critical for clinical decision making. Both the kidneys were examined through the entire kidney by fanning in both longitudinal and transverse views. The presence or absence of hydronephrosis was noted and if present graded into mild, moderate or severe according to the severity.[12] Presence of free fluid in the abdomen was also screened to rule out ruptured ectopic pregnancy in females and the diameter of the abdominal aorta was also noted in ED. The formal USG was performed with a 1-4 MHz convex type transducer (MEDISON ACCUVIX XG) by registered radiologists. Each patient underwent standard renal ultrasound, including evaluation of the kidneys, ureters and bladder. The kidneys were evaluated completely in the longitudinal and transverse projections at real time evaluation. If hydronephrosis was present detailed examination of the ureter was performed to detect the level of obstruction and presence of calculus. Other conditions that could resemble hydronephrosis in BUS was ruled out by formal ultrasonography in transverse scan where renal pelvis is seen beyond renal region The bladder was also evaluated at real time imaging with an attempt to image the ureterovesical junction bilaterally. If bilateral hydronephrosis was present review scan was done after micturition. The size of the stone was recorded and divided into 3 groups according to its longest dimension: ≤4.9 mm, 5-9.9 mm and ≥ 10 mm.[13] If more than one calculus were detected the largest one was taken into consideration. The formal USG findings regarding size and location of ureteric stone if present, presence of hydronephrosis or other alternative diagnosis were recorded. The accuracy of the emergency physician detection of hydronephrosis was determined using the scan reported by the radiologists as the "gold standard". Though CT and IVP are regarded as accurate diagnostic tests,[7] it couldn't be done to all patients and therefore not recorded. Statistical analysis was performed using SPSS 17.0 with the $p<0.05$ considered as significant.

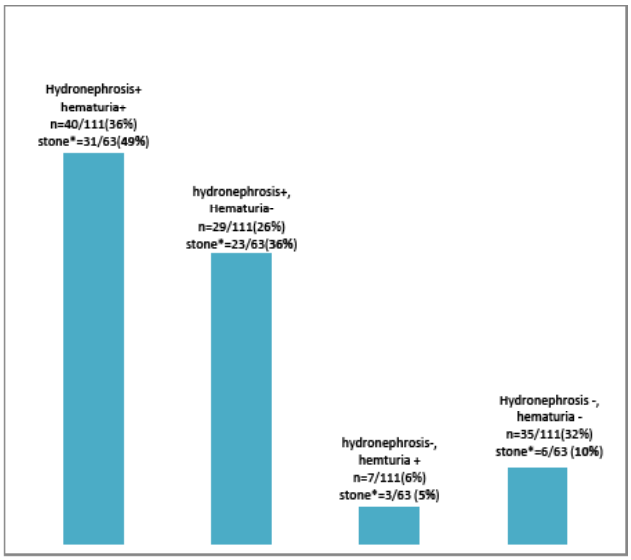
RESULTS

Among 290 clinically suspected case of ureteric colic in ED during the study period 111 patients met inclusion criteria. Table 1 summarizes the characteristics of our study population.

Based on formal radiology USG 63/111 patients (56.7%) had ureteric stones detected. Half of the cases with formal USG proven stones, 31/63 (49%) had both hydronephrosis in BUS and hematuria, 23/63 (36%) had hydronephrosis but no hematuria, 3/63 (5%) did not have hydronephrosis but had hematuria and 6/63 (10%) did not have both hydronephrosis and hematuria (Figure1).

Table 1. Characteristics of the study subjects (n=111)

Gender (Female) (%)		49/111 (44.1)
Age, Year	mean (±SD)[range]	30(±12)[11-77]
	median (IQR)	28 (22-35)
Hematuria, n (%)		47/111 (42.3)
Pyuria, n (%)		25/111 (22.5)
ED BUS hydronephrosis, n (%)		69/111 (62.2)
Radiology USG, hydronephrosis, n (%)		65/111 (58.6)
Radiology USG, detection of ureteric stones, n (%)		63/111 (56.7)



*=in relation to total number of USG detected ureteric stones (n=63)

Figure 1. Stone detected in relation to hydronephosis in BUS in ED and hematuria.

The overall sensitivity, specificity, positive predictive value and negative predictive value of bedside ultrasound performed by emergency physician for detection of hydronephrosis with that of formal ultrasound performed by radiologist was 90.8%, 78.3%, 85.5% and 85.7% respectively (Table 2). Bedside ultrasound and formal ultrasound both detected hydronephrosis more often in patients with larger stones and the difference was statistically significant (p=.000) (Table 3). All patients with stone size ≥ 10 mm had hydronephrosis in both USG and had hematuria.

Table 2. Comparison of the BUS in ED and formal USG to detect hydronephrosis, n(%)

		Hydronephrosis Radiology				
		Absent	Mild	Moderate	Severe	Total
Hydronephrosis BUS (ED)	Absent	36/42 (85.7)	6/42 (14.3)	0	0	42/111 (37.8)
	Mild	10/51 (19.6)	41/51 (80.4)	0	0	51/111 (45.9)
	Moderate	0	7/14 (50)	6/14 (42.9)	1/14 (7.1)	14/111 (12.6)
	Severe	0	0	1/4 (25)	3/4 (75)	4/111 (3.6)
	Total	46/111 (41.4)	54/111 (48.6)	7/111 (6.3)	4/111 (3.6)	P=.000

Microscopic hematuria was present in 34/63(54%) of cases with USG proven ureteric stones. All subjects with stone ≥10 mm had hematuria. The overall sensitivity, specificity, positive predictive value and negative predictive value of hematuria was 72%, 54%, 53% and 72.9% respectively.

KUB x-ray was ordered only in 21/111(18.9%) patients among which only 8/21(38%) revealed ureteric stones.

Table 3. Variables in relation to stone size, n (%)

Stone (mm)	Hematuria		Pyuria		Hydronephrosis (BUS in ED)		Hydronephrosis (radiologist)	
	Yes	No	Yes	No	Yes	No	Yes	No
Absent	13/48 (27.1)	35/48 (72.9)	12/48 (25)	36/48 (75)	15/48 (31.3)	33/48 (68.8)	10/48 (20.8)	38/48 (79.2)
≤4.9	11/26 (42.3)	15/26 (57.7)	2/26 (7.7)	24/26 (92.3)	19/26 (73.1)	7/26 (26.9)	22/26 (84.6)	4/26 (15.4)
5-9.9	19/33 (57.6	14/33 (42.4)	9/33 (27.3)	24/33 (72.7)	31/33 (93.9)	2/33 (6.1)	29/33 (87.9)	4/33 (12.1)
≥10	4/4 (100)	0	2/4 (50)	2/4 (50)	4/4 (100)	0	4/4 (100)	0
p-value	.004		.133		.000		.000	

DISCUSSION

In this study the sensitivity, specificity, positive predictive value and negative predictive value of BUS performed by the treating emergency physician in ED was 90.8%, 78.3%, 85.5% and 85.7% respectively accounting that performed by a radiologist as gold standard. Hydronephrosis is useful to the clinician if suspicion for renal stones is high, because it can be taken as presumptive evidence of obstructing stone and possibly the size of obstructing stone.[2,3,14] Focused BUS for detection of hydronephrosis by emergency physician is an established practice in developed country,[1] however even though USG is available frequently in emergency department of Nepal including in remote places we are unaware of any previous studies in our context exploring the validity of emergency physician performed BUS in ED to detect hydronephrosis. Furthermore BUS can help detect other dangerous causes in ED like ruptured ectopic pregnancy, abdominal aortic aneurism. Mandavia and colleagues found that residents with 16 h USG training could identify hydronephrosis with accuracy of 96% compared with certified ultrasonographers.[10] In other previous studies the sensitivity and specificity of BUS performed by emergency physicians was found to be 72-97% and 73-83% compared with either CT or IVP as gold standard.[3-6] Interestingly the study done by Henderson and colleagues had a higher sensitivity of 97% as part of their protocol included administration of 500 ml normal saline prior to scanning which could have unmasked the previously obscured hydronephrosis.[6] While CT and IVP are accurate diagnostic tests and define clearly the size, shape and position of ureteric stones, they also present a number of factors that would discourage use including the

potential risks of exposing patients to repeated doses of ionizing radiation.[7,8] Recent international literature has also emphasized that urinalysis and bedside renal ultrasound are effective, safe, and less expensive than repeat CT scans.[11] Moreover in developing countries like ours CT is not practical due to its unavailability and financial constraints. CT is not available in our hospital therefore it couldn't be used as gold standard.

Nephrolithiasis is commonly a self-limiting disease with few serious complications.[13,14] Persistent pain and the presence of severe obstruction are primary indication for intervention or admission. It is generally stated that most stones <5 mm will ultimately pass, stones 5-9 mm will likely pass (and may be candidates for urological consultation) and stones ≥ 10 mm will likely require intervention.[13-15] In our study 100%, 93.9% and 73.1% of patients with stone size ≥10 mm, 5-9.9 mm and <5 mm respectively had hydronephrosis in BUS (p<0.000). As stones larger than 5 mm are less likely to pass, the improving sensitivity of BUS for detection of hydronephrosis with larger stones may help treating emergency physicians to select patients who require urological consultation.[13-15]

Based on previous and this studies there is compelling evidence that the skills of BUS can be easily learnt and can be helpful in managing cases of ureteric colic in ED.[3,4,10,11,14,17] USG is relatively cheap and generally available even in rural health care facilities. It can obviate the need to wait for imaging in the radiology department, which can be lengthy even in developed urban setting. Therefore focused short training in BUS to the doctors working in emergency department and rural areas would greatly improve the diagnosis and disposition of patients with suspected renal colic immediately in ED without additional cost and risk. However the training should be standardized and validated. A prospective validated algorithm would greatly assist emergency doctors and primary physicians in rural areas to evaluate cases of suspected ureteric colic.[11,12]

Limitations

The BUS diagnosis of hydronephrosis was not compared to CT or IVP as gold standard therefore even if the formal USG was reported as normal some ureteric stone could have been missed by the radiologists as the sensitivity of USG may be variable according to the size and site of the ureteric stone.[16] BUS was done immediately in ED as patient arrived after or simultaneously with initial pain management whereas the formal USG was done after some time after intravenous fluid administration with full bladder which may have altered the detection of hydronephrosis.[6] Moreover, the quality of USG machine varied in two departments which could have influenced the detection rate.

CONCLUSION

Bedside ultrasound can be potentially used as an important tool in detecting clinically significant hydronephrosis in ED to evaluate suspected ureteric colic. However as a small percentage of BUS negative cases were proven to have renal stones, for safety this group of patients should have definitive diagnostic study and follow ups.

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