ORIGINAL ARTICLE

THE DIAGNOSTIC VALUE OF CURRENT PRACTICE OF PEDIATRIC INTRAVENOUS UROGRAPHY IN AFGHANISTAN IN PRESENCE OF ULTRASONOGRAPHY; CROSS-SECTIONAL ANALYTIC STUDY IN A PEDIATRIC TERTIARY CARE HOSPITAL

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ABSTRACT

BACKGROUND: Intravenous urography (IVU), an old imaging method was accepted as the mainstay of urologic imaging and the gold standard for assessing the upper urinary tract anatomy and excretory function for many years; but with advances in the uroradiologic examinations; its usage is now in universal decline in pediatric population. Due to various reasons, IVU is still widely practiced in children in Afghanistan. On the other hand, Ultrasonography (USG) is accepted universally as first-line imaging modality in pediatric uroradiology. **OBJECTIVES:** To evaluate the diagnostic value of current practice of pediatric IVU in Afghanistan in presence of USG; to evaluate the prediction of renal excretory function by means of USG ultrasonographic features; and to compare the validity of USG, plain radiograph, and their combination with IVU in detection of urolithiasis. **METHOD:** Cross-sectional analytic study at radiology department of French Medical Institute for mothers and Children, on children aged >1 month and < 18 years who were prescribed to undergo IVU examination from 17 June 2016 to 31 August 2016. USG of urinary tract was performed for each participant followed by IVU. The diagnostic value of IVU considered positive whenever IVU could add additional diagnostic information over USG and negative if it could not. P value of <0.001 was considered as statistically significant. **RESULTS:** Total 139 affected kidneys were included. The diagnostic value of IVU was positive in 6.5% and negative in 93.5% of cases. **CONCLUSION:** IVU can be largely replaced by USG in the pediatric population and by combination of USG and plain radiograph in urolithiasis work up.

Keywords: Intravenous urography, pediatric uroradiology, upper urinary tract abnormalities, ultrasonography

List of abbreviations: (CT) Computed tomography, (FMIC) French Medical institute for Mothers and children, (IVU) Intravenous urography, (PUR) Pediatric uroradiology, (Rad) Plain abdominal radiograph, (UPJ) Ureteropelvic junction, (UPJO) Ureteropelvic junction obstruction, (USG) Ultrasonography, (UT) Urinary tract, (VUR) Vesico-ureteral Reflux

Introduction

Imaging is the mainstay of the diagnostic workup for urinary tract morphological and sometimes functional abnormalities in the pediatric population.[1] Today various conventional and modern imaging techniques are utilized in pediatric uroradiology (PUR) and the trend in their selection is to reduce and/or avoid radiation exposure, choose the least invasive and more sensitive method and when applicable to obtain

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both morphological and functional information.[2] Intravenous urography (IVU) also known as intravenous pyelography and excretory urography is one of the oldest uroradiologic imaging methods (First introduced in 1923) and was accepted as the mainstay of urologic imaging and the gold standard for visualization of the upper urinary tract (UT) for many years. IVU is an x-ray based imaging method in which water-soluble contrast material is injected through a peripheral venous access to the patient, excreted by the kidneys and outlining the urinary tract. Initially, it was the only method for assessing the upper UT anatomy and excretory function but with the establishment of renal scintigraphy and advances in ultrasonography (USG) and magnetic resonance urography; its usage is now in universal decline in pediatric population and indications are limited to few specific conditions.[3-7] IVU becomes an alternative, primarily in the absence of cross-sectional imaging facility.[2] The European society of pediatric radiology working groups mentioned IVU as one of the last options in PUR in order to reduce invasiveness and radiation exposure to children.[4] The concerns beyond IVU are radiation exposure, higher cost, time-consuming nature; intravenous access related possible adverse effects, the risk of contrast material reaction and sometimes lower image quality.[7-10] Dehydration, impaired global renal function and allergic reactions to contrast media are relative contraindications for IVU.[7] As the tubules and glomeruli are immature in neonates and the glomerular filtration rate is very low, IVU is not advised in the neonatal period.[11]

Ultrasonography on the other hand, the universally accepted first-line imaging modality in PUR as it can answer many common queries when performed by expert hands and proper machinery.[10] USG is a sound based, radiation free imaging modality mainly for soft tissue structures. It is an inexpensive, noninvasive, readily available, painless, real-time technique with the possibility of repeated examination and needs no contrast material injection.[7]

Urolithiasis is one of the common urologic disorders in children. Unenhanced CT is considered as gold standard for detection of urolithiasis but USG and plain abdominal radiograph (Rad) are the preferred initial imaging modalities in children as they limit radiation exposure.

Despite all these issues, the IVU still has its considerable role in PUR in the developing countries 12 and is widely practiced in Afghanistan (About 560 IVU examinations were performed in radiology department of FMIC). Anecdotal evidence shows that the common prescriptions for IVU in Afghanistan are: to confirm USG findings, to find additional details in inconclusive USG examinations and to evaluate renal function indirectly by assessing the contrast excretion on IVU.

Research Objectives

To evaluate the diagnostic value of current practice of pediatric IVU in Afghanistan in presence of USG
To evaluate the prediction of renal excretory function in IVU by means of ultrasonographic features especially severity of hydronephrosis.
To compare the validity of USG, plain abdominal radiograph, and their combination with IVU in detection of urolithiasis in children.

Methodology

Cross-sectional analytic study was used to fulfill the research objectives.

Approval was taken for the study from institutional radiology department, Ethical Review Committee (ERC) and governmental Institutional Review Board (IRB). Written consent was obtained from the participants/ attendants.

This study enrolled all pediatric patients aged above one month and bellow 18 years who were prescribed to undergo IVU at radiology department of (FMIC), which is a pediatric tertiary care hospital. Consecutive sampling was used and all patients with including criteria were included in the study. The data was collected from 17 June 2016 to 31 August 2016. Transabdominal USG of urinary tract was performed for each participant followed by IVU - including plain abdominal radiograph. All the examinations were interpreted by a single fourth-year radiology resident. The diagnostic value of IVU was considered positive whenever IVU could add additional diagnostic information over USG - or USG plus Rad in the case of urolithiasis - and negative If it could not add any additional diagnostic information over USG - or USG plus Rad in the case of urolithiasis. To compare the

validity of USG, Rad and their combination with IVU in detection of urolithiasis, sensitivity, specificity, positive and negative predictive values of these tests were evaluated considering IVU as the reference examination. Cohen s kappa (k) was calculated for evaluation of agreement between these tests. Fishers T-test was applied for observation of the association between severity of hydronephrosis and contrast excretion. P value of <0.001 was considered as statistically significant for all statistical analysis.

Results

The diagnostic value of current practice of pediatric IVU: The sample consisted of (n=110, 75 male and 35 female) pediatric patients, aged one month to 17 years (mean + SD = 7.53 + 4.96). Seventy Six patients (69.1%) had unilateral and thirty patients (27.3%) had bilateral urinary tract abnormalities while 4 participants had no abnormality. This made total of 139 affected kidneys and each kidney was accepted as unit for study rather than the participant (n=139). The most common disease entity detected was urolithiasis (n=73; 52.5%) followed by congenital anomalies (n=60; 43.2%). The diagnostic value of IVU was found positive in 6.5% (9 cases) and negative in 93.5% (130 cases) (Tab. 1). In 115 cases (82.7%) the USG and IVU findings were equal, in 15 cases (10.8%) USG was more informative while in 9 cases (6.5%); IVU was more informative in compare to USG.

Prediction of renal excretory function by means of ultrasonographic features especially severity of hydronephrosis: (Tab. 2) shows the association between grades of hydronephrosis and contrast excretion. In none of 13 cases of grade IV hydronephrosis contrast excretion was seen while in lower grades of hydronephrosis variable degrees of contrast enhancement was seen. Factors associated with non-visualization of contrast excretion in grades 0, 1, 2 and 3 were: pyonephrosis (n=2), atrophic kidney with altered corticomedullary differentiation (n=1), complete acute obstruction due to stone (n=1) and overlapping bowel loops (n=2). The fisher s exact test for association between grade of hydronephrosis and status of contrast excretion was highly significant (P<0.001).

Pathologic entity	n	%
Positive	**9**	**6.5**
Ureteropelvic junction obstruction	3	2.2
Primary Megaureter	3	2.2
Simple duplex kidney	2	1.4
Chronic infection like tuberculosis	1	0.7
Negative	**130**	**93.5**
Isolated urolithiasis	62	44.6
Ureteropelvic junction obstruction	29	20.9
Primary megaureter	10	7.2
Inconclusive: Nonspecific hydroureteronephrosis	7	5.0
Renal agenesis	3	2.2
Small atrophic kidney	3	2.2
Duplex kidney (1 case with dysplastic moiety)	3	2.2
Crossed fused kidney	2	1.4
chronic infection like tuberculosis	2	1.4
Inconclusive: possible ureteral obstruction	2	1.4
Renal cystic disease (single patient)	4	2.8
Pyonephrosis	2	1.4
Pediatric renal cystic disease (Single patient)	2	1.4
Post-surgical dilatation of collecting system	1	0.7
Total	**139**	**100**

Table 1: The diagnostic value of IVU in presence of conventional USG in different pathologic entities

		Grade of hydronephrosis					Total
		Grade 0	Grade 1	Grade 2	Grade 3	Grade 4	
Contrast ecretion	No	1[a]	0	2(1[b],1[c])	3[d](1[c],2[d])	13[e]	19
	Yes	18	14	62	23	0	117
		19	**14**	**64**	**26**	**13**	**136***

* Three cases of renal agenesis were excluded from the list for evaluation of hydronephrosis
a Atrophic kidney with altered corticomedullary differentiation
b Complete acute obstruction due to stone
c overlapping bowel, Nonvisualization of contrast excretion
d Pyonephrosis
e Severe parenchymal loss

Table 2: Cross tabulation for association between severity of hydronephrosis with contrast excretion

Validity of USG, plain radiograph, and their combination in detection of urolithiasis From the total 73 cases of urolithiasis 3 patients had concurrent stones in different locations; therefore 76 entities of urolithiasis were documented (Tab. 3). USG could detect 69 cases (90.8%) of urolithiasis and majorities

Location	USG(n)		Rad n (n)		Rad + USG		IVU (n)	
	+	-	+	-	+	-	+	-
Kidney 43 (56.6)	42	1	35	8	42	1	34	9
Ureter 29 (38.2)	23	6	26	3	28	1	25	4
UPJ 12 (41.4)	12	0	11	1	12	0	11	1
SIJ 8 (27.6)	2	6	7	1	7	1	8	0
VUJ 9 (31.0)	9	0	8	1	9	0	6	3
Urinary bladder 4 (5.3)	4	0	1	3	4	0	4	0
Total (n)	**69**	**7**	**62**	**14**	**74**	**2**	**63**	**13**
(%)	**(90.8)**	**(9.2)**	**(81.6)**	**(18.4)**	**(97.4)**	**(2.6**	**(82.9)**	**(17.1)**

Table 3: Frequency and location of urolithiasis and their detection by USG, Rad, and IVU

(6 out of 7) of ultrasonographically missed stones were located in the mid ureter. Rad detected calculi in 62 cases (81.6%). USG along with radiograph could detect 74 cases (97.4 %) of urolithiasis while IVU could detect 63 cases (82.9%). The Kappa coefficient for comparison of the validity of USG versus Rad in the detection of urolithiasis was 0.717 (P< 0.001) indicating substantial agreement. The Kappa coefficient for comparison of the validity of USG along with radiograph versus IVU in the detection of urolithiasis was 0.804 (P< 0.001) representing the almost complete agreement. The sensitivity of USG was calculated as 90.5%, specificity of 84.8%, positive predictive value of 82.6% and negative predictive value of 91.8%.The sensitivity of RAD was calculated 84.1%, specificity of 88.6%, positive predictive value of 85.5% and negative predictive value of 87.5%. The sensitivity of USG + Rad was calculated as 98.4%, specificity of 84.8%, positive predictive value of 83.8% and negative predictive value of 98.5% (Tab. 4).

USG could reach the final diagnosis in 81.3% of cases and no further imaging examination was needed. Rad could pick urolithiasis in 4.3% of remaining cases. IVU could reach the final diagnosis in 6.5 % of cases while 7.9% cases remained undiagnosed with all these three conventional techniques and further workup were required.

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
USG	90.5	84.8	82.6	91.8
Rad	84.1	88.6	85.5	87.5
USG + Rad	98.4	84.8	83.8	98.5

Table 4: Sensitivity, specificity, PPV and NPV of USG, Rad and their combination in detection of urolithiasis

Discussion

In our study it was found that in 9 cases (6.5%) where the diagnostic value of IVU was positive; 3 cases were uretero-pelvic junction obstruction (UPJO) with low-grade hydronephrosis, 3 cases of primary mega ureter, 2 cases of the simple duplex kidney without other abnormality and one case of ureteral stricture. It is stated in literature USG is not so sensitive in detection of the simple duplex kidney that can be detected by IVU as it can outline non-dilated collecting systems and ureters.[13] The points reducing the diagnostic value of IVU versus USG were, unprepared bowel loops resulting in non-visualization of contrast excretion and inability of discovering the pathology of severely affected kidney that failed to excrete contrast material (Pyonephrosis, acute complete obstructions, atrophic kidneys with altered cortico-medullary differentiation, depiction of renal cystic disease). The significantly lower positive diagnostic value of IVU in presence of conventional USG is closely concordant with the literature. A similar study conducted by Lewis-Jones H et al (n= 328) for the possible replacement of IVU by USG as a preliminary investigation of urinary tract disease in adults revealed that IVU can give addition information over USG and Rad in only 6.1% of cases.[14] Two separate studies on (evaluation of diagnostic yield of IVU in patient management by D.A. Collie et al. and the diagnostic yield of IVU based on referral center and patients presentation) by Mark A. little reported the diagnostic yield of IVU as 37.5% and 23% respectively.[6,15] The difference in results is probably due to the marked difference between the study nature and population. A prospective study by john C. leonaidas et al. on the possible substitution of IVU with ultrasonography in pediatric urinary tract infection suggested that USG can be used as a radiation-free alternative of IVU in children with urinary tract infection.[16]

The accuracy of various imaging modalities in detecting urolithiasis depends on the location, composition and size of the stone and overlying bony structures, bowel gas and body habitus.[17] USG is less sensitive in detection of small stones and ureteral stones.[18] Rad cannot detect radiolucent stones (10 -20% of stones).[19] Palmer and colleagues stated that USG has a sensitivity of 90%, 38%, and 75% in detection of stones in kidneys, ureters, and both kidneys and

ureters, respectively.[20] IVU previously accepted as the gold standard for detection of urolithiasis is really not the gold standard, but in the conventional imaging modalities, it can be selected as the reference examination.[21] It cannot surely differentiate ureteral stone from stricture or external compression; and it is unable in depiction of non-obstructive stones and non-excretory kidneys. Kit LC et al. reported the sensitivity of USG, Rad and IVU in the detection of pediatric urolithiasis as 98%, 41% and 95% respectively.[22] In a more focused study on the need of IVU in the presence of US and radiograph, in the case of pre-ureteroscopic stone extraction, SMK Aghamir et al. concluded that IVU is not useful enough as a routine practice.[8] In two separate prospective studies in Belgium and Australia on comparison of IVU versus CT in detection of urinary tract calculi, the authors, reported failure of IVU in detection of stones in a third of the patients compared to CT.[23]

In our study Ultrasonography was very good in the detection of renal calculi (detected 97.7%) with only one missed case due to grade 4 hydronephrosis resulted by UPJO ignoring the small nonobstructive calyceal stone. From total 29 cases of ureteral stones, 23 (79.3%) were detected with USG and 6 cases (20.7%) were missed. All stones at UPJ (n=12) and vesicoureteric junction (n-9) were successfully detected with USG whereas 6 out of 8 of mid ureteral stones were missed. These findings are closely correlating with the literature saying that USG is less sensitive in detection of ureteral stones; particularly the mid of the ureter, due to obscuration by overlying bowel loops and the deep location of the ureter in the retroperitoneum.[17,18,24,25] Rad could pick up 7/8 mid ureteral stones but in one case the mid ureteral stone was not directly detected by USG, Rad, and even IVU. USG detected hydroureteronephrosis to the mid ureter without any cause. The stone was not seen on Rad. IVU demonstrated abrupt narrowing of the ureter at the level of crossing the sacroiliac joint. The possibility of extrinsic compression/internal obstruction was raised and computed tomography detected a large stone in the middle ureter. The sensitivity and specificity of USG were (90.5%) and (84.8%) for urolithiasis that correlated will with a study by Ray AA et al. that showed a sensitivity of 19-93% and specificity of 84-100%.[26]

Prediction of renal excretory function by means of ultrasonographic findings can result in elimination of this indication of IVU. Hydronephrosis as the most important feature of obstructive uropathy is one of the main indications for imaging workup.[7] With increase in the grade of hydronephrosis, the renal parenchymal loss occurs and the more prominent the parenchymal loss, the more deterioration of renal excretory functional,[27] therefore in none of 13 cases with grade 4 hydronephrosis no contrast excretion was seen. With less severe hydronephrosis (grade 1, 2 and 3) contrast excretion can be visualized, and if not seen, other conditions resulting in impaired renal excretory function can also be evaluated by USG, as Pyonephrosis, small atrophic kidney with altered corticomedullary differentiation, acute complete obstruction, unprepared bowel loops.

Conclusion

USG should be practiced as the first-line imaging method in pediatric uroradiology. While performed by expert hands, it would answer the clinical query in the majority of cases. When there is evidence of a need for further imaging workup, the prescription of next modality (including IVU) should always be judged based on the clinical suspicion, ultrasonographic findings, and knowledge about the indications, advantages, and limitations of these imaging methods. If IVU is prescribed to evaluate renal excretory function, the ultrasonographic features can predict the overall renal functioning status. In cases of urolithiasis combination of USG and Rad can mostly answer the clinical question and there may be no need to perform IVU.

Limitation and strength:

Limitation of the study was unavailability of the clinical information or indication from the referral physician to classify the patients according to the clinical context. Strength of this study was its prospective nature and single rater based study; therefore no possible inter-rater bias was expected

Recommendations:

Conducting larger multi-center studies considering the referral physician's perspective and patients perspective.

Developing guidelines for prescribing radiologic examinations in order to reduce the number of unnecessary, useless and sometimes harmful examination.
Enrich the knowledge and practice of sonographers especially in pediatric uroradiology to answer the clinical queries of the referral physicians by accurate, structured and detailed ultrasonographic reports.

Conflict of interest: None

References

1. Hhamidi H, Alam T. Choosing the Appropriate Imaging Modality for Pediatric Urologic Disorders. PJR. May 2016; **24(3)**.

2. Darge K, Grattan-Smith JD, Riccabona M. Pediatric uroradiology: state of the art. Pediatric radiology. Jan 2011; **41(1):** 82-91.

3. Dalla Palma L. What is left of iv urography?. European radiology. May 2001; **11(6):** 931-9.

4. Riccabona M, Avni FE, Dacher JN, Damasio MB, Darge K, Lobo ML et al. ESPR uroradiology task force and ESUR paediatric working group: imaging and procedural recommendations in paediatric uroradiology, part III. Minutes of the ESPR uroradiology task force minisymposium on intravenous urography, uro-CT and MR-urography in childhood. Pediatric radiology. Jul 2010; **40(7):** 1315-20.

5. Riccabona M, Lindbichler F, Sinzig M. Conventional imaging in paediatric uroradiology. European journal of radiology. Aug 2002; **43(2):** 100-9.

6. Little MA, Stafford Johnson DB, O'Callaghan JP, Walshe JJ. The diagnostic yield of intravenous urography. Nephrology Dialysis Transplantation. Feb 2000; **15(2):** 200-4.

7. Leppert A, Nadalin S, Schirg E, Petersen C, Kardorff R, Galanski M, et al. Impact of magnetic resonance urography on preoperative diagnostic workup in children affected by hydronephrosis: should IVU be replaced?. Journal of pediatric surgery. Oct 2002; **37(10):** 1441-5.

8. Aghamir SM, Modaresi SS, Salavati A, Aloosh M, Meysami AP. Is intravenous urography required when ultrasonography and KUB evidence a ureteroscopy plan?. Urology journal. Dec 2012; **9(4):** 648-51.

9. Thomson JM, Glocer J, Abbott C, Maling TM. Computed tomography versus intravenous urography in diagnosis of acute flank pain from urolithiasis: a randomized study comparing imaging costs and radiation dose. Australasian radiology. Aug 2001; **45(3):** 291-7.

10. Wille S, von Knobloch R, Klose KJ, Heidenreich A, Hofmann R. Magnetic resonance urography in pediatric urology. Scandinavian journal of urology and nephrology. Jan 2003; **37(1):** 16-21.

11. Riccabona M. Imaging of the neonatal genito-urinary tract. European journal of radiology. Nov 2006; **60(2):** 187-98.

12. Elhag B, Omer H, Sulieman A. Estimation of pediatric radiation doses in intravenous urography. Asian J Med Clin Sci. 2012; **1(1):** 4-8.

13. Patel NA, Suthar PP. Ultrasound appearance of congenital renal disease: Pictorial review. The Egyptian Journal of Radiology and Nuclear Medicine. Dec 2014; **45(4):** 1255-64.

14. Lewis-Jones HG, Lamb GH, Hughes PL. Can ultrasound replace the intravenous urogram in preliminary investigation of renal tract disease? A prospective study. The British journal of radiology. Nov 1989; **62(743):** 977-80.

15. Collie DA, Paul AB, Wild SR. The diagnostic yield of intravenous urography: a demographic study. British journal of urology. Jun 1994; **73(6):** 603-6.

16. Leonidas JC, McCauley RG, Klauber GC, Fretzayas AM. Sonography as a substitute for excretory urography in children with urinary tract infection. American journal of roentgenology. Apr 1985; **144(4):** 815-9.

17. Faiq SM, Naz N, Zaidi FB, Rizvi A. Diagnostic accuracy of ultrasound & x-ray kub in ureteric colic taking CT as gold standard. Int J Endorsing Health Sci Res. 2014; **2(1):** 22-7.

18. Hoppe B, Kemper MJ. Diagnostic examination of the child with urolithiasis or nephrocalcinosis. Pediatric nephrology. Mar 2010; **25(3):** 403-13.

19. Dhar M, Denstedt JD. Imaging in diagnosis, treatment, and follow-up of stone patients. Advances in chronic kidney disease. Jan 2009; **16(1):** 39-47.

20. Palmer JS, Donaher ER, O riordan MA, Dell KM. Diagnosis of pediatric urolithiasis: role of ultrasound and computerized tomography. The Journal of urology. Oct 2005; **174(41):** 1413-6.

21. Mutazindwa T, Husseini T. Imaging in acute renal colic: the intravenous urogram remains the gold standard. European journal of radiology. Nov 1996; **23(3):** 238-40.

22. Kit LC, Filler G, Pike J, Leonard MP. Pediatric urolithiasis: experience at a tertiary care pediatric hospital. Canadian Urological Association Journal. Aug 2008; **2(4):** 381.

23. Lindbloom E. What is the best test to diagnose urinary tract stones?. Clinical Inquiries, 2001 (MU). 2001.

24. Tamm EP, Silverman PM, Shuman WP. Evaluation of the patient with flank pain and possible ureteral calculus. Radiology. Aug 2003; **228(2):** 319-29.

25. Hiorns MP. Imaging of the urinary tract: the role of CT and MRI. Pediatric Nephrology. Jan 2011; **26(1):** 59-68.

26. Ray AA, Ghiculete D, Pace KT, Honey RJ. Limitations to ultrasound in the detection and measurement of urinary tract calculi. Urology. Aug 2010; **76(2):** 295-300.

27. Asghar M. Evaluation of renal excretory function by intravenous urography. Gomal Journal of Medical Sciences. Jun 2010; **8(1)**.