Standardised ultrasound technique for evaluation of urinary tract infection in South African children highlighting the capabilities and pitfalls of this modality

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Abstract

Urinary tract infection (UTI) is one of the commonest bacterial infections in childhood and has potentially disastrous consequences. The imaging of UTI in children is a controversial subject with divergent imaging protocols existing in the current literature. As ultrasound (US) is a cheap, non-invasive, non-ionizing procedure, it is almost universally accepted as the initial investigation of choice in children with UTI. US reliably demonstrates many important features of the urinary system, including renal size, congenital abnormalities, calculi and, in particular, obstruction to flow of urine (pelvicalyceal dilation). Due to the subjective, user-dependent nature of US, we suggest the adoption of a standardised scanning approach to improve diagnostic accuracy and reproducibility, thereby facilitating patient follow-up. We also hope that standardisation will limit the misinterpretation of US findings that are not evidence-based. This is a pictorial review of the standardised US technique used in the investigation of UTI in children at the Red Cross War Memorial Children's Hospital.

Introduction

Urinary tract infection (UTI) is considered the most common invasive bacterial infection in childhood and may result in permanent renal damage, especially hypertension and chronic renal failure, prompting the routine investigation of these children in order to identify those at risk.[1-3] The investigation of UTI in childhood is a controversial topic in current literature with little consensus as to the ideal investigation protocol.[2,4] However, the availability, low cost and absence of significant biological side-effects of ultrasound (US) have made it the most popular initial investigation of UTI in childhood.[3,5] US elegantly demonstrates many features of the urinary tract including renal size, congenital abnormalities, calculi and, in particular, obstruction to flow (pelvicalyceal dilation), a treatable though relatively rare cause of UTI.[2,4] As is well recognised, the diagnostic accuracy and reproducibility of US findings are user-dependent.[4,6] Standardisation of US technique not only improves its diagnostic power, but also facilitates easy and reliable patient follow-up. In addition, it highlights the limitations of US and discourages over-zealous comment on these parameters.[6] This pictorial summary of the standardised US technique at the Red Cross War Memorial Children's Hospital (RXH) also highlights a few abnormalities demonstrated by this modality.

Fig. 1a. The bladder should always be studied first in order to image it when distended. The transverse view is important to assess for possible hydro-ureter. The bladder is demonstrated in the axial plane and its transverse diameter measured. Vesical wall thickness is measured on the lateral wall in this view. There is good through-transmission and visualisation of structures posterior to the bladder.

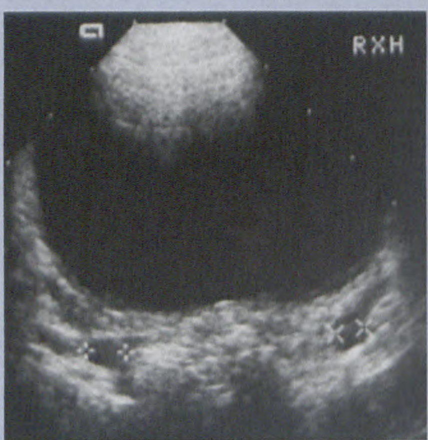

Fig. 1b. Abnormal, bilaterally dilated ureters. This appearance, especially if unilateral, may be mimicked by a transient ureteric peristaltic wave.

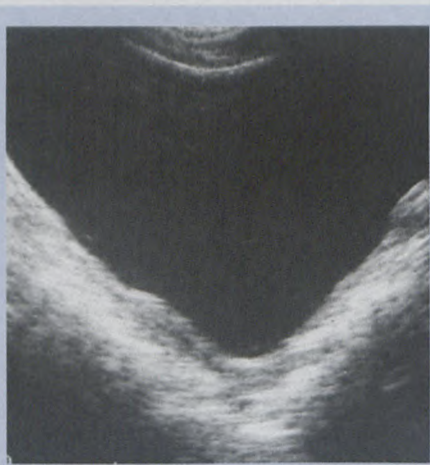

Fig. 2a. The bladder is shown in the sagittal plane. Assess for sediment and calculi.

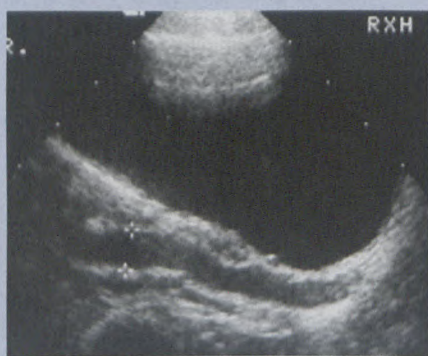

Fig. 2b. Parasagittal image of the patient shown in Fig. 1b (above) confirms the persistent ureteric dilatation.

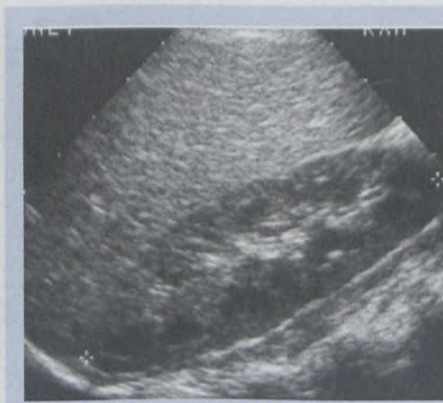

Fig. 3a. Right parasagittal plane — this image shows the kidney inferior to the liver and allows comparison of their echogenicities. Normal echogenicity of the liver is greater than that of the spleen and in turn, the spleen is more echogenic than the kidneys. The neonatal kidney is an exception (see Fig. 6a below).

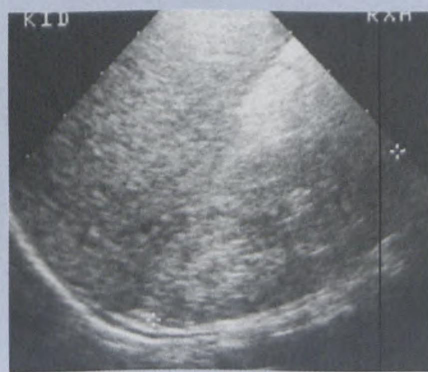

Fig. 3b. This kidney is hyperechoic relative to the liver and is abnormal.

Capabilities and limitations of US

US is complementary to radionuclide scanning and radiographic imaging in the investigation of UTI in children.[4] While it cheaply, effectively and safely provides information regarding many facets of the urinary tract, cognizance should be taken of its limitations.[6]

The principal benefits of US lie in its ability to elucidate: (*i*) the presence of two kidneys in their correct position; (*ii*) renal sizes — small kidneys in chronic renal failure, large kidneys — e.g. duplex kidneys and multicystic dysplastic kidneys; (*iii*) congenital abnormalities — horseshoe or duplex kidneys; (*iv*) hydronephrosis and/or hydro-ureter — suggests obstruction; (*v*) calculi; and (*vi*) post-micturition vesical residual volume (Figs 1 - 9).[2,4,6]

US cannot provide reliable assessment of: (*i*) vesico-ureteric reflux; (*ii*) renal scars; (*iii*) current renal infection; and (*iv*) renal function.[2-4,6]

Standardisation (Figs 1 - 9)

While many operators are comfortable with a free-scanning US technique, the standardisation of US technique involves adherence to a definite sequence. The ultrasonographer/ultrasonologist, in the course of the examination, aims to measure preset parameters in predetermined views or planes. This improves diagnostic accuracy, allows for reproducibility and encourages a comprehensive examination.[6] The aim is to record data pertinent to the investigation of UTI objectively, while limiting comment on parameters that are inadequately assessed on US. A pro forma data sheet for recording the scan results reinforces the standardised

Fig. 4a. Right coronal/sagittal plane — renal length is recorded as the greatest cephalo-caudal dimension. Comparison is made with standardised centile charts of renal size versus age.

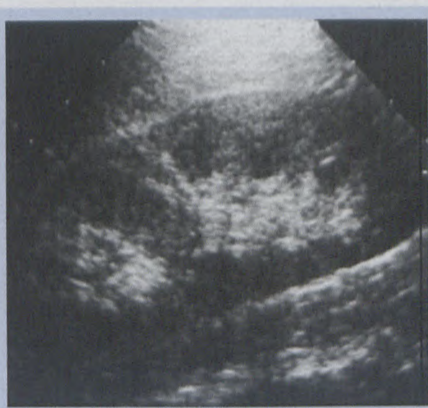

Fig. 4b. A duplex kidney is usually larger than normal and may show an obstructed upper pole with a shrunken lower pole.

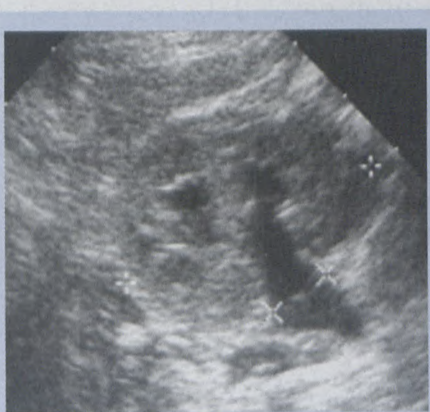

Fig. 5a. Axial plane — the renal pelvis should be measured in the AP axis at the position indicated (x • x) This is the most reliable measurement in the assessment of hydronephrosis and the most reproducible indicator of serial change especially in pelvi-ureteric junction (PUJ) obstruction follow-up.

Fig. 5b. Increased AP renal pelvis measurement. A measurement of < 10 mm is normal and > 20 mm is abnormal. A value between 10 and 20 mm represents an equivocal finding.

Fig. 6a. Left parasagittal plane — this image demonstrates the left kidney in relation to the spleen and permits comparison of their echogenicities. The kidney should be less echogenic than the spleen. The neonatal kidney may have a normally echogenic cortex. Note the prominence of the relatively hypo-echoic medullary pyramids; this appearance must not be misinterpreted as hydronephrosis. In hydronephrosis, connection can be demonstrated between the dilated calyces.

Fig. 6b. Echogenic infantile polycystic kidney disease.

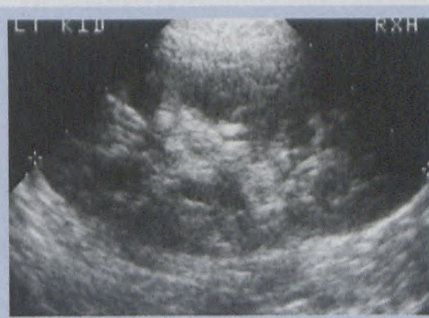

Fig. 7a. Left coronal/sagittal plane — the length of the left kidney is measured on this image (compare with Fig. 4a above).

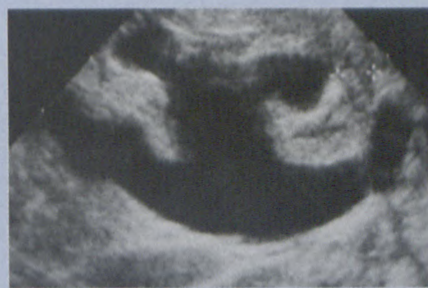

Fig. 7b. Hydronephrotic left kidney.

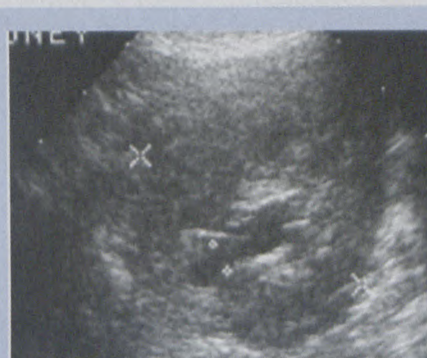

Fig. 8a. Axial plane — as on the right, the pelvis of the left kidney is measured in the AP axis.

Fig. 8b. An extrarenal pelvis is a normal variant and is measured at the position indicated (+ • +).

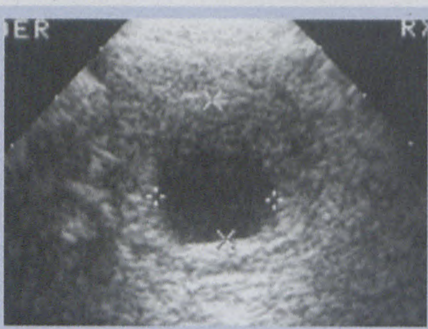

Fig. 9a. The patient is allowed to micturate and any post-micturition residual volume is measured. This is not a reliable assessment in neonates as they do not void completely.

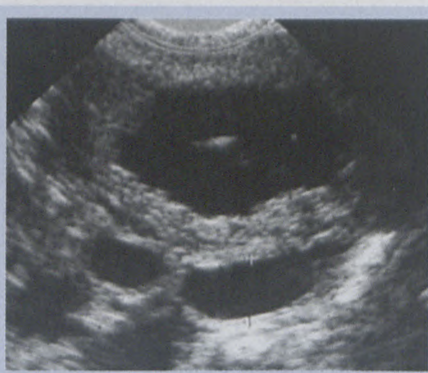

Fig. 9b. Enlarged, trabeculated bladder with a significant residual volume and visibly dilated ureters posterior to it.

Table I. An example of a standard data sheet that can be used to encourage uniformity of reporting of ultrasound studies between various operators and allow long-term follow-up

Urinary tract ultrasound assessment pro forma data sheet

Patient name..

Folder number ....

Age ....

Renal size — 50th centile for age (from standardised charts) ....

	Right Kidney	Left Kidney
Length (mm)		
Echogenicity		
Pelvicalyceal system		
Normal		
Hydronephrosis		
(Mild/moderate/severe)		
AP pelvis measurement		
Ureter seen?		
Other (e.g. calculus, renal anomaly)		

Bladder:
- Wall thickness
- Post micturition measurement and volume
- Dilated ureters posterior to the bladder:
- Other:

Comment:

approach. An example of a standardised data sheet is shown in Table I.

Conclusion

A standardised examination is essential to detect relevant pathological states related to UTI consistently, and to enhance reproducibility for long-term patient follow-up. It promotes objective data recording on urinary parameters pertinent to the investigation of UTI, which are reliably demonstrated on US, and limits over-zealous comment on findings attributed to US that are not evidence-based.

References

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