The role of MR imaging for the assessment of complicated duplex kidneys in children: preliminary report

Abstract  Objective. To determine whether MR imaging, including MR urography, is able to assess complicated duplex kidneys and to determine the possible role of MRI compared to other imaging techniques in such uropathies.

Material and methods. Twenty consecutive patients (age 1 month–11 years) presenting with a suspicion of a complicated duplex kidney were prospectively studied with MRI and MR urography. The examinations were performed on a 0.5-T machine using routinely available sequences that were optimised to the patient’s age and size. MR images were reviewed separately by two observers blinded to the patient history. They were asked to assess the presence of a duplex kidney, the presence of an abnormality that may require surgery and to indicate the type of the inferior ureteric insertion. A qualitative gradation of these results was performed on the basis of the final diagnosis provided at endoscopy (n = 6) or surgery (n = 14). MR results were compared to those provided by US examinations and excretory urography, when available, and a non-parametric statistical analysis was performed.

Results. MRI differentiated well between the upper and the lower poles of the kidneys and correctly answered the three questions in all 20 patients. The two observers agreed completely in all the 20 patients. MR was statistically superior to both US and excretory urography in the evaluation of the distal ureter (P < 0.05).

Conclusions. MRI provides a precise assessment of the complications associated with duplex kidneys. Its optimal role seems to be the assessment of ectopic extra-vesical ureteric insertions and whenever an occult upper pole is suspected.

Introduction

Various anomalies can occur in the upper or lower poles of duplex kidneys (i.e. obstruction or vesico-ureteric reflux (VUR), ectopic ureter or ureteroceles). Many of these anomalies require surgical correction and the information which is useful for the surgeon includes precise characterisation of the anomaly involving the upper or lower poles, the status of the corresponding parenchyma and the type of ureteric insertion around the bladder. The classical radiological work-up of abnormal duplex kidneys is based on US, voiding cystourethrogram (VCUG) and excretory urography (EU). The aim of US and EU is to assess the urinary tract morphology, whereas the role of VCUG is to demonstrate the presence of VUR and to visualise the urethra. Radionuclide scintigraphy is required to assess renal function [1]. The anatomical assessment may be incomplete when one moiety is markedly dilated or when little parenchyma is left. In such cases, the anomaly may not be recognized by EU, or even by US [2–4]. The use of CT has also been advocated in order to diagnose poorly functioning, atypical duplex kidneys and ectopic ureter [5, 6]. More recently, MR urography has demonstrated its ability to
display the dilated urinary tract and to display ectopic ureretic insertions in children [7–9].

The purposes of this preliminary study are: (1) to determine whether MRI, including MR urography, are able to assess complicated duplex kidneys and (2) to specify what could be the role of MRI compared to other imaging techniques.

Material and methods

Patient selection

Over a 2-year period (December 1997–December 1999), 20 consecutive patients (14 girls, 6 boys) aged 1 month to 11 years (mean age 4.5 ± 3.7 years), with a confirmed diagnosis of a complex duplex kidney and who ultimately required surgery, were prospectively evaluated with MRI including MR urography. The presence of a duplex collecting system had been suggested by antenatal US in nine patients, by US or VCUG during the work-up of a urinary tract infection (UTI) in eight, and clinically in three (urinary dribbling). Prior to the MR study, all the patients had undergone US examination and VCUG. 10 patients underwent EU and 15 had undergone radionuclide studies.

MR imaging

MR studies were performed using a 0.5-T superconducting magnet (Philips Gyroscan NT5, Best, The Netherlands) equipped with a conventional gradient system (15 mT/m, 17 mT/m/ms). In our first four patients, MR urography was performed with heavily T2-weighted (T2-W) 2D turbo-spin-echo (TSE) coronal sequences [TR 8.541 ms, TE 150 ms, TSE factor 18, half Fourier 62.5%, 15 slices, section thickness 3 mm, gap 0.3 mm, field of view 280 mm (neck quadrature and paediatric coils) or 375 mm (body wrap-around coil), NSA 12, matrix 170 x 256, flow compensation, nominal acquisition time per sequence 6 min 3 s]. For the other 16 patients, coronal and sagittal heavily T2-W, 3D TSE respiratory-triggered sequences with inversion-recovery fat-suppression were used. The parameters included: minimum TR 3.500 ms, TE 600 ms, TI 110 ms, 32 slices, 2.7/1.3 mm oblique-section sequence thickness/incubent, FOV 250 mm, NSA 2, matrix 188 x 256 and nominal acquisition time per sequence: 4 min 40 s. Maximum intensity projections (MIP) were reconstructed. After MR urography, conventional MRI was performed for the assessment of the renal parenchyma in the coronal plane without respiratory triggering. For this purpose, we used a turbo-field-echo (TFE) T1-W (TR 19 ms, TE 7.1 ms, 10 slices, slice thickness 4 mm, flip angle 20°), FOV 300 mm, matrix 256 x 256, NSA 14 and acquisition time 6 min 6 s) and a fat-suppressed TSE (SPIR TSE) T2-W sequence (TR 7.503 ms, TE 120 ms, 12–18 slices, slice thickness 4 mm, FOV 350 mm, matrix 188 x 256, NSA 10, acquisition time 6 min 15 s). For optimal signal-to-noise ratio, the coils were chosen according to the child’s size. Newborns were positioned supine into a standard neck quadrature coil; a body-wrap-around (BWA) coil or a paediatric coil were used in older children.

Fraseline (0.3 mg/kg) was injected prior to the examination in four patients. Patients under the age of 6 years were sedated. Chlo- ral hydrate was used in newborns and general anaesthesia, as preferred by our anaesthesiologists, in older children. Informed consent was obtained from the parents. The work-up of all patients was in accordance with recommendations of our institution review board.

Other imaging techniques

Sonography was performed using sector, curvilinear and/or linear transducers (7–10 MHz), as dictated by the patient’s size; the entire urinary tract was assessed (kidneys, bladder and ureters). Excretion urography was performed according to our routine procedure: a conventional radiograph of the abdomen first, X-rays of the abdomen at 15 and 30 min and, when necessary, at 60 min (or even later) after contrast medium injection.

Radionuclide studies included 99m-Tc-MAG3 renography and 51Cr-EDTA overall clearance. Split renal function was calculated on the basis of the 1–2 min counts on the left and right renograms. Absolute individual renal function was obtained by combining split renal function and overall 51Cr-EDTA clearance. The results were expressed in ml/min/1.73 m2/ kidney (N = 50 ml/1.73 m2/kidney). All the patients also underwent VCUG performed through retrograde filling of the bladder. Multiple (cyclic) fillings were performed in neonates. VUR was graded using the international grading system (grades I–V).

Imaging analysis

In order to determine the ability of MRI to assess duplex kidneys, all MR sequences were reviewed on hard copies. All images were reviewed by two observers, each blinded to the patient history, to any previous examination and without any knowledge of the review of the other observer. The reviewers were asked to answer the following questions: (a) Is there a complicated duplex kidney? (b) What is the type of complication that may require surgery? (c) How does the distal insertion of the ureter correspond to the abnormal pole (intravesical, extravesical, ureterocoele)?

The final diagnosis was determined by the endoscopic (n = 6) and surgical (n = 14) data.

In order to determine what would be the role of MR for the preoperative assessment of abnormal duplex kidneys, the information provided by MR studies was compared to that given by US and EU when available. The above-mentioned questions were independently addressed for the interpretation of the US and EU examinations. Furthermore, the answers to these questions were also scored qualitatively for all three examinations (US, EU and MRI) as follows: score 0, when an incorrect answer was given or when no answer could be given and score 1 when the correct answer was provided.

Statistics

For each question, sensitivity and specificity of the MR examination was calculated. A qualitative comparison between MR and either US or EU was achieved by using the McNemar test 3. Values < 0.05 were considered significant.

Results

The clinical data, the scintigraphic and VCUG results, final diagnosis and treatment of all 20 patients are summarized in Table 1.

For the MR images, the two reviewers agreed on all three questions regarding the 20 patients. The comparisons between MRI, EU and US are detailed in Table 2. MRI differentiated well between the upper and lower