Magnetic Resonance Urography for Evaluating Outcomes After Pediatric Pyeloplasty

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Purpose: We report the role of magnetic resonance urography in children with ureteropelvic junction obstruction. Differential renal function, the single kidney glomerular filtration rate index, renal transit time, renal length and renal pelvis anteroposterior diameter were compared before and after pyeloplasty.

Materials and Methods: Magnetic resonance urography was performed before and after pyeloplasty in 24 patients with a mean age of 1.9 years (range 3 months to 10 years). Renal length, renal transit time and renal pelvis anteroposterior diameter were determined by the radiologist. The volume of functioning renal tissue and descending aorta were segmented and the ratio of the volumes of functioning kidney tissue was used to calculate differential renal function. Rutland-Patlak plots were used to calculate single kidney glomerular filtration rate index, that is the Patlak score.

Results: Mean renal pelvis renal pelvis anteroposterior diameter was 3.3 cm preoperatively and 2.5 cm postoperatively ($p = 0.0003$). There was no difference in average renal length ($p = 0.22$). Of the 24 cases 22 (92%) showed stable or improved differential renal function. Improvement in renal transit time was seen in 20 of 23 cases (87%). Of 15 patients with complete Patlak scores 14 (93%) showed postoperative improvement. Mean preoperative and postoperative differential renal function, renal transit time and Patlak score were 36% and 41% ($p = 0.003$), 16.2 and 8.6 minutes ($p = 0.0005$), and 6.6 and 11.9 ml per minute ($p = 0.01$), respectively.

Conclusions: Magnetic resonance urography provides superior anatomical and unprecedented functional information to fully define the preoperatively and postoperative status of corrected ureteropelvic junction obstruction. Magnetic resonance urography has the potential to become the imaging study of choice for evaluating pediatric hydronephrosis and obstructive uropathy.

Key Words: kidney, hydronephrosis, magnetic resonance imaging, ureter

While a combination of US, VCUG and DRS is typically used to investigate hydronephrosis in children, there is no gold standard for assessing upper tract obstruction.[1] MRU has been used in children to study acute pyelonephritis and VUR, and determine renal function.[2,3] The advantage of MRU is that anatomical and functional data can be obtained in 1 study without patient exposure to ionizing radiation. Superior spatial and contrast resolution is achieved with dynamic contrast enhanced MRU compared to that of US or DRS.[4] Analysis of renal function with MRU is comparable to that of DRS.[4,5] The quality of dynamic MR images enables additional functional parameters to be derived, such as RTT.[6] Moreover, single kidney GFR can be estimated by dynamic contrast enhanced MRU.[7]

More than 500 MRUs were performed in children at our institution between July 2000 and July 2005. To assess outcomes in children after pyeloplasty we evaluated changes in DRF, single kidney GFR index, RTT, renal length and renal pelvic AP diameter using MRU.

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MATERIALS AND METHODS

Patient Population

A total of 24 patients who underwent dismembered pyeloplasty without renal pelvic reduction underwent MRU before and after pyeloplasty. Postoperative imaging was done 2 to 4 weeks after stent removal. Mean patient age was 1 year (range 3 months to 10 years). Surgical indications were hydronephrosis without ureteral dilatation, DRF less than 45% and/or RTT in the obstructed range. Children with bilateral UPJ obstructions were excluded.

MRI Technique

Our technique has been reported previously.[5] Briefly, children were sedated using propofol under the supervision of an emergency medicine physician. A bladder catheter was placed. The patient was positioned supine on the scanner bed of a 1.5 Tesla Symphony or 1.5T Avanto scanner (Siemens Medical Solutions USA, Malvern, Pennsylvania) fitted with 30 mT/m gradient coils.

At 15 minutes after intravenous injection of 1 mg/kg furosemide (maximum 20 mg) 0.1 mmol/kg Gd-DTPA (Magnevist®) was injected intravenously at the start of the fourth images in a series of dynamic images. Three-D MIPs were

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obtained from each dynamic volume to provide an overview of contrast material uptake and excretion. Following the dynamic series 3D volumes with higher spatial resolution were acquired to delineate urinary tract anatomy in a manner similar to that of excretory urography. When no contrast material was observed in the ureters during the 15 minutes of dynamic scanning, the patient was turned prone to promote contrast agent mixing in the collecting system before the acquisition of high spatial resolution images. Total imaging time was typically less than 45 minutes. In the 15 minutes between furosemide and contrast material injection standard 2-dimensional T1 and T2-weighted anatomical images. and a strongly T2-weighted 3D volume covering the collecting system, ureters and bladder were acquired.[6]

Image Analysis and Interpretation

Dynamic volumes were transferred to a workstation for analysis using Analyze 5.0 (Mayo Clinic, Rochester, Minnesota). Functioning tissue, ie that showing appreciable contrast material uptake, in each kidney was segmented using the last volume acquired before the appearance of contrast material in collecting system calyxes. The signal from all voxels in the segmented volume was averaged at each time point to provide a signal vs time curve for each kidney. They were converted into relative signal curves. As for the aorta, the signal from all voxels within the segmented volume was averaged.[8] When separate curves were required for the cortex and medulla, the cortex was segmented using the first time point that showed strong signal enhancement in the cortex. Cortical volume was then subtracted from total volume to determine medullary volume.[8]

Anatomical assessment included renal size, degree of dilatation of collecting system and ureter based on SFU criteria for hydronephrosis and renal pelvis AP diameter in cm. Excreted contrast medium was observed for swirling in the renal pelvis and fluid level formation in the calyxes. Medullary pyramid atrophy, fetal folds and crossing vessels were noted. The diagnosis of crossing vessels, which historically was made at retrograde ureteropyelography, can now be made preoperatively with MRU (fig. 1). Anatomical criteria suggestive of obstruction were severe hydronephrosis with parenchymal thinning (SFU grade 4), pyramidal loss and UPJ disproportion. Anatomical findings are used in conjunction with RTT to define obstruction.

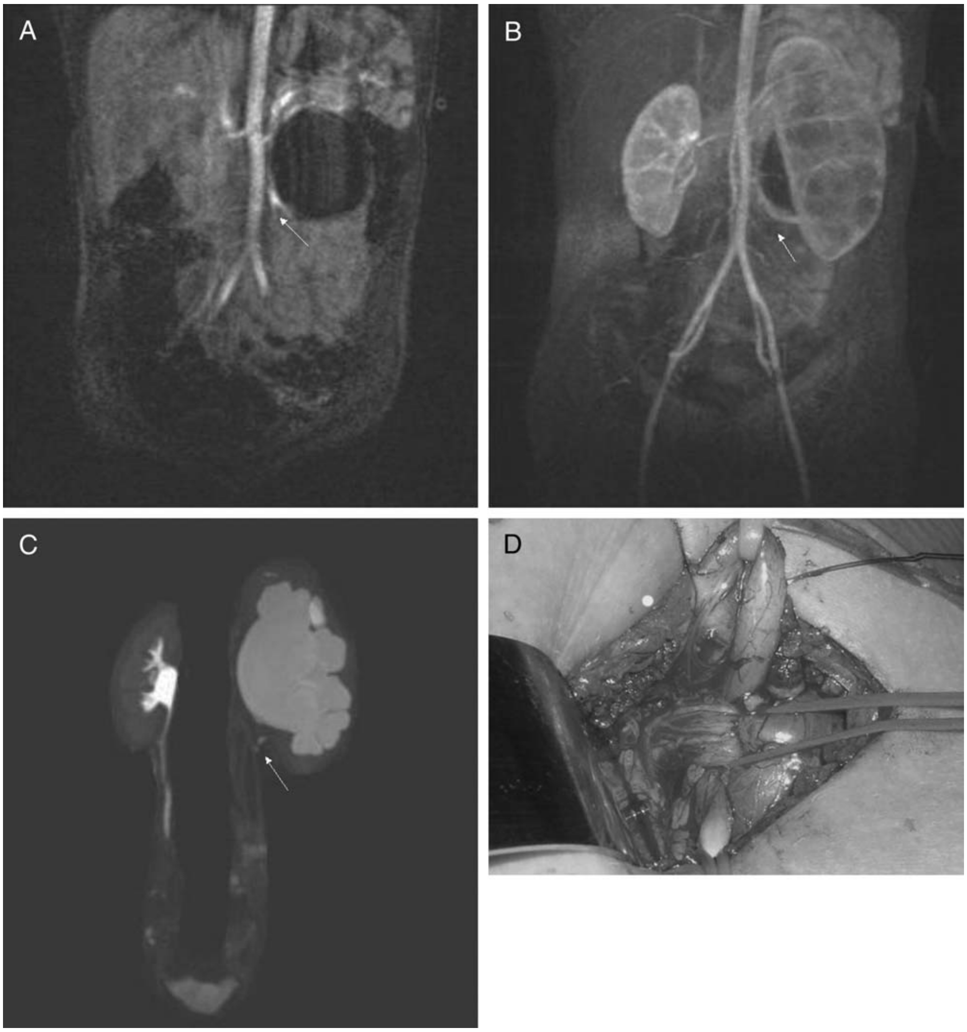

FIG. 1. Preoperative MRU shows crossing vessels (arrow) at vascular phase (*A*), venous phase (*B*) and MIP (*C*). Note increased renal length, marked caliectasis and UPJ disproportion of obstructed left kidney. Intraoperative photograph demonstrates crossing vessels supplying lower kidney pole in same patient (*D*).