Magnetic Resonance Urography in the Evaluation of Prenatally Diagnosed Hydronephrosis and Renal Dysgenesis

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Purpose: We present our experience with dynamic contrast enhanced magnetic resonance urography for evaluation and treatment in infants born with prenatally recognized hydronephrosis. We determined the characteristics of renal dysgenesis in this population.

Materials and Methods: We reviewed magnetic resonance urography images done within the first 6 months of life in 67 infants born with prenatally recognized hydronephrosis. High resolution imaging was used to establish a morphological diagnosis. Functional evaluation was used to assess obstruction and individual renal function. Voiding cystourethrography was performed in 62 patients.

Results: Our study included 67 infants (87 renal units). There were 54 boys and 13 girls with a mean age of 2.8 months (range 0.9 to 4.6). Of these 87 renal units 30 (35%) had ureteropelvic junction obstruction, 18 (21%) had primary megaureters, 10 (11%) had nondilating vesicoureteral reflux, 10 (11%) had fetal folds, 8 (9%) had posterior urethral valves, 6 (7%) had ectopic ureters, 4 (5%) had multicystic dysplastic kidneys and 1 (1%) had a normal study. Magnetic resonance urography revealed renal dysgenesis in 24 renal units (28%), consisting of loss of corticomedullary differentiation, renal cystic changes distinct from multicystic dysplastic kidneys, solid renal dysplasia, hypoplasia and dysmorphic calyces.

Conclusions: Magnetic resonance urography is an excellent addition to our armamentarium for evaluating neonatal hydronephrosis and renal dysgenesis. Due to its comprehensiveness magnetic resonance urography has the potential to become the study of choice for evaluating infants with significant prenatally recognized hydronephrosis. However, further prospective, comparative studies in larger patient populations are needed to justify the cost and the need for sedation in infants.

Key Words: kidney, abnormalities, magnetic resonance imaging, prenatal diagnosis

Widespread use of prenatal ultrasound has resulted in the increased recognition of prenatal hydronephrosis. Approximately 1/800 to 1/1,500 pregnancies is associated with the incidental finding of hydronephrosis.[1] Currently there is no gold standard for assessing upper tract obstruction.[2] Radiographic approaches to evaluate hydronephrosis in children have evolved in the last decade. Imaging modalities used to evaluate upper tract dilatation in children typically include renal US, DRS, and on rare occasions excretory urography and pressure flow studies (the Whitaker test). VCUG is frequently performed in conjunction with these studies to rule out VUR. These studies provide good anatomical or good functional information but none except MRU provides each type of information.

MRU has been used in children to determine renal function and evaluate acute pyelonephritis, VUR, hydronephrosis, renal obstruction and parenchymal defects.[3–8] The advantage of MRU over other modalities is that comprehensive data can be obtained at 1 study without exposing children to ionizing radiation. MRU can be used to guide management and assess outcome after pyeloplasty in children with UPJ obstruction.[9] Additionally, certain MRU findings of RD are suggestive of renal dysplasia. We present our experience with MRU for evaluating and treating infants born with ANH. We also determined the MRU characteristics of RD.

MATERIALS AND METHODS

Patient Population

We retrospectively reviewed the records of 54 male and 13 female infants with a history of ANH. Mean patient age was 2.8 months (range 0.9 to 4.6). Inclusion criteria were infants with documented prenatal hydronephrosis who underwent MRU in the first 6 months of life. Because of the cost and the need for sedation, typically only infants with moderate to severe hydronephrosis on postnatal US are referred for MRU at our institution. High resolution MRU provided information to establish a morphological diagnosis and assess obstruction and individual renal function. VCUG was performed in 62 of 67 patients (93%).

MRU Technique

Our MRU protocol has been reported previously.[6] Briefly, infants were hydrated before the study with lactated Ringer's solution and sedated for the examination using

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propofol. Sedation procedures were supervised by an emergency department physician. A bladder catheter was placed. The patient was positioned supine on the scanner bed of a 1.5 Tesla Symphony® or 1.5 Tesla Avanto® scanner. Each is 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 image in a series of dynamic images. Three-D MIPs were 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 the anatomy of the urinary tract in a manner similar to that of excretory urography. Total imaging time was typically less than 45 minutes.

Image Analysis and Interpretation

Dynamic volumes were transferred to a workstation for analysis using Analyze 5.0 (Mayo Clinic, Rochester, Minnesota). Anatomical assessment included renal size, morphology, cysts and the degree of dilatation of the collecting system and ureter. DRF was determined following contrast enhancement by calculating the relative volume of functioning parenchyma for each kidney. We used the formula, percent renal function = individual kidney volume/(right kidney volume + left kidney volume) × 100. UPJ obstruction was defined as a morphological narrowing at the UPJ with proximal dilatation and functionally it was defined as RTT prolongation. Our method of assessing obstruction using RTT has been reported by Jones et al.[7] Briefly, a 3D sequence is used to track contrast material passage through the kidneys. Time between the appearance of contrast material in the renal cortex and its appearance in the ureter at or below the level of the lower pole was used to define RTT. As derived from comparisons made with DTPA scans, kidneys were classified as unobstructed—RTT less than 4, equivocal—RTT 4 to 8 or obstructed—RTT more than 8 minutes.[7]

Statistical Analysis

DRF and RTT values are expressed as the mean ± SEM. Preoperative and postoperative values were compared using the Wilcoxon signed rank test with $p < 0.05$ considered significant.

RESULTS

Figure 1 shows the diagnosis in the 67 infants (87 renal units) with ANH. Since some infants had more than 1 diagnosis, diagnoses were grouped according to renal units. Of the 87 renal units 30 (35%) had UPJ obstruction (fig. 2, *A*). A total of 16 infants (18 renal units) underwent dismembered pyeloplasty after initial MRU. Mean age in those who underwent pyeloplasty was 3 months. In this subgroup MRU was done before and after surgery to assess anatomy, function and surgical outcome. Overall function and RTT improved after pyeloplasty. Mean DRF preoperatively and postoperatively was 40.4% ± 1.6% and 44.4 ± 1.9%, respectively ($p < 0.05$). Mean RTT preoperatively and postoperatively was 20.3 ± 1.9 and 8.7 ± 1.7 minutes, respectively ($p < 0.05$). The remaining 11 infants

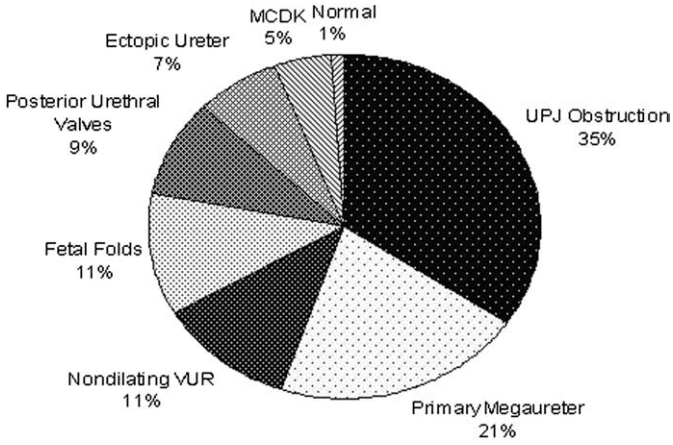

FIG. 1. Diagnosis in 67 infants (87 renal units) with prenatally diagnosed moderate to severe hydronephrosis. UPJ obstruction and primary MUs represented more than half of diagnoses.

with UPJ obstruction were initially observed. Seven of these patients underwent followup MRU after age 6 months, of whom 5 (71%) with preserved DRF remained on observation, while 2 (29%) with DRF deterioration underwent pyeloplasty.

Fetal folds were observed in 8 infants (10 renal units) (fig. 2, *B*). Mean age in this subgroup was 3 months. Excluding 1 infant with a solitary kidney, mean DRF in kidneys associated with fetal folds was 51% ± 1.2%. All renal units with fetal folds had RTT in the unobstructed (6) or equivocal (4) category. Mean RTT was 3.9 ± 0.7 minutes. Therefore, fetal folds were not associated with obstruction or functional impairment and they were managed nonoperatively.

Primary MUs were noted in 18 of 87 renal units (21%). There were 6 primary obstructed, 8 primary refluxing and 4 nonobstructed, nonrefluxing MUs. Six renal units were associated with ectopic ureters. Preoperatively MRU correctly delineated the insertion of these ureters into the bladder neck vagina and posterior urethra in 1, 1 and 4 cases, respectively. Posterior urethral valves were noted in 4 patients.

Information gained from MRU was used to determine management for primary MU. Eight of the 18 patients with MU were treated nonoperatively. One patient had a solitary kidney with an RTT of 8.2 minutes. Followup MRU 3 months later showed interval renal growth and RTT normalization. Ten patients with primary MUs underwent surgery. Two patients underwent nephrectomy for poorly functioning renal units. Four patients underwent reimplantation of obstructed MUs associated with functioning renal units. Followup MRU in 2 patients after reimplantation showed preserved function and improved RTT. In 1 patient deterioration in renal function and prolonged RTT prompted soft ureteral stent dilation. Followup imaging after stent removal showed equalization of renal function and no obstruction. Renal function deteriorated in 1 infant after reimplantation (23% to 12%) but there was interval renal growth and normalization of RTT. Four patients with refluxing, nonobstructed MUs underwent endoscopic correction with Deflux®, of whom 2 with grades 5 and 4 VUR, respectively, showed no reflux on followup VCUG and 2 with grade 4 VUR showed persistent grade 4 reflux, requiring subsequent ureteral reimplantation.