The contribution of MR Urography in imaging congenital malformations in children - preliminary results.

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ABSTRACT: Magnetic resonance urography (MRU) is a fairly new technique which has been studied for the last 10 years. MRU offers increased spatial and temporal resolution and provides quantitative functional information on renal perfusion, excretion and drainage. This article presents the first results obtained from MRU studies in children in Northern Greece. 21 children (3-11 years old) diagnosed with congenital malformations were studied with MRU. A standardized protocol was created in order to make MRU feasible in everyday use, based on protocols suggested by other researchers. Both T1 and T2 weighted images were obtained using the following sequences: 2D T2-weighted fat saturation, 3D single shot fast spin-echo (SSFSE/RARE), 2D Radial SSFSE and T1-weighted gradient LAVA (3D SPGR). In 16 out of the 21 cases the MRU images and data agreed with the previous diagnosis based on radionuclide and ultrasound studies. In 5 cases MRU provided additional information, altering or even overruling the previous diagnosis. These 5 cases are presented in this article.

Key Words: MR urography, Renal MRI, Congenital malformations in children.

INTRODUCTION

According to recent data from publications around the world, Magnetic Resonance Urography (MRU) is the next step in the evolution of uroradiology in children1. MRU combines superb anatomic imaging as well as quantitative evaluation of the urinary system, without the use of ionizing radiation, in a single test2-5.

The quantitative information provided by MRU imaging is mostly functional information of renal perfusion, excretion and drainage. However, one of the most significant advantages of this procedure is the acquisition of images with higher contrast, spatial and temporal resolution in any orthogonal plane compared with conventional techniques2-4.

During the last two years we began applying this technique, in pediatric patients with urological and kidney problems in northern Greece. Our goal was to establish a complete protocol for the procedure, which can produce adequate imaging, both static and dynamic.

Despite the fact that we are still beginning to apply MRU, we choose to present five cases in which the MRU contribution was vital in revealing the disorder and clarifying the differential diagnosis.

METHOD

All patients, regarding this study were children (ages from 3 to 11 years old). We investigated 21 children, 8 of which were girls (ages 5-10y) and 13 boys (ages 3-11y). Their parents were informed about the examination procedure and both parents and the children were informed that good cooperation during the acqui-
sition of the breath-hold sequences is very important for the best image quality to be achieved. All children were hydrated prior to the study and remained fasted for 5 hours prior to the examination. No sedation was used and all patients were asked to void before undergoing the examination.

All patients were placed in a supine position on the scanner bed and scout images were taken in order to determine the accurate position of the kidneys and bladder and to improve, as much as possible, the signal-to-noise ratio for those anatomical structures.

The children were positioned on the table with the head first. The axis of the body coincided with the isocenter of the magnet, with the hands parallel to the body, in order to ensure easier access for the administration of contrast agents.

Patients were instructed to hold their breath during each acquisition and breathe during the intervals between acquisitions. These guidelines helped to reduce motion artifacts otherwise seen in these images.

Furosemide was administered (furosemide, 20 mg/2ml - LASIX, Sanofi Aventis AEBE) to all patients 15 minutes prior to the examination.

Two types of contrast agents were used: OMNISCAN 0.5 mmol/ml (287 mg/ml) and MAGNEVIST 469mg/ml, Gadopentetic acid, Dimeglumine salt with a 0.2mmol/kg dosage.

The imaging protocol consisted of 2D and 3D acquisitions. The scanner was a GE Signa Infinity HD 1.5T with EXCITE III and upgrade 2007. And the flip angle that was chosen was 90°.

Images were acquired with the following sequences: 2D T2-weighted fat saturation, 3D single shot fast spin-echo (SSFSE/RARE), 2D Radial SSFSE and T1-weighted gradient LAVA (3D SPGR).

RESULTS

The MRU images agreed with the previous diagnosis for the 16 out of the 21 children investigated in this study. In the 5 remaining cases the contribution of MRU was significant, altering or in some cases overruling the previous diagnosis. These five cases are presented in detail and the role of MRU is discussed.

Case 1

An 18 month old boy developed acute pyelonephritis and imaging revealed bilateral vesicoureteral reflux (VUR) with severe dilatation of the ureters; especially the left one.

The left kidney was smaller than the right, with...
two scars. Since then, and until the age of 5, when we met him for the first time, his investigation included only renal ultrasound (US). The US showed dilatation of the pelvic-calyceal system and the left ureter.

The MRU image (Figure 1) revealed obstructive uropathy with dilatation of the left ureter, in the upper 2/3 of its length, to the level of the iliac vessels.

**Case 2**

A 12 year old boy presented his first macroscopic hematuria episode after being injured in the kidney area, during a basketball game. The kidney Doppler US (Figure 2a) depicted a lesion of mixed echo-consistency with distinct boundaries and approximately 3.5 dilatation, lacking vessels. A CT examination showed, in the same area of the right kidney, a space occupying lesion with distinct boundaries and heterogenic structure with hypodense necrotic and hyperdense hemorrhagic elements.

After the intravenous administration of the contrast agent, the mass showed no significant enhancement. The differential diagnosis included: complicated cyst after hemorrhage, solid hematoma, angiomyolipoma with hemorrhagic lesions and primary space occupying lesions.

The MRU (Figure 2b), which took place three months later revealed a cyst, with inner septi and relatively abnormal wall. The content had signal intensity similar to water. The MRU findings clarified that it was a complicated renal cyst.

**Case 3**

A 5 year old girl, with relapsing urinary tract infections and bilateral VUR grade III, underwent a DMSA scan which showed a photopenic region at the lower pole of the left kidney. The radionuclide imaging conclusion raised the question as to if it was a scar or a renal cyst. The MRU (Figure 3) demonstrated a triangular incision on the contour of the lower pole of the left kidney and clarified that it was a renal scar.

**Case 4**

Boy aged 12 years old, was diagnosed with chronic renal failure (urea 200 mg/dl, creatinine 7 mg/dl) after complaints of bone pains in his calves. His kidney and bladder US showed a solid, ectopic, pelvic left kidney with increased echogenicity. He was referred for MRU (Figure 4), which revealed the single left kidney in the minor pelvis, the collecting system malrotated...
and the calyces oriented anteriorly. The single kidney had a duplex system. A right ureter was also revealed, which entered more cranially to the bladder and appeared to cross the midline. These findings indicated that the lower pole of a involuted right kidney was fused with the upper pole of the left kidney (crossed fused ectopia). The dynamic study, after the administration of the contrast agent, determined visually the chronic renal failure (low concentration and low excretion).

**Case 5**

A 6.5 year old girl with severe hydronephrosis underwent a MAG-3 scan, which showed delayed excretion on the right. However, the diuretic scan showed good preservation of the differential function in the kidneys ($R = 47.4\%, L = 52.6\%$) and acceptable washout after LASIX administration (Figure 5a), and that delay was characterized as functional. The MRU was requested because an ultrasound check showed that the dilatation of the right pelvic-calyceal system was severe, but there was no dilatation of the right ureter. This finding demonstrated a strong possibility that the right ureteropelvic junction was obstructed. The MRU (Figure 5b) revealed, with great sharpness, the existence of ureteropelvic junction obstruction on the right and the child was submitted to pyeloplasty on the right.

**DISCUSSION**

The diseases of the urinary system in children, whether hereditary or acquired, are very common. Various modalities have been used to image the urinary system in children, such as ultrasound, voiding cystourethrography (VCUG), static and dynamic scintigraphy (DMSA, DTPA or MAG-3) and intravenous urography (IVU). These techniques are either invasive, operator dependent, expensive or use radiation. Recent data show that MRU provides reliable information, both anatomical and functional. MR imaging has inherently greater soft-tissue contrast than other imaging techniques and combines high spatial and temporal resolution. When used with dynamic scanning, it provides a non-invasive analysis of the perfusion, concentration and excretion of each kidney. So far, it appears that MRU can substitute all other techniques in a single test.

In our cases, despite our inexperience, MRU provided the answers to the pediatricians’ questions and contributed significantly in the correct diagnosis, management and treatment of these children.

In the first case, the hydronephrosis on the left and the dilatation of the left ureter was attributed to VUR on the left. The MRU revealed an obstructive ureter, due to pressure from the iliac vessels in the middle and lower third of the left ureter.

In the second case, the space occupying mass that was depicted in the middle of the right kidney, worried
ΠΕΡΙΛΗΨΗ: Η μαγνητική ουρογραφία (MRU) είναι μία σχετικά καινούρια τεχνική που μελετάται τα τελευταία 10 περίπου χρόνια. Η MRU προσφέρει εξαιρετική χωρική και χρονική διακριτική ικανότητα και προσφέρει ποσοτικοποιημένα λειτουργικά δεδομένα για την αιμάτωση, συγκέντρωση και απέκκριση κάθε νεφρού. Στο άρθρο αυτό παρουσιάζονται τα πρώτα αποτελέσματα που ελήφθησαν από μελέτες MRU σε παιδιά, στη Βόρεια Ελλάδα. Μελετήθηκαν 21 παιδιά (ετών 3-11) με διαγνωσμένες συγγενείς διαμαρτίες του ουροποιητικού. Δημιουργήθηκε ένα τυποποιημένο πρωτόκολλο με σκοπό να μπορεί να εφαρμόζεται εύκολα η MRU, βασισμένο σε πρωτόκολλα που προτάθηκαν από άλλους ερευνητές. Αποκτήθηκαν Τ1 και Τ2 εικόνες με βάση τις παρακάτω ακολουθίες: 2D Τ2-weighted fat saturation, 3D single shot fast spin-echo (SSFSE/RARE), 2D Radial SSFSE and T1-weighted gradient LA V A (3D SPGR). Οι εικόνες και τα δεδομένα που προέκυψαν από την MRU συμφωνούσαν με τις προηγούμενες διαγνώσεις των 16 από τους 21 ασθενών, οι οποίες προέκυπταν από ραδιοϊσοτοπικές και υπερηχοτομογραφικές μελέτες. Στις υπόλοιπες 5 περιπτώσεις η MRU προσέφερε επιπλέον δεδομένα που άλλαξαν σε μικρό ή και μεγάλο βαθμό τις προηγούμενες διαγνώσεις. Στο άρθρο αυτό παρουσιάζονται οι 5 αυτές περιπτώσεις.

Λέξεις Κλειδιά: Μαγνητική ουρογραφία, Μαγνητική τομογραφία νεφρών, Συγγενείς διαμαρτίες του ουροποιητικού.
REFERENCES