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The comparison of magnetic resonance urography with the combination of diuretic renal scintigraphy and urinary ultrasound in the diagnosis and follow up of ureteropelvic junction obstruction

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Abstract

Objectives: To evaluate the efficiency and reliability of MRU in diagnosis and follow up of children with UPJO.
Methods: The data of 64 patients with the diagnosis of primary UPJO were analysed. All patients underwent Anderson-Hynes pyeloplasty and pelvic reduction. Pre and postoperative results of renal pelvis AP diameter (RPAPD), separated renal function, renal transit time (RTT), and anatomical findings in USG and renal scintigraphy were compared with MRU findings to evaluate the possible differences and analyse the efficiency and reliability of MRU in the management of UPJO.
Results: All patients had unilateral hydronephrosis including 16 grade 2, 24 grade 3 and 24 grade 4. Pre- and postoperative RPAPDs in two techniques were also similar (P = 0.084, P = 0.576). Separated renal functions were evaluated by MRU with similar and sensitivity in DRS (P = 0.867). The comparison of mean pre and postoperative RTT results showed a significant improvement in mean postoperative RTT value (P = 0.024).
Conclusions: MRU has the potential to become the imaging study of choice in the diagnosis and follow up of obstructive uropathy, and it may have a more significant role in the management of UPJO in the near future.

Key words: MR urography, ultrasonography, renal scintigraphy, UPJ obstruction, pyeloplasty, children

Introduction

Currently there is no gold standard for assessing upper urinary tract obstruction, while the combination of ultrasound (USG), voiding cystourethrography (VCUG), and diuretic renal scintigraphy (DRS) is commonly used to investigate hydronephrosis in children (1). Magnetic resonance urography (MRU) is a more recent imaging concept in the evaluation of urinary tract. MRU has been used to investigate acute pyelonephritis and VUR, and determine renal function in children (2, 3). The advantage of MRU over other modalities is that anatomical and functional data can be obtained in one study without patient exposure to ionizing radiation. MRU can be used to guide management and assess outcome after pyeloplasty in children with ureteropelvic junction obstruction (UPJO). Superior spatial and contrast resolution is achieved with dynamic contrast enhanced MRU compared to that of USG 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 renal transit time (RTT) (6). Moreover, single kidney glomerular filtration rate (GFR) can be estimated by dynamic contrast enhanced MRU (7).

The aim of this study was to analyze the efficiency and reliability of MRU in diagnosis and follow up of children with UPJO. Pre and postoperative results of renal pelvis AP diameter (RPAPD), separated renal function, RTT, and anatomical findings in USG and ^{99m}Tc MAG3 renal scintigraphy (DRS), which are still used as gold standard in the diagnosis of UPJO, were compared with MRU findings to evaluate the possible differences

Materials and Methods

Between January 2005 and 2009, a total of 64 patients who were presented to Urology Clinic of Ibni Sina Hospital, School of Medicine, Ankara University, with the diagnosis of primary UPJO were included. A detailed clinical history, physical examination, blood urea-creatinine level, urine analysis, direct urinary system X-ray, renal USG, and DRS were performed. Renal size (longitudinal and transverse), RPAPD, and the hydronephrosis level were measured by USG. Separated renal function (SRF) was determined by DRS. All patients underwent MRU imaging to separately evaluate

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kidney size, RPAPD, separated renal function (SRF in MRU = differential renal function: DRF), and RTT. The alteration higher than 5% in separated renal functions, which was measured by DRS (SRF) and MRU (DRF), was considered significant. Subsequently, Anderson-Hynes pyeloplasty and pelvic reduction were performed in all patients. The indications for surgery were recurrent flank pain, increasing level of hydronephrosis in elder children. For neonatal hydronephrosis and RPAPD greater than 30 mm and/or impaired DRF lower than 40% and progression of hydronephrosis level were considered as operation criteria. At sixth month postoperatively, USG, DRS, and MRU were repeated to evaluate postoperative improvement of UPJO. During USG analysis, there was no need of sedation. DRS was performed after USG analysis. All patients and families were informed about DRS application. Initially, hydration was performed with 15 ml/kg 0.9% NaCl solution until 30th minute before starting the test. Bladder in older children was emptied just before DRS study. Sedation was administered only to younger children (generally ≤ 5 years).

Patient was fixed to the application table by two belts covering upper and lower parts of the body, and the parents stayed near the children during to whole test to calm down them. 99mTc MAG3 was administered to all children with the dosage of 50 µCi/kg (1.85MBq/kg), minimum 1 mCi intravenous bolus injection (8). Subsequently, 1mg/kg (maximum of 20 mg) furosemide was intravenously injected at 15th minute. MRU was performed under 1.0 T MR Unit (Hispeed, GE Medical Systems) with a body coil (body coil) by using T2-weighted (HASTE) technique 2-3 days after DRS to decrease the artefacts that might occur related to DRS testing. Patient was placed in supine position and kept breathing during application. Urination was inquired before the shooting. RPAPD, obstruction level, DRF, renal anatomy, and RTT were determined by MRU testing. While reconstruction was being made, raw images were also taken into consideration. Sudden change in ureteral diameter was accepted as the level of obstruction point. The sensitivity and specificity of MRU in the diagnosis of UPJO were analyzed.

In addition, before and after surgery results of AP diameter, SRF on DRS, DRF on MRU, RTT, and anatomical findings on USG and DRS were compared with MRU findings to evaluate the possible differences.

Statistical analysis

For statistical analysis SPSS version 11.0 (SPSS, Inc, Chicago, IL, USA) was used and a P-value of 0.05 was considered significant. The results were measurable and the sample size had adequate capacity. The pre and postoperative data were compared by using Pearson regression and correlation analysis.

Results

The sample included 32 boys and 32 girls with a mean age of 7.2±1.8 years (range 2 months-11 years). The diagnosis of UPJO was performed by the combination of USG and DRS. All patients had unilateral hydronephrosis and the level of the hydronephrosis was found grade 2 in 16, grade 3 in 24 and grade 4 in 24 patients according to the society for fetal urology. Only four patients had UPJO on the right side (4/64). Although no patient was suspected to have a crossing vessel during USG testing, it was determined by MRU in two patients.

The mean preoperative pelvic RPAPD was 32.7 mm ± 11.2 mm on USG and 33.2 mm ± 10.8 mm on MRU, respectively. There was no statistically significant difference between two results (P = 0.084). Postoperative RPAPDs were 19.5±6.4 mm in USG and 19.4±5.9 mm on MRU. Postoperative RPAPDs in two techniques were also similar (P=0.576). RPAPD was reduced approximately 13.5 mm postoperatively, and it was related to perform pelvic reduction during pyleloplasty.

All patients underwent similar rate of pelvic reduction during pyleloplasty and measurements were performed on the postoperative 6th month as we had previously shown that the level of hydronephrosis became more stable. According to DRS results, 40 patients (62.5%) had no significant changes, 16 patients (25%) had 5% or more improvement, and 8 patients (12.5%) had deterioration in SRF after surgery.

The evaluation with MRU showed that 36 patients (56%) were with no significant changes, 20 patients (31.5%) were with 5% or more improvement, and 8 patients (12.5%) were with deterioration in DRF after the operation. In 4 patients, 3% improvement was found in SRF by DRS, whereas 5% improvement was seen in DRF by MRU. Except for that patient, the results detected by DRS were in accordance with MRU results.

The mean values of SRF detected by DRS before and after the operation were 33.3% and 32.5%, respectively. Whereas the mean DRF values before and after the surgery on MRU were 32.9% and 31.5%, respectively (Figure 1)

Figure 1: Mean values of separeted renal function (on DRS) and differential renal function (on MRU) before and after the operation.

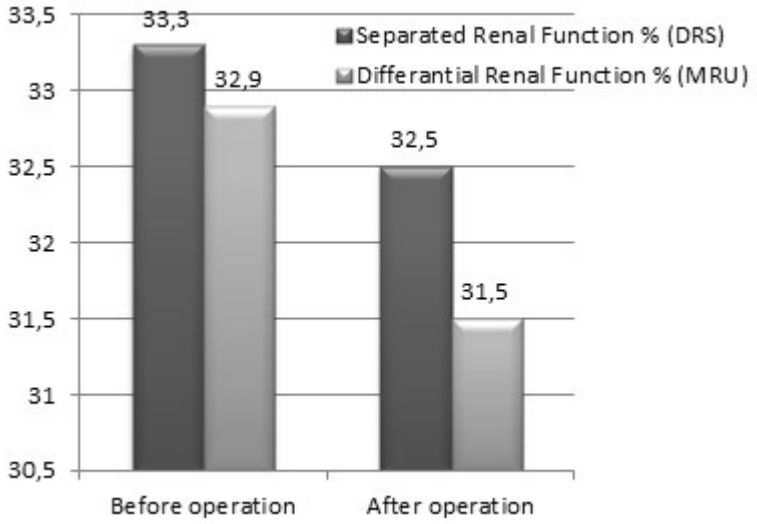
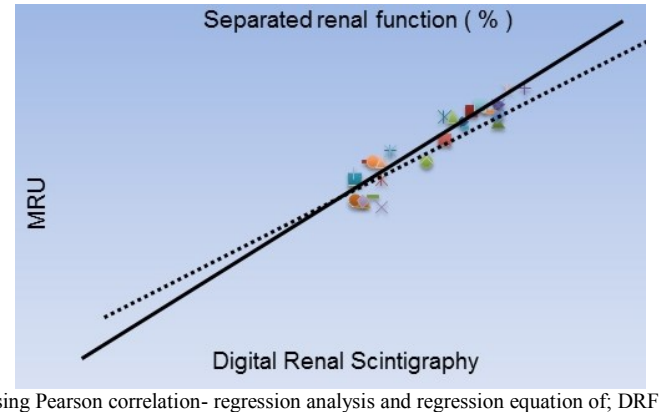
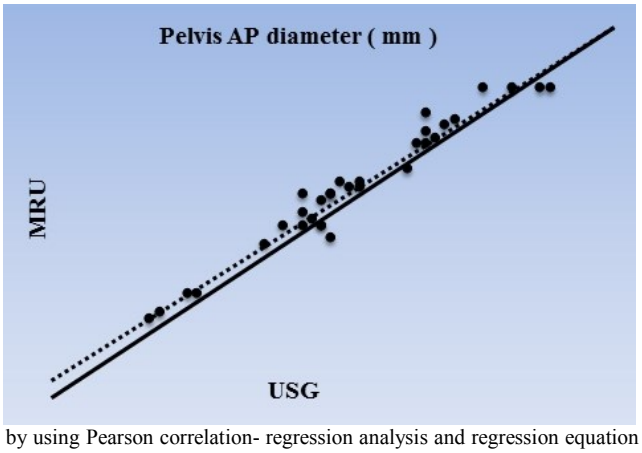


Figure 2: The demontration of correlation curve of separated renal function(SRF) that was obtained by DRS and differential renal function (DRF) that was obtained by MRU.



Correlation was obtained by using Pearson correlation- regression analysis and regression equation of; DRF (on MRU) = 7.359 + 0.797 × SRF (on DRS). Similarly, there was a significant correlation between RPAPDs, which was preoperatively obtained by USG and MRU (P = 0.076)

Figure 3: The demonstration of correlation curve of renal pelvis AP diameters, which were obtained by renal USG and MRU.



The correlation was determined by using Pearson correlation- regression analysis and regression equation of; RPAPD (on MRU) = 1.828 + 0.959 × RPAPD (on USG).

There was no statistically significant difference between the separated renal function results before and after the surgery in two methods (P:0.867). Preoperative and postoperative RTT values were determined by MRU, and compared.

Eight patients (12.5%) had RTT < 4 minutes that was accepted as normal UPJ. 20 patients (31%) were with RTT between 4 and 8 minutes that was accepted as mild UPJO. 36 patients (56.5%) had RTT > 8 minutes, which was accepted as significant UPJO. The mean preoperative and postoperative RTT were 17.7± 5.9 min (7-32 min) and 11.3±6.5 min (3-30 min), respectively. The comparison of them showed a significant improvement in mean postoperative RTT value (P=0.024). Although it was observed that 60 patients out of 64 (93.75%) had improvement in RTT value, just four were postoperatively stable in terms of RTT. Both of them were in 'normal UPJ' group with a RTT < 4 minutes preoperatively. These patients underwent surgery due to severe recurrent pain that was diminished in all postoperatively.

There was a significant correlation between DRF on MRU and SRF on DRS
(P=0.184), (Figure 2).

Discussion

Many developments occurred in radiological evaluation of renal obstruction during last 10 years. Previously, the first choices of diagnostic tests in the management of suspicious ureteropelvic junction obstruction (UPJO) were intravenous urography (IVU) and antegrade pressure flow (Whitaker) tests. After the technological developments, an increased number of diagnostic tests including USG, DRS, and MRU were started to be used in the evaluation of hydronephrosis. Although these diagnostic tests provide only well anatomic visualization or good functional evaluation, combined information can simultaneously be obtained just by MRU. There are still no accepted gold standards in the evaluation of renal obstruction (1).

The diagnosis of UPJO on MRU is seen as dilatation of renal pelvis and/or collecting system with ureteral obstruction and the combination of atrophy of renal pyramids and medulla (9). Preoperative determination of the presence of a crossing vessel that can change the surgical management style is very important. Previous studies reported that the visualization rate of a crossing vessel by USG was 39% (10, 11). In the present study, a crossing vessel, which could not be diagnosed by USG, was manifested by MRU.

MRU provides much more data than DRS in the evaluation of antenatal hydronephrosis. Furthermore, it gives pretty much data about the dilatation of ureter and bladder in patients with suspicious vesicoureteral reflux or infravesical obstruction. Another important data, which was provided by USG in the management of hydronephrosis, was dimension of renal pelvis. Nevertheless, USG alone can give faulty results in cases with intrarenal pelvis, therefore the management of hydronephrosis, which is a dynamical problem, is required to use other management procedures that must be simultaneously performed with USG. Whereas USG and DRS are separately performed in current practice, they get the clinicians' decision more difficult in some conditions with their conflicting findings.

Both of USG and DRS results may be affected by hydration status and patient may not have the same hydration status during USG and renal scintigraphy. This deficiency may cause to have faulty results.

Nevertheless MRU can simultaneously obtain anatomical and functional evaluation, thus there will be no different and/or faulty results, which can occur because of the different hydration status during the detection.

The detection of pelvicaliceal dilatation level by USG may give faulty results, wherefore USG evaluation may be affected by hydration status, intravesical volume, and position of patient. Quality of USG examination can also be affected by intestinal gas, thus the conjunction point of ureter to renal pelvis cannot be clearly shown.

The evaluation of renal anatomy and dimension of renal pelvis on MRU may not be influenced by patients' position, and MRU can also obtain more detailed anatomical images. Thus, a more detailed detection can be performed in course of ureter, and the requirement of preoperatively performing retrograde pyelography is removed. Beside its simple applicability, USG has a disadvantage of being influenced by individually interpretation of radiologist. MRU images can subsequently be pressed and analyzed. In current practice, while USG and DRS are simultaneously evaluated in the diagnosis of UPJO, they cannot be simultaneously performed.

A single detection on MRU may discriminate an obstructed pelvis from non-obstructed system, because it additionally provides the evaluation of RTT with morphological images (6). The description of obstruction on MRU is defined as decreased and retarded contrast media infiltration in calyxes and ureter beside the anatomical image of an obstruction. This description can objectively be performed by calculating RTT and DRF. MRU manifests better findings in the diagnosis of UPJO.

In a previous study, Chu and et al. analyzed 8 children with unilateral hydronephrosis and a decreased renal function in the range of 30% to 40% by MRU and DRS. DRS revealed drainage in 3 dilated systems and obstruction in 5, while MRU showed drainage in 7 systems and obstruction only in 1. The 18 months follow up in 7 patients with normal urine drainage on MRU showed no deterioration in renal function or progressive hydronephrosis. Two cases those had an obstruction on DRS and drainage on

MRU underwent antegrade pyelography, and it was found that there was no evidence of UPJO on antegrade pyelogram. Thus, DRS tended to overestimate obstruction (12).

Previously, it was reported that USG and renal scintigraphy might be misleading in clinical follow up [12]. RTT can be helpful in clinical follow up. In the present study, RTT was evaluated before and after the operation, and it was found that RTT significantly decreased after surgery. Nevertheless, RTT was much more in accordance with other parameters even in the clinical follow up of the patients who had no improvements on DRS postoperatively.

Single kidney glomerular filtration rate (GFR) can be estimated by creating Rutland-Patlaks' graph with the findings on MRU. This data is useful in patients with bilateral renal disorder or unilateral disorder in solitary kidney, and MRU has a distinct advantage over DRS with this. In addition, RTT can independently show the separate function of each kidney in bilateral renal disorders, therefore it can provide more objective and helpful results. It is the lack of our study that single kidney GFR could not be calculated because of technical insufficiencies. Some previous studies reported that DRF on MRU was in correlation with SRF on DRS [4,5]. We have also determined a significant correlation between DRF and SRF, and our data suggest that each procedure is useful in the determination of renal function.

Our study allowed us to compare and evaluate the pre and postoperative results by two different visions, thus its results were important and beneficial for clinicians. Hopefully, this study can provide additional data to pediatric urologist as the postoperative follow up of operated UPJO patients, which is still controversial.

MRU has also some limitations beside its advantages. There are still no completely accepted standardized values and formulas for determining renal function and classifying renal drainage. MRU is generally required sedation and monitorization in most of the children.

Besides, Rutland-Patlaks' formula, which is used for the determination of GFR, was created just for adults, and it is not modified for children yet. The high prices of MRU and no existence in all medical centres are also important limitations of this procedure. Nevertheless, the comparison of total cost between other diagnostic procedures and MRU especially in the analysis of complicated cases showed that MRU had commonly similar cost and sometimes it had the cost advantage.

On the other hand, the required training period to learn the evaluation of MRU is longer than other investigation procedures. The limitations of MRU compared to that of other procedures can be eliminated by its higher quality and more detailed and comprehensive results.

Conclusion

After the development of MRU in the late 1980s, it was hailed as being an excellent diagnostic tool for differentiating among pediatric urological diseases with the advantages of MRU, which include no use of ionizing radiation, image acquisition with higher contrast material that is not affected by bowel motion or bowel gas, and image quality is independent of renal function. The approach to UPJO using MRU provides simultaneous functional and anatomic evaluation of renal parenchyma in one study. With MRU we are able to determine pathophysiological differences in children with UPJO that are occult on USG and DRS. We believe that the limitations of MRU compared to that of USG and DRS is offset by the quality and comprehensiveness of the information obtained.

In addition, MRU has the potential to become the imaging study of choice in the diagnosis and follow up of obstructive uropathy, and it may have a more significant role in the management of this disorder in the near future

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All authors state that there is no conflict of interest

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