ORIGINAL PAPER

Evaluation of Congenital Hydronephrosis with Static and Dynamic Magnetic Resonance Urography in Comparation to Dynamic Renal Scintigraphy

Amra Dzananovic[1] , Amela Begic[2] , Danka Pokrajac[3]

[1]Department of Paediatric Radiology, Clinic for Radiology, Clinical Center University of Sarajevo, Sarajevo, Bosnia and Herzegovina

[2]Clinic for Nuclear Medicine and Endocrinology, Clinical Center University of Sarajevo, Sarajevo, Bosnia and Herzegovina

[3]Paediatric Clinic 2, Clinical Center University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Corresponding author: Assistant Professor Danka Pokrajac, MD, PhD. Pediatric Clinic 2, Clinical Center University of Sarajevo. Patriotske lige 81, 71000 Sarajevo, Bosnia and Herzegovina. Phone: ++ 387 61 724 284. E-mail: dankapokrajac@hotmail.com. ORCID ID: https://orcid.org/0000-0002-5998-5620.

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ABSTRACT

Introduction: Congenital hydronephrosis (CH) is a condition with dilated renal pelvis with or without dilation of renal calyces. **Aim**: To examine the role of magnetic resonance urography in the detection of congenital hydronephrosis in comparison to dynamic renal scintigraphy (DRS). **Patients and methods**: Resarch included 58 (n=58) patients with diagnosis of congenital unilateral or bilateral dilatation of kidney duct system. Each patient had a one-time or multiple hospitalization at the Nephrology Department of the Pediatric Clinic, with performed: ultrasound which confirmed CH, voiding cystourethrography / voiding urosonography was confirmed based on which the vesicoureteral reflux (VUR) was established / excluded, dynamic renal scintigraphy and magnetic urography (analysis was made by CHOP-fMRU software) on the basis of which the uterine anatomy and the relative renal function were evaluated. **Results**: Male patients were represented in 40 cases (69%). The average age was 4.4 ± 4.3 years with the youngest patient at the age of 2 months, and the oldest was 17 years old. According to diagnostic entities, the most common diagnosis was ureteropelvic junction (UPJ) obstruction in over half of cases (30 or 51.7%), followed by subjects with ureterovesical junction (UVJ) obstruction (11 or 19%), VUR was recorded in 9 (15.5%) cases, and pyelon fissus in 7 (12.1%), and one case (1.7%) was recorded with bilateral megaureter. Comparison of the value of the renal function obtained with DRS and CHOP-fMRU methods shows that there were no statistically significant differences between two methods. In the case of right kidney, the mean DRS value was 53.4 ± 18.4% (range 13-100%), while CHOP-fMRU was 51.8 ± 22.4 (range 0-96.7%). In the case of left kidney, the average value according to the DRS method was 46.9 ± 18.9% (range 0-87%) and according to CHOP-fMRU 47.6 ± 21.5% (range 8.3-100%). The correlation coefficients of both right and left kidneys show a highly statistically significant correlation between these two methods. **Conclusion**: Magnetic resonance urography in the pediatric population in CH based on results should be an integral part of the management of these patients, especially in congenital obstructive uropathy, in complex and associated congenital anomalies, as it provides morphological and functional data on the state of the kidneys and urinary tract.

Keywords. hydronephrosis, urography, scintigraphy, kidney, pediatrics.

1. INTRODUCTION

Congenital hydronephrosis (CH) is a condition with dilated renal pelvis with or without dilation of renal calyces (1). It can be diagnosed by prenatal ultrasound examination and can be detected from the twelfth to the fourteenth week of gestation (1, 2). Prenatal anomalies in the fetus are increasingly diagnosed with prenatal ultrasound examination since the early 1970s. In the early years of its use, prenatal ultrasonography revealed structural abnormalities in approximately 1-3% of all pregnancies (1, 2). The aim of postnatal evaluation of CH are: confirmation of hydronephrosis, determination of its cause and evaluation of renal function. Postnatal evaluation has a difficult and responsible task to identify newborns and children with significant abnormalities of the kidney or urinary tract that require surgical treatment, and to limit unnecessary radiological searches and thus minimize that children and parents who have a clinically insignificant or normal findings to go through the same (3, 4). Historically, intravenous urography (IVU) was used in the evaluation of patients with CH. Dynamic renal scintigraphy (DRS) with diuretic administration is a method

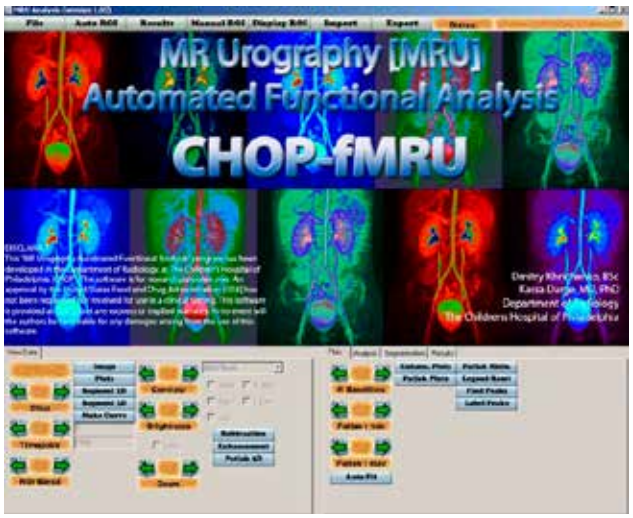

Figure 1. CHOP-fMRU software is developed by developed by The Children's Hospital of Philadelphia (Philadelphia, Pennsylvania, United States of America) (5)

of choice for assessing renal function and drainage (3). Magnetic resonance urography (MRU) has been shown to be the imaging modality of the urinary tract of children with the most benefits, and which has the potential to provide comprehensive morphological and functional data in one review. The absence of ionizing radiation makes it an appropriate method for use in children. The role of functional magnetic urography is determining relative renal function, morphological identification of anatomical and structural anomalies of the urotract, and evaluation of the site of obstruction. Comparative functional studies with scintigraphy performed so far have shown a high compatibility of these two methods in determining the relative renal function of the kidney, opposite to renal excretion, while he use of a functional magnetic resonance urography analysis with the help of CHOP-fMRU software (developed by The Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, United States of America) enables the correlation of functional parameters of the kidneys obtained by dynamic renal scintigraphy and magnetic resonance urography to open the door for more standardized, multicentre studies and receiving results based on evidence (5-10).

2. AIM

The functional parameter obtained by analyzing functional value of dynamic magnetic resonance urography (CHOP-fMRU software) with an insight into the morphological data of the dilated urinary tract, correlates with the functional parameter obtained in dynamic renal scintigraphy which gives this method a leading role in the assessment of congenital hydronephrosis of any etiology. Since the method of magnetic urography does not use ionizing radiation, which is a significant aspect of pediatric radiology, the question arises as to whether this method will be able to suppress dynamic renal scintigraphy in the future in the assessment of renal function.

3. MATERIAL AND METHODS

The research was conducted in a period of one year as a retrospective-prospective clinical study at the Radiology Clinic and the Clinic for Nuclear Medicine and Endocrinology at Clinical Center University of Sarajevo. The study included 58 patients. Planned clinical, laboratory, ultrasound parameters, as well as data obtained by voiding cystourethrography and contrast-enhanced ultrasound cystography were collected during routine treatment of patients at the Nephrology Department of the Pediatric Clinic, respecting the ethical principles of working with patients and the approval of the Ethics Committee of the Clinical Center University of Sarajevo to carry out the study.

Criteria for inclusion in study were as follows: patients with congenital unilateral or bilateral dilatation of kidney duct system, patient without duplicated ureter, patients older than 6 weeks (earlier than this age, paramagnetic contrast media applications are not recommended due to renal immaturity) patients given an indication for performing magnetic urography and dynamic renal scintigraphy by a pediatrician or a surgeon with signed informed consent by one or both parents.

Criteria for exclusion from the study were as follows: patients with acute urinary tract infection, patients with diagnosed renal cysts, patients with diagnosed kidney and urinary tumors, patients with congenital calculosis and patients diagnosed with duplicated ureter.

The study used medical documentation of patients who met the criteria for inclusion in the study, from which we had an insight into the required clinical, laboratory and demographic data. Each patient had a one-time or multiple hospitalization at the Nephrology Department of the Pediatric Clinic, with performed: ultrasound which confirmed CH, voiding cystourethrography / voiding urosonography was confirmed based on which the vesicoureteral reflux (VUR) was established / excluded, dynamic renal scintigraphy and magnetic urography on the basis of which the urinary tract anatomy and the relative renal function were evaluated. An overview of magnetic urography is performed at the Radiology Clinic at the Avanto 1.5T and Trio Tim 3T Siemens according to the static and dynamic magnetic urography protocol established at the Children's Hospital of Philadelphia (CHOP).

Preparation for MRI requires several procedures. Intravenous hydration (0.9% NaCl, or Ringer's solution) and intravenous furosemide are crucial to reduce the concentration of the required contrast medium. Morphological (static) MRU evaluation with the use of static T2 TSE sequences covering the whole abdomen is performed in an axial and sagittal level on a scrutiny. These T2W sequences provide a good anatomical display, well illustrate the renal parenchyma with a clear corticomedular differentiation. As a contrast agent in the performance of magnetic urography, we used gadoterate meglumine in a dose of 0.2 mg / kg in the test, the contrast medium application was performed manually. Gadoterate meglumine proved to be the safest paramagnetic contrast medium in the pediatric population because renal elimination is predominantly (98%) glomerular filtration without tubular secre-

tion and reabsorption.

For postcontrast scans we applied the 3-D T1W GRE sequence with fat saturation (volumetric enterprising "breath hold" T1 VIBE FS -Siemens) (9). The ideal software for MRU functional analysis should be simple, easy to use for the average radiologist and radiology engineer, fast and free. Such software for the functional analysis of magnetic urography was made by a team of pediatric radiology experts from the Children's Hospital of Philadelphia (Philadelphia, Pennsylvania, United States of America) and named CHOP-fMRU software (11). Using this program in our study, we compared the results of the relative renal function, i.e. the split renal function (SRF) in DRS and the volume of differential renal function in functional MRU with the application of CHOP-fMRU software. Precise protocols for MAG3 diuretic renal scintigraphy in children have been established by the European Association of Nuclear Medicine and the North American Society of Nuclear Medicine.

The preferred radioisotope in the pediatric population is Technetium-99m (99mTc) mercaptoacetyltriglycine (MAG3). MAG 3 diuretic scintigraphy allows the determination of differential renal function through the extraction of radioisotope from the blood, as well as the observation of excretion through the urinary tract via the disappearance of the radioisotope.

The results of the tests are shown in tabular and graphical use of descriptive statistics, which includes the absolute number of cases, the relative number of cases, the mean value (X), the standard deviation (SD), and the standard error (SEM). Comparison of mean values among groups was done by Student's t-test for normal distribution variables, with the Mann-Whitney test and the Wilcoxonon ranking test for variables that do not have normal distribution. A chi-square test was used to compare the categorical variables between groups. Sperman's nonparametric bivariate correlation was used to assess the correlation of the proportion of individual renal function in the total renal function obtained with fMRU and DRS. The accepted statistical significance is at a confidence level of 95% or with p <0.05. Statistical processing was performed using the statistical statistics IBM Statistics SPSS v21.0 (Chicago, Illinois, USA).

4. RESULTS

The study included a total of 58 subjects with CH. Male patients were represented in 40 cases (69%). The average age was 4.4 ± 4.3 years with the youngest patient at the age of 2 months, and the oldest was 17 years old. According to diagnostic entities, the most common diagnosis was ureteropelvic junction (UPJ) obstruction in over half of cases (30 or 51.7%), followed by subjects with ureterovesical junction (UVJ) obstruction (11 or 19%), vesicoureteral reflux (VUR) was recorded in 9 (15.5%) cases, and pyelon fissus in 7 (12.1%), and one case (1.7%) was recorded with bilateral megaureter. Positive anamnesis of urinary tract infections was noted in 44 (75.9%) of cases.

Comparison of the value of the renal function obtained with DRS and CHOP-fMRU methods shows that there were no statistically significant differences between two methods. In the case of right kidney, the mean DRS value was 53.4 ± 18.4% (range 13-100%), while CHOP -fMRU was 51.8 ± 22.4 (range 0-96.7%). In the case of left kidney, the average value according to the DRS method was 46.9 ± 18.9% (range 0-87%) and according to CHOP-fMRU 47.6 ± 21.5% (range 8.3-100%) (Table 1). The correlation coeffi-

Comparation between avarage values of DRS and CHOP-fMRU					
	N	X	SD	Min.	Max.
DRS–right kidney (%)	58	53,421	18,4390	13,0	100,0
DRS–left kidney (%)	58	46,900	18,8825	,0	87,0
CHOP-fMRU–right kidney	58	51,7983	22,42478	,00	96,67
CHOP-fMRU–left kidney	58	47,6352	21,52839	8,31	100,00

Table 1. Proof of correlation of the method in evaluating relative renal function (dynamic renal scintigraphy (DRS), the mean value (X), the standard deviation (SD))

		CHO–fMRU–right kidney
DRS–right kidney (%)	ro	,607**
	p	,000
	N	58
**. level of significance p<0,01		

Table 2. Correlation for right kidney (dynamic renal scintigraphy (DRS), ro–Sperman's nonparametric bivariate correlation)

		CHOP-fMRU–left kidney
DRS–left kidney (%)	ro	,566**
	p	,000
	N	58
**. level of significance p<0,01		

Table 3. Correlation for left kidney (dynamic renal scintigraphy (DRS), ro–Sperman's nonparametric bivariate correlation)

cients of both right and left kidneys show a highly statistically significant correlation between these two methods (Table 2, Table 3)

5. DISCUSSION

CH is a condition that does not but may be caused by anomalies of the kidneys and urinary tract. In developed countries, it is most commonly diagnosed with prenatal ultrasound examination. In our study in a total of 58 subjects, only 25 of them (43.1%) were prenatally diagnosed with hydronephrosis. Until now there was no single method that provided all the information needed for a reliable assessment of the situation. Conventional methods have many limitations: the ultrasound examination is dependent on the examiner, with sometimes difficult visualization of the lower third of the ureter flow, retrograde methods, e.g. retrograde pylography is invasive with limited use, scintigraphy has poor anatomical resolution (2).

In recent times, new methods have been developed to overcome the existing limitations of conventional methods, magnetic resonance urography (MRU) is one of the most attractive. MRU is a method that promises early diagnosis and has an impact on therapeutic procedures in congenital malformations and other urogenital anomalies in children. This diagnostic method provides detailed visualization of the various morphological abnormalities of the genitourinary system and is not based on the principles of ionizing radiation. Avoiding ionizing radiation is one of the most important diagnostic approaches in child-

hood. (12-15). After switching off VUR, with VCUG / UMCG magnetic urography gives us a complete insight into the kidney and urinary morphology, with excellent spatial resolution. It can give us reliable answers about the existence of a cystocele, a duplicated duct system, can assess corticomedular differentiation, assess the degree of hydronephrosis / ureterohydronephrosis, and determine the site of obstruction.

According to diagnostic entities, the most common diagnosis was UPJ stenosis, in over half of cases (30 or 57%). DRS is a routine procedure in the assessment and monitoring of CH in obstructive uropathy. At the end of twenty years, great efforts have been made in the standardization of procedures. Tubular radioisotope Tc-99m MAG-3 takes precedence over the glomerular radioisotope Tc.99m DTPA due to a higher rate of renal excretion and rapid plasma klierance, which is particularly significant in neonates and children, and in patients with impaired renal function (16). An estimate of renal excretion with DRS is less reliable in estimating renal obstruction than determining the relative renal function (16). The unstructured system is easily assessed by spot flushing of radiopharmaceuticals, while the growing curve is highly susceptible to obstruction. Simple parameters such as Time to Peak (TTP) (<3min) and the half-life of radiopharmaceutical rinsing are used to quantify the response.

Other quantitative parameters are used in assessing the drainage relative to the renal function (efficacy of the outcome, pelvic excretion efficiency, parenchymal transit time, normalized residual activity) can be used in evaluating the response to the applied radiopharmacy. The literature states that none of the parameters allows the undeniable interpretation of diuretic renography in damaged kidneys (2, 10, 14). Therefore, in addition to assessing the diuretic response, the quantification of the renal function is even more important. Differential renal function represents the percentage contribution of each kidney to total sum of renal activity and is normally 45-55%. Differential renal function below 40%, or a decrease in differential renal function of> 5% on successive diuretic renal scintigraphy, is generally considered indicative of deterioration of renal function, possibly due to obstructive uropathy (17). MRU is an effective method for assessing dilated urinary tract. The technique offers high anatomical resolution and information on the renal function without the use of ionizing radiation.

In addition to magnetic urography in the assessment of CH, no single diagnostic method has been described so far, that it combines morphological and functional criteria in one method with no ionizing radiation (18, 19). Recent scientific research suggests that fMRU can estimate obstruction of the urotract that would require surgical treatment (20). A careful correlation of morphological and functional parameters is required. Although the design of CHOP-fMRU software enables a light analysis of functional parameters in the pediatric radiology departments, only a careful analysis of morphological and functional parameters can make the correct case judgment (20).

In our sample of 58 subjects with CH of different etiologies, we compared the relative renal function measured by dynamic renal scintigraphy and magnetic resonance urography. Statistical measurements have shown that there is a statistically significant correlation between these two methods, with a high degree of coincidence in estimating the relative renal function between the DRS and fMRU methods. Other clinical studies show similar results (20).

6. CONCLUSION

Magnetic resonance urography in the pediatric population in CH based on results should be an integral part of the management of these patients, especially in congenital obstructive uropathy, in complex and associated congenital anomalies, as it provides morphological and functional data on the state of the kidneys and urinary tract. A careful analysis is necessary in the evaluation of renal function based on several parameters and in correlation with morphological parameters.

- **Declaration of patient consent:** The authors certify that they have obtained all appropriate patient consent forms.
- **Author's contribution:** A.Dz., A.B. and D.P. gave substantial contribution to the conception or design of the work and in the acquisition, analysis and interpretation of data for the work. Each had role in drafting the work and revising it critically for important intellectual content. Eech author gave final approval of the version to be published and they agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- **Conflict of interest:** none declared.
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