Advantages of T2 Weighted Three Dimensional and T1 Weighted Three Dimensional Contrast Medium Enhanced Magnetic Resonance Urography in Examination of the Child Population

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ABSTRACT

Aim: The aim of this study is to prove the advantages of combined use of T2 weighted three dimensional (T2 W 3D) and T1 weighted three dimensional contrast medium enhanced (T1 W 3D CE) magnetic resonance (MR) urography in displaying urinary tract in child population. **Material and methods:** Total of 120 patients were included in the study, 71 (59%) male patients and 49 (41%) female patients. The study was conducted on the Radiology clinic, University of Sarajevo Clinical Center, during the period from February to November 2016. Patients were examined on the 1.5T and 3T MRI, with standard protocol which includes T2 W 3D and T1 W 3D contrast medium enhanced MR urography. In the post processing quantitative measurement of signal intensity and evaluation of the display quality in the area of renal pelvis, middle of ureter and the mouth of the ureter were done. Measurement was concluded on Syngo software B13. **Results:** Analyzing the acquired data and statistically processing them we got results which have shown higher signal intensity of measured structures on T1 W 3D contrast medium enhanced MR urography on the level $p < 0.01$ and $p < 0.05$ compared to T2 W 3D MR urography in patients that had normal dynamics of contrast medium secretion. However, in kidneys with decreased function, T2 W 3D MR urography provided higher signal intensity and better display compared to T1 W 3D contrast medium enhanced MR urography on the level $p < 0.05$ and $p < 0.01$. **Conclusion:** T2 W 3D MR urography is useful in imaging nonfunctional kidney as well as in patients prone to allergic reactions, where as T1 W 3D CE MR urography is at an advantage over T2 W 3D MR urography in imaging the kidney functionality, kidney dynamics measurement, it provides higher MRI signal intensity required for clear 3D reconstructions. **Keywords:** T2 weighted 3D MR urography, T1 weighted 3D MR urography, MR urography protocol, contrast medium enhanced MR urography.

1. INTRODUCTION

Urinary tract diseases in children are mostly congenital type diseases that present 20–30% of all anomalies (1). Defects can be bilateral, unilateral, but more different disorders can coexist in one patient, as well.

Until now conventional urography was the basic diagnostic technique for evaluation of urinary tract condition. However, because of the patient exposure to ionizing radiation, the possibility of occurrence of reactions to contrast medium (vasovagal and anaphylactic), neurotoxicity, nephrotoxicity, this technique is not completely safe. On grounds of this the alternative methods were developed, such as magnetic resonance imaging (MRI). In the recent years the development of new hardware and software in MRI system has enabled the expansion of the quality

image similar to the computerized tomography equipment (2).

MR urography enables overall evaluation of the urinary tract by one examination where ionizing radiation is not used and it presents the next step in the development of uro-radiology in children.

MR urography combines inner high spatial and contrast resolution with fast temporal resolution as an addition to anatomic cross section of high resolution of whole urinary tract with functional information on kidney concentration and excretion.

By dynamic scanning after the contrast medium application, signal changes related to perfusion, concentration and excretion of contrast medium can be evaluated, especially in the area of renal cortex and medulla. The urinary tract anatomy is evaluated by

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using T2 sequences and postcontrast T1 sequences. Anatomic and functional information acquired in MR urography provide the insight into pathophysiology of urinary tract diseases.

For the last 10 years MR urography (MRU) has been used as a complementary method for the evaluation of urinary tract canal system. In that period T2 weighted measurements were used (3). Intravenous contrast enhanced MR urography technique based on T1 measurement was recently added to T2 weighted measurement. These two methods are being used as they complement each other, as the result of this technique development MR urography has started to be applied not only in adult patients, but in children with different indications, too (4).

The most frequent indication for MR urography is the evaluation of hydronephrosis, especially in infants and small children. It is difficult to describe the obstruction clinically, and that is usually done in two ways: either it is the issue of urinary tract discharge restriction that when it is not treated results in progressive kidney function failure, or as a condition that endangers normal development of urinary tract. Obstructive uropathy is referred to urine outlet obstruction from the kidneys into the urinary bladder that leads to the kidney defect (5). In children the result of this is usually chronic partial obstruction, generally related to stenosis of pyeloureteric neck or because of obstructive hydromegaureter. The consequences of the obstruction do not depend only on the degree of obstruction, but also occur secondarily as a complex syndrome with the defect of hemodynamic glomerular and tubular function caused by interaction of number of vasoactive factors and cytokins (6, 7). Adequate immobilization of the child and fast sequences enable the acquisition of high quality images (8).

The aim of this study is to prove the significance of the combined use of T2 weighted three dimensional (T2W 3D) and T1 weighted three dimensional (T1 W 3D) contrast medium enhanced MR urography in displaying urinary tract canal system in children when there is suspicion of decreased kidney function.

2. METHOD

The study was conducted in the Radiology clinic of University Clinical Center of Sarajevo, during the period from February to November 2016. 120 patients of both gender and different age structure were included in the study.

Every patient underwent MR urography with standard protocol on our clinic. The examinations were conducted on 1.5 T „Avanto“ and 3 T „Trio“, Siemens, Erlangen, Germany. Before the examination the patient parents gave their written agreement to consent to the examination and the contrast medium application, noncooperative patients were examined with the help of anesthesiology team under general anesthesia, all the patients underwent the preparation for the examination that consisted in applying Ringer lactat 10ml/kg, for the purpose of hydrating the patient. Patient is positioned into the supine position,

head towards the gantry. During the scanning two standard coils “body matrix” were used. Apart from standard scanning protocol for the display of urinary tract contrast enhanced T2 W 3D and T1 W 3D contrast medium enhanced sequences were conducted in coronal plane from which 3 D reconstructions were done. Two minutes before the beginning of dynamic sequence diuretic Furosemid is applied in a ratio 1 mg/kg, max. 20 mg, and at the beginning of the sequence paramagnetic contrast medium gadoteric acid is given (Dotarem) in a ratio 1 mmol/kg, during the dynamic scanning its secretion is being followed. When the desired opacification by contrast medium was acquired, gadolinium enhanced T1 W 3D sequence is conducted, after which follows the 3D maximal intensity projection (MIP) reconstruction for the purpose of better display of urinary tract canal system. After the examination was finished visual evaluation of acquired images and signal intensity measurement on acquired images were conducted, in axial reconstructive plane in T2 W 3D MR urography and T1W3D contrast medium enhanced MR urography in three areas: (area of renal pelvis, the middle of ureter, mouth of the ureter area). Signal intensity measurement was done on the right and left kidney excretory system with the help of software 3D option on satellite stations of MRI device, on software syngo b13, where by measuring region of interest the size of max. 5 pixels, the results were acquired in the form of MRI number. Higher MRI number provides higher signal intensity.

Statistical analysis

Descriptive retrospective analysis was used and that includes: percentual representation, Pearson nonparametric correlation, SD and arithmetic mean. The data were processed in statistical software SPSS ver.20.0.

3. RESULTS

On total of 120 pediatric patients were included in the study, 71 (59%) male patients and 49 (41%) female patients. According to age structure there were: 66 patients (55%) from 0 to 3 years, 22 patients (18%) from 4 to 7 years, 6 patients (5%) from 8 to 11 years, 26 patients (21%) from 12 to 17 years. Of the 120 patients included in the study 2 patients or 1.67 % didn't have the left kidney, and 3 patients or 2.5% were without the right kidney. In 6 patients (5%) the examination was stopped. In 2 patients it was not possible to show canal system by T1 W3D contrast medium enhanced MR urography (there was not any contrast in the system), and canal system of nonfunctional kidney was shown only by T2 W 3DMR urography. Measuring signal intensity on T1W3D

	Renal pelvis t1 w 3d	Renal pelvis t2 w 3d	The middle part t1w 3d	The middle part t2w 3d	Mouth of ureter t1w 3d	Mouth of ureter t2w 3d
Renal pelvis t1w 3d	1	.175	.791**	.166	.717**	.190*
Renal pelvis t2w 3d	.175	1	.082	.517**	.161	.553**
Middle t1w 3d	.791**	.082	1	.223*	.870**	.233*
Middle t2w 3d	.166	.517**	.223*	1	.166	.879**
Mouth of ureter t1w 3d	.717**	.161	.870**	.166	1	.225*
Mouth of ureter t2w 3d	.190*	.553**	.233*	.879**	.225*	1

Table 1. Display of the correlation between T1 W 3D contrast medium enhanced MR urography and T2 W 3D MR urography for left kidney and ureter *Correlations significant on the level $p < 0.01$ **Correlations significant on the level $p < 0.05$

	Renal pelvis t1 w 3d	Renal pelvis t2 w 3d	The middle part t1w 3d	The middle part t2w 3d	Mouth of ureter t1w3d	Mouth of ureter t2w 3d
Renal pelvis t1w 3d	1	.241*	.721**	.143	.652**	.178
Renal pelvis t2w 3d	.241*	1	.302**	.485**	.379**	.460**
Middle t1w 3d	.721**	.302**	1	.306**	.766**	.330**
Middle t2w 3d	.143	.485**	.306**	1	.212*	.830**
Mouth of ureter t1w 3d	.652**	.379**	.766**	.212*	1	.321**
mouth of ureter t2w 3d	.178	.460**	.330**	.830**	.321**	1

Table 2. Display of the correlation between T1W 3D contrastenhanced MR urography and T2 W 3D MR urography for the right kidney and ureter. *Correlation significant on the level 0.01 **Correlation significant on the level 0.05

contrast medium enhanced MR urography in the area of renal pelvis, the middle part of ureter and the area of the mouth of the ureter in functional kidneys statistically significant difference was acquired on the level $p < 0.01$ and $p < 0.05$ compared to measured signal intensity of the same area on T2 W native sequence.

By Pearson coefficient of signal intensity correlation of left and right kidney excretory system it was determined that there is statistically significant difference on the level $p < 0.01$ and $p < 0.05$ between the images done by T1 W 3D contrast medium enhanced MR urography and images done by T2 W 3D MR urography (Table 1).

4. DISCUSSION

By Pearson correlation coefficient of signal intensity it was established that there is statistically significant difference on the level $p < 0.01$ and $p < 0.05$ between the images done by T1 method and images done by T2 method. Higher signal intensity was measured on the acquired MRI images of T1W contrast enhanced MR urography compared to T2 W 3D MR urography. Owing to high signal intensity better and clearer 3D reconstructive layers were acquired (Figure 1).

Quantitative information that MR imaging provides is

Figure 1. T2 w and T1 w MR urography reconstructed maximum intensity projection datasets

Figure 2. T2 W and T1 W of non functional canal system (Right urinary tract)

mostly information on kidney perfusion, excretion speed and drainage, it is acquired in post-processing analysis and can be compared to information that dynamic scintigraphy provides. However, one of the most important benefits of this practice is the acquirement of the images with higher contrast, higher spatial and temporal resolution in any orthogonal plane compared to conventional imaging techniques (9). Acquired clear 3D data sets that are acquired can be really helpful to surgeons because they provide morphologic appearance of urinary tract condition. In

their study Cerwinka and associates state that MR urography is mostly used for the evaluation of hydronephrosis and that it provides valuable insight into the wide range of obstructive uropathy (3).

In 2 patients it was not possible to show canal system by T1 W 3D MR urography (there was not any contrast in the system), canal system of non functional kidney was shown only by T2 W 3D MR urography (Figure 2).

Owing to the presence of fluid in ureters as a natural contrast medium, similar to magnetic resonance cholangiopancreatography (MRCP) T2 W 3D MR urography has shown morphological appearance of kidney excretory system and ureter. In their study Leyedeker and associates describe that static MR urography is independent on renal excretory function, therefore it has been used in patients with nonfunctional kidneys (10).

In their study Maria Karaveli and associates state that excretory MR urography that uses T1 sequences is the most helpful in the reproduction of quantitative results, because it provides information on kidney system function, as well as its anatomy (11).

Common indications for pediatric MR urography include the evaluation of the complex anatomy of the kidneys and urinary tract, suspect high or low obstructions of urinary tract, evaluation of the operative and postoperative treatment (12).

5. CONCLUSION

T2 W 3D MR urography is a useful method in displaying the nonfunctional kidneys and in patients prone to allergic reactions, as well as in new born babies where there is extensive dilatation of canal system. Considering their early maternal age application of paramagnetic contrast medium is not recommended, thus this sequence enables anatomic display of urinary system, but without the information on kidney function.

T1 W 3D MR urography is superior, considering it provides morphological and dynamical information. It has advantages over T2 W 3D MR urography in display of kidney functionality, it provides higher MRI signal intensity necessary for clear 3D reconstructions. Since this is dynamic scanning, sequences are being repeated until the optimal display of urinary tract is acquired.

These two methods complement each other in examination of urinary system in child population.

• Conflict of interest: none declared.

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