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Diuretic ^{99m}Tc DTPA renography in assessment of renal function and drainage in infants with antenatally detected hydronephrosis

Značaj diurezne ^{99m}Tc DTPA scintigrafije u proceni renalne funkcije i drenaže kod dece sa prenatalno otkrivenom hidronefrozom

Marija Radulović*, Dragan Pucar*, Ljiljana Jauković*†, Marija Šišić*, Zoran Krstić‡, Boris Ajdinović*†

***Institute of Nuclear Medicine, Military Medical Academy, Belgrade, Serbia; †Faculty of Medicine of the Military Medical Academy, University of Defence, Belgrade, Serbia; ‡University Children's Clinic, Belgrade, Serbia**

Abstract

Background/Aim. The controversy over the postnatal management of infants with antenataly detected hydronephrosis (ANH) still exists. We presented the results of diuretic ^{99m}Tc diethylenetriamine pentaacetic acid (DTPA) renography in 30 infants with the antenatal diagnosis of unilateral renal pelvic dilatation. The aim of this study was to assess the renal function determined by the pattern of drainage and split renal function (SRF) on diuretic renography and to correlate these findings with anteroposterior pelvic diameter (APD) estimated by ultrasonography. **Methods.** A total of 30 infants with 60 renal units (RU) (25 boys and 5 girls, median age 6.0 months, range 2–24) presented with unilateral hydronephrosis on ultrasound in the newborn period, underwent DTPA diuretic renal scintigraphy (F+15 protocol). The median APD evaluated on perinatal ultrasound was 15 mm (range 5–30). The postnatal associated clinical diagnosis were pelviureteric junction obstruction (PUJ), simple hydronephrosis, megaureter, vesicoureteral reflux (VUR) and posterior urethral valves in 11, 10, 6, 2 and 1 infant, respectively. Images and Tmax/2 after diuretic stimulation on the background subtracted renographic curves were used as the criteria for classifying the drainage as good, partial, and poor or no drainage. The SRF was calculated with the integral method. **Results.** Good drainage was shown in 36/60, partial drainage in 13/60 and poor or no drainage in 11/60 RU. The SRF > 40% was observed in 55/60 RU, with no RU showing SRF lower than 23.5%. In infants with severe ANH the obstruction was not excluded in 94.1%. **Conclusion.** Diuretic renography in antenatally detected hydronephrosis should be a useful tool in postnatal follow up, especially in differentiating nonobstructive hydronephrosis from obstructive. It is also importanat to assess and monitor the SRF. Our results suggest that even in the presence of partial or no drainage, SRF may not be significantly impaired.

Key words:
infant; hydronephrosis; prenatal diagnosis; radioistope renography.

Apstrakt

Uvod/Cilj. Još uvek postoje kontroverze o načinu postnatalnog praćenja dece sa prenatalno dijagnostikovanom hidronefrozom. U ovom radu prikazali smo rezultate diurezne ^{99m}Tc *diethylenetriamine pentaacetic acid* (DTPA) scintigrafije bubrega kod 30-oro dece sa antenatalnom dijagnozom dilatacije bubrežne karlice. Cilj ove studije bio je procena renalne funkcije na osnovu stepena pražnjenja bubrega nakon diuretske stimulacije i separatnog klirensa, kao i korelacija ovih nalaza sa anterioroposteriornim prečnikom (*anterioposterior pelvic diameter* – APD) bubrežne karlice dobijenog ultrazvukom. **Metode.** Diurezna DTPA scintigrafija bubrega (F+15 protokol) urađena je kod 30-oro dece (25 dečaka i 5 devojčica, uzrasta 2–24 meseca, medijana 6 meseci) sa 60 renalnih jedinica (RU) kod kojih je perinatalno ultrazvučno utvrđena hidronefroza lakog do teškog stepena. Medijana APD iznosila je 15 mm (5–30 mm). Postnatalno udružene kliničke dijagnoze bile su opstrukcija pelviureteričnog spoja (PUJ) kod 11, hidronefroza kod 10, megaureter kod 6, vezikoureteralni refluks (VUR) kod 2 i zadnja valvula uretre kod jednog deteta. Na osnovu scintigrama i vrednosti Tmax/2 nakon diuretske stimulacije na renografskim krivuljama renalna drenaža je klasifikovana kao dobra, parcijalna i loša ili odsutna. Separatni klirens je računat metodom integrala. **Rezultati.** Dobra renalna drenaža dobijena je kod 36/60 RU, parcijalna kod 13/60 RU i loša ili odsutna kod 11/60 RU. Separatni klirens > 40% dobijen je kod 55/60 RU, dok

Correspondence to: Marija Radulović, Institute of Nuclear Medicine, Military Medical Academy, Crnotravska 17, 11 040 Belgrade, Serbia. Phone: +381 11 3608 625. E-mail: mradulovic.79@gmail.com

ni kod jedne RU separatni klirens nije bio manji od 23,5%. Opstrukcija se nije mogla isključiti kod 94,1% dece sa teškom hidronefrozom. **Zaključak.** Diurezna scintigrafija bubrega preporučuje se kao korisna metoda u postnatalnom praćenju i terapijskom odlučivanju kod dece sa prenatalno dijagnostikovanom hidronefrozom, posebno u izdvajanju neopstruktivne hidronefroze od opstruktivne. Takođe, važna je procena i praćenje vrednosti separatnog klirensa. Naši rezultati ukazuju da čak i kod parcijalne ili odsutne renalne drenaže, separatni klirens ne mora biti značajno smanjen.

Ključne reči:
novorođenče; hidronefroza dijagnostika, prenatalna; renografija, radioizotopska.

Introduction

The widespread ultrasound screening during pregnancy has resulted in increasing recognition of antenatal hydronephrosis (ANH). Depending on the diagnostic criteria and gestation, the prevalence of antenatally detected ANH ranges from 0.6% to 5.4% [1–3]. The causes of ANH vary from transient benign conditions – transit hydronephrosis, which resolves by birth or during infancy to conditions that can significantly affect renal function. The outcome of ANH depends on the underlying etiology, so it is very important to determine these causes [4]. The definition and grading of ANH is based on anteroposterior pelvic diameter (APD) of the fetal renal pelvis [5]. It is an objective parameter, although it varies with gestation, maternal hydration and bladder distension. ANH is present if the APD is ≥ 4 mm in the second trimester and ≥ 7 mm in the third trimester [4]. ANH is further graded as mild, moderate and severe depending on the size of the measured APD. While fetuses with minimal pelvic dilatation (5–9 mm) have low risk of postnatal pathology, the APD ≥ 15 mm at any gestation represents severe hydronephrosis and requires close follow-up [6–9]. Antenatal management includes antenatal ultrasound monitoring, which is usually repeated every 4–6 weeks, but its frequency depends on the gestation at which ANH was detected, as well as its severity and the presence of oligohydramnios [5].

Almost 80% of the fetuses diagnosed in the second trimester show resolution or improvement of findings with the low likelihood of postnatal pathology [10]. Patients with persistence or worsening hydronephrosis in the third trimester show higher rates of postnatal pathology and require more frequent monitoring. Also, more frequent monitoring is required for fetuses with findings that suggest lower urinary tract obstruction. It is recommended that additional prenatal ultrasound evaluation is done at 16–20 weeks pregnancy in fetuses with the ANH detected [5]. It includes evaluation of lower urinary tract obstruction, renal dysplasia and extrarenal structural malformations. The controversy about the postnatal management of infants with the ANH still exists. It is emphasized that an ultrasound in the first few days of life underestimates the degree of pelvic dilatation due to dehydration and a relatively low urine output. Despite this limitation, an early ultrasound, 24–48 hour after birth, is necessary in the neonates with suspected lower urinary tract obstruction, oligohydramnios and bilateral severe hydronephrosis or severe hydronephrosis in a solitary kidney [4]. In others, the first ultrasound examination should ideally be delayed until the end of the first week. An ultrasound at 6 weeks is more sensitive and specific for obstruction. The presence of the two normal postnatal renal ultrasounds excludes the presence of the significant renal disease including dilating vesicoureteral reflux (VUR) [11]. It is recommended that the assessment of the severity of postnatal hydronephrosis is based on the anteroposterior diameter of the renal pelvis. The diuretic renal scintigraphy is important in postnatal evaluation of these infants, particularly in distinguishing kidney with the poor drainage from the nonobstructive hydronephrosis with the good drainage.

The aim of this study was to assess the renal function determined by the pattern of drainage and split renal function (SRF) on diuretic renography and to correlate these findings with the APD estimated by ultrasonography.

Methods

A total of 30 infants with 60 renal units (RU) (25 boys and 5 girls, median age 6.0 months, range 2–24) presented with unilateral mild to severe hydronephrosis on ultrasound in newborn period underwent diethylentriaminepentaacetic acid (DTPA) diuretic renal scintigraphy (F+15 protocol). The postnatal associated clinical diagnosis were pelviureteric junction (PUJ) obstruction, simple hydronephrosis, megaureter, VUR and posterior urethraL valves in 11, 10, 6, 2 and 1 infant, respectively. The median anteroposterior pelvic diameter evaluated on perinatal ultrasound was 15 mm (range 5–30). In 32/60 RU APD was ≥ 5 mm, while in 28/60 RU APD was < 5 mm. The diuretic renal scintigraphy was performed during 30 minutes (60 frames, 30 seconds each, matrix size 128 × 128) after *iv* injection of ^{99m}technetium labeled DTPA using the dose of 1.8 Mbq/kg in posterior projection. The single-head "Orbiter-Siemens" gamma camera filtered with low energy all-purpose collimator and with the Pegasys computer was used. To asses renal drainage 15 minutes after starting the study, 0.50 mg/kg furosemide *iv* was injected. Images and Tmax/2 after diuretic stimulation on the background subtracted renographic curves were used as the criteria for classifying the drainage as good (Tmax/2 < 10 min), partial (Tmax/2 from 10 min–20 min) and poor or no drainage (Tmax/2 > 20 min). The SRF was calculated with the integral method, and the range of 45–55% was considered as normal finding. We used statistical program SPSS version 20 for analyzing the descriptive statistic of our findings.

Results

We classified hydronephrosis into three groups according to ultrasound measurement of the renal pelvis diameter: mild (APD 5–9.9 mm) in 5/60 RU, moderate (APD 10–14.9 mm) in 10/60 RU and severe (APD ≥ 15 mm) in 17/60 RU.

Good or almost good drainage was shown in 36/60, partial drainage in 13/60 and poor or no drainage in 11/60 RU. SRF > 40% was observed in 55/60 RU, with no RU showing SRF lower than 23.5% (Figure 1). Significant obstruction was excluded in 39/60 RU (Figure 2). In infants with severe ANH obstruction was not excluded in 94.1%. We considered the correlation between the pattern of the drainage and the magnitude of SRF (Figures 3 and 4), as well as the correlation between the APD and the grading of SRF (Table 1).

Discussion

In our study the most frequent cause for ANH detected by prenatally ultrasound was PUJ obstruction in 33% of in-

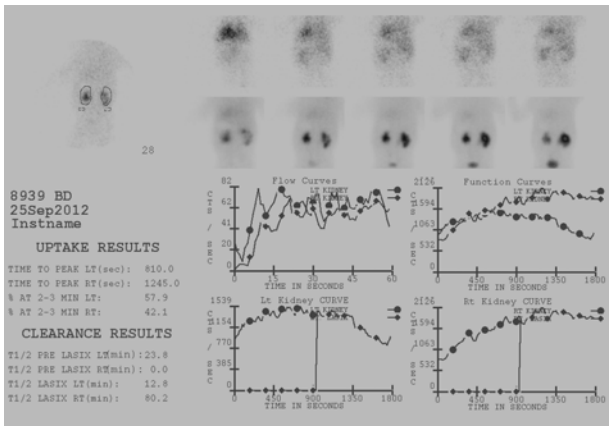

Fig. 1 – Diuretic renal scintigraphy 20MBq ^{99m}Tc diethylenetriamine pentaacetic acid (DTPA) in a 6 month-old infant: Unilateral right hydroneprhosis was diagnosted prenataly by ultrasound; slowing in drainage on the left side and almost no drainage on the right side, without diuretic response; relative function of the right kidney is not significantly impaired [split renal function (SRF) 42.1%].

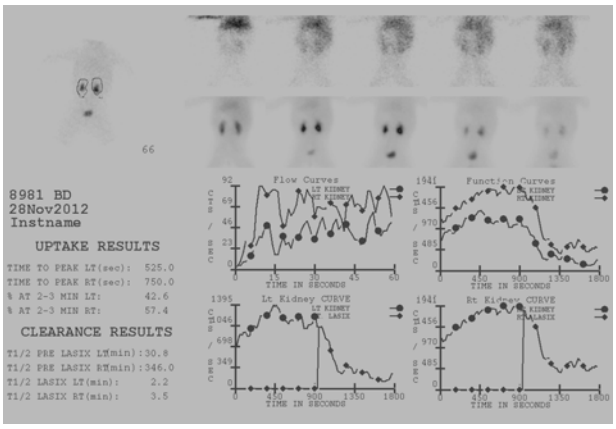

Fig. 2 – Diuretic renal scintigraphy 20 MBq ^{99m}Tc diethylenetriamine pentaacetic acid (DTPA) in a 4-month-old infant: rapid drainage on both sides after diuretic stimulation – significant obstruction is excluded; no signs of vesicoureteral reflux (VUR) were detected by micturating cystoureterogram (MCUG).

Fig. 3 – Magnitude of split renal function (SRF) in different patterns of drainage on the right side.

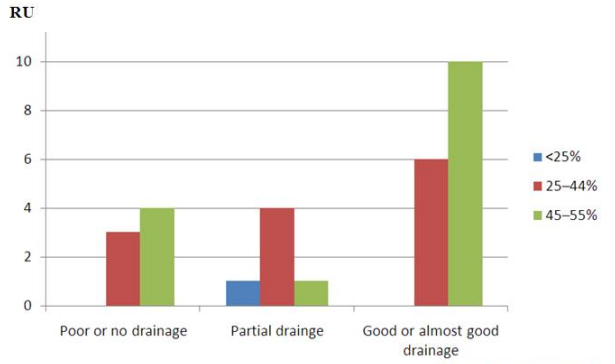

Fig. 4 – Magnitude of split renal function (SRF) in different patterns of drainage on the left side.

Table 1

Split renal function (SRF) grading according to anteroposterior (AP) pelvic diameter

AP pelvic diameter	SRF grading (%)			Total
	≤ 30	30–44	≥ 45	n (%)
Mild, n (%)	0 (0.0)	0 (0.0)	5 (100.0)	5 (100.0)
Moderate, n (%)	0 (0.0)	2 (20.0)	8 (80.0)	10 (100.0)
Severe, n (%)	3 (17.6)	4 (23.5)	10 (58.8)	17 (100.0)
Total, n (%)	3 (9.4)	6 (18.8)	23 (71.9)	32 (100.0)

n – number of renal units.

fants. According to our findings the risk of postnatal pathology strongly correlated with the magnitude of the fetal APD. We considered the pathological finding of the obstruction which could not be excluded if we found the curve that rises continuously over 20 minutes or appears as a plateau, despite the furosemide and post micturition. Our findigs show that the risk of detecting obstruction for severe hydronephrosis was 94.1%. In line with our study in one meta-analysis on 1,308 neonates from 17 studies, Lee et al. [6] found that the risk of postnatal pathology increased with the degree of antenatal pelvic dilatation, from 11.9% for mild, 45.1% for moderate and 88.3% for severe hydronephrosis.

There is no worldwide consensus on the exact timing of renography in the postnatal period. The European Society of Pediatric Radiology recommends two ultrasounds scans three months apart before obtaining renal scintigraphy, whereas in the United States a single ultrasound scan is deemed sufficient [12]. Our patients, at the time of diuretic renography had at least one postnatal ultrasound scan. The latest recommendations suggest indications and the exact timing for the procedure of diuretic renal scintigraphy. Sinha et al. [5] recommend that infants with moderate to severe hydronephrosis (APD > 10 mm), or mild hydronephrosis with ureteric dilatation and no evidence of VUR, undergo diuretic renography. Since immaturity of the renal function results in reduced radiotracer uptake, these authors suggest that renography should be done at 6–8 weeks of life, but may be performed earlier in patients with severe hydronephrosis and cortical thinning, and the procedure may be repeated after 3–6 months in infants where ultrasound shows worsening of pelvicalyceal dilatation. We suggest that the timing of the repeated procedure is not definite and that it varies with the patient's age, initial renal function and the persistence or worsening of ultrasonographic findings.

Diuretic renography allows detection non obstructive hydronephrosis, and estimating SRF. Initial SRF below 35–40% in the kidney with poor drainage signifies impaired function [13].

Our results suggest that even in the presence of partial, poor or no drainage, SRF may not be significantly impaired. Possible explanation for this finding is the delayed elimination of radiotracer. Our results confirm the conclusion of Moon et al. [14] study that other features, including ipsilateral supranormal SRF (≥ 55%) and prolonged time to clear 50% of radionuclide (Tmax/2 >20 minutes) [15,] can indicate obstruction. On the other hand, our study confirms a strong correlation between the APD and grading SRF.

In the absence of prospective controlled studies, there is a variability in practice regarding the use of antibiotics in children with moderate to severe obstructive hydronephrosis. The rates of urinary tract infections (UTI) in patients with severe obstructive hydronephrosis due to PUJ obstruction or megaureter varied from 0–4.3% to 19–36.2% in different studies [16, 17]. Coelho et al. [18] report that infants with the postnatal renal pelvic APD of 10 mm or more have significantly greater risk of UTI (relative risk 2.6, 95% confidence interval 1.2–5.8) comparing to those with mild hydronephrosis. We suggest that infants with the postnatally confirmed moderate or severe hydronephrosis (APD >10 mm) or dilated ureter should receive antibiotic prophylaxis, as well as all the patients detected to have VUR while awaiting evaluation.

Infants with lower urinary tract obstruction are immediately referred to the surgeon, while surgery is considered also in those with bilateral hydronephrosis or with solitary kidney showing worsening dilatation and deterioration of function [5]. While most experts suggest that pyeloplasty should be considered in patients showing poor drainage and differential function below 40% [19], others propose surgery at differential function below 35% [20], or obstructed renogram with prolonged Tmax/2 > 20 minutes [21]. Other indications for surgery include the presence of pain, palpable renal lump or recurrent febrile UTI [22]. The presence of large APD exceeding 20–30 mm predicts the need for surgery in 50–55% patients [19]. We emphasize the importance of monitoring the magnitude of SRF, because the decrease of SRF indicates deterioration and possible need for surgical correction in order to prevent significant damage of renal function.

Conclusion

Although ANH is mostly benign condition and has favorable outcome, it can also cause a significant morbidity. For this reason we want to stress the importance of prenatal ultrasound screening in pregnancy. The purpose of our study was to describe the clinical outcomes of infants with ANH and to contribute to the definition of postnatal evaluation of these patients. Based on our results and practice, we also want to emphasize the importance of diuretic renography, especially in distinguishing nonobstructive hydronephrosis from obstructive, and in the assessment and monitoring of SRF. Our results suggest that even in the presence of partial or no drainage, the SRF may not be significantly impaired.

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