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The role of ultrasonography in the assessment of congenital hydronephrosis

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Abstract

Anomalies of the reno-urinary tract are very frequent in pediatrics. The pelviureteric junction obstruction is the most frequent of the obstructive anomalies of the urinary tract. The aim of this study was to determine the ultrasonographic evolution of the pelvic dilatations and of the renal parenchyma thickness in patients with congenital hydronephrosis who underwent either surgery or conservative treatment. **Methodology**. The study group consisted of 36 patients with hydronephrosis. The including criteria was the presence of IInd-IVth degree unilateral congenital hydronephrosis. Excluding criteria were represented by bilateral severe hydronephrosis, unique kidney, vesico-ureteric reflux and other associated ureteral anomalies. All patients were examined through reno-urinary ultrasonography, voiding urethrocystography and diuretic renal scintigraphy. Reno-urinary ultrasonography determined the following parameters: the anterior-posterior diameter of the renal pelvis and the thickness of the renal parenchyma. **Results**. In 13 patients a conservative approach was adopted and the other 23 patients underwent pyeloplasty. Pyeloplasty was performed during infancy in 6 patients, between the ages of 2 and 3 in another 6 patients and in 11 patients after the age of 3. 11 out 13 of the patients who were treated conservatively had a favorable evolution. Pyeloplasty before the age of 3 also had a favorable outcome, but no significant improvement of the renal parenchyma thickness was seen in patients who underwent surgery after the age of 3 (p=0,40). As a complication we mention one of the 23 pyeloplsties that were unsuccessful. In **conclusion**, the authors show a decrease of the pelvic dilatation after pyeloplasty in all age groups. An improvement of renal parenchyma thickness was observed in patients who underwent surgery before the age of three.

Key words: congenital hydronephrosis, ultrasonography, pyeloplasty

Rezumat

Anomaliile tractului urinar sunt foarte frecvente în pediatrie. Obstrucţia joncţiunii pielo-ureterale este cea mai frecventă anomalie obstructivă a tractului urinar. Obiectivul acestui studiu a fost determinarea ultrasonografică a evoluţoei dilatării pelvisului şi evoluţiei grosimii parenchimului renal la pacienţii cu hidronefroză congenitală care au fost trataţi chirurgical sau la care s-a adoptat management conservativ. **Metodologie**. Lotul de studiu a inclus 36 pacienţi cu hidronefroză. Criteriul de includere în studiu a fost hidronefroza congenitală unilaterală grad II-IV. Criteriile de excludere au fost reprezentate de: hidronefroză severă bilaterală, rinichiul unic, refluxul vezico-uretral sau alte anomalii ureterale asociate. Investigaţiile imagistice efectuate au fost: ultrasonografia reno-urinară, uretrocistografia mictională şi scintigrafia renală diuretică. Ultrasonografia reno-urinară a vizat determinarea următorilor parametri: diametrul anteroposterior al pelvisului renal şi grosimea parenchimului renal. **Rezultate**. La 13 pacienţi a fost adoptat managementul conservativ, restul de 23 pacienţi au beneficiat de pieloplastie. Pieloplastia s-a efectuat la vârsta de sugar la 6 pacienţi; la 6 pacienţi pieloplastia s-a efectuat între vârsta de 2 si 3 ani, iar la 11 pacienţi la vârsta de peste 3 ani. Evoluţia a fost favorabilă la 11 din cei 13 pacienţi la care nu s-a efectuat pieloplastie. La pacienţii la care pieloplastia s-a efectuat sub vârsta de 3 ani s-a evidenţiat în majoritatea cazurilor o evoluţie favorabilă. La pacienţii la care pieloplastia s-a efectuat după vârsta de 3 ani s-a semnalat o reducere semnificativă a dilatării pelvisului (p=0,0016), fără a se constata o imbunătăţire semnificativă a grosimii parenchimului renal (p = 0,40). Dintre complicaţiile apărute la lotul de studiu semnalăm insuccesul unei din cele 23 de pieloplastii efectuate. **În concluzie**, autorii au demonstrat scăderea dilatării pelvisului după pieloplastie la toate grupele de vârsta. Îmbunătăţirea parenchimului renal s-a semnalat doar la pacienţii care au beneficiat de pieloplastie înaintea vârstei de trei ani.

Cuvinte cheie: hidronefroză congenitală, ultrasonografie, pieloplastie.

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Introduction

Anomalies of the reno-urinary tract are very frequent in pediatrics, representing 20-30% of all prenatal discovered anomalies [1]. Often their diagnosis is only possible

through imaging as they are asymptomatic. The importance of reno-urinary anomalies resides in the fact that they can represent the cause of severe conditions such as chronic renal failure [2,3], renal hypertension, recurrent urinary tract infection, urinary incontinence. Of all prenatal diagnosed reno-urinary anomalies, the pelviureteric junction obstruction and the vesico-ureteric reflux are the most frequently encountered in current practice [4]. The pelviureteric junction obstruction is the most frequent of the obstructive anomalies of the urinary tract

Establishing adequate therapy is extremely important in congenital hydronephrosis caused by anomalies of the pelviureteric junction. Surgical therapy has been used less and less in pediatric urology in the last years and only in adequately monitored and selected cases. This approach was adopted because it was observed that many of these conditions may have a naturally favorable evolution. An intense monitoring of these patients is required to properly appreciate the evolution of congenital hydronephrosis in order to identify the optimal timing of the surgical intervention.

The ideal imaging investigation used for monitoring renal collecting system dilatations and renal parenchyma thickness must be non-invasive. Renal ultrasonography is the imaging technique of election for intense monitoring as it can be repeated as often as necessary. Appreciation of the dilated urinary tract can be performed in the B-mode by determining pelvic and calices measurements at different levels. The three dimensional ultrasonographic technique that has developed lately allows for better evaluation of the urinary collecting system volumes and of the renal parenchyma [5].

There are many studies in the specialized literature that classify the hydronephrosis determined by pelviureteric junction obstruction. We mention the Fernbach classification [6] published in 1993 which defines 4 grades of hydronephrosis. Other studies classify hydronephrosis by the dimensions of the renal pelvis, the anterior-posterior diameter being the most frequently used parameter [7, 8].

The aim of this study was to determine the ultrasonographic evolution of the pelvic dilatations and of the renal parenchyma thickness in patients with congenital hydronephrosis who underwent either surgery or conservative treatment.

Methodology

The study group consisted of 36 patients with hydronephrosis. The including criteria was the presence of IInd- IVth degree unilateral congenital hydronephrosis. Excluding criteria were represented by bilateral severe hydronephrosis, unique kidney, vesico-ureteric reflux and other associated ureteral anomalies (primary megaureter).

All patients in the study group were examined through reno-urinary ultrasonography, voiding urethrocystography and diuretic renal scintigraphy.

Reno-urinary ultrasonography determined the following parameters: the anterior-posterior diameter of the renal pelvis and the thickness of the renal parenchyma. The ultrasonographic measurements were taken with the patient in lateral decubitus both a jeun and at 45-60 minutes after hydration. The degree of vesical filling was also appreciated. Initially, the kidney was evaluated in a coronal section from the flank for a qualitative evaluation of the pelvic and caliceal dilatations (fig 1), according to the classification recommended by Fernebach [6].

The classification of hydronephrosis was developed by The Society of Fetal Urology [6]: grade 0 – intact central renal complex (renal pelvis); grade I – mild splitting of central renal complex; grade II – pelvic dilatation, without dilatation of calyces; grade III – a markedly split pelvis with uniformly dilated calyces, but normal renal parenchyma; grade IV v characteristics of grade III with thinning of renal parenchyma (fig 2).

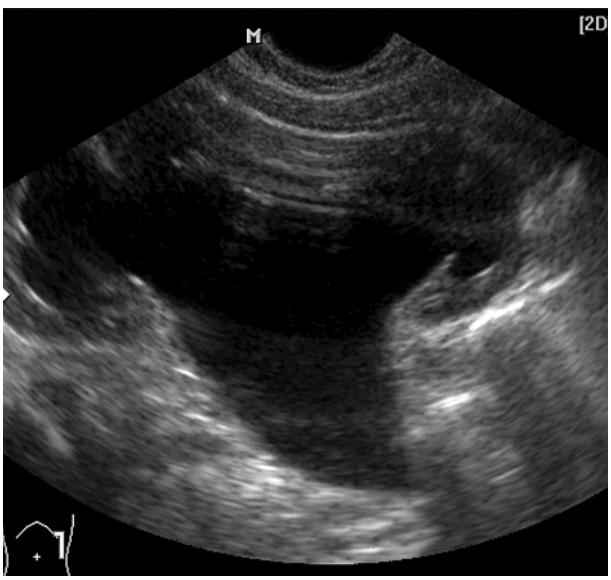


Fig 1. Longitudinal section on the left kidney – IIIrd grade hydronephrosis in an infant with ureteropelvic junction obstruction.

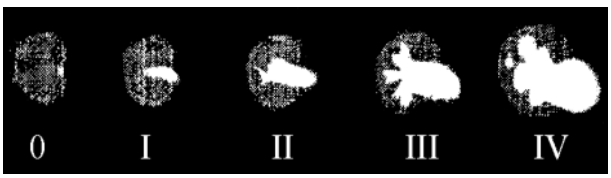


Fig 2. Hydronephrosis classification – adapted after Fernbach [6].

The longitudinal view was used to measure the renal parenchyma thickness at mid-kidney level. For the latter we followed the descent of a mid-kidney pyramid and measured the thickness of the parenchyma at the level of the calices, tangent to the renal pyramid, up to the renal capsule. The thickness of the renal parenchyma was taken in millimeters, compared to the thickness of contralateral parenchyma (normal) and then expressed in percents (example: 5 mm vs 11 mm – 50%). The long view examination was followed by a transverse view examination at the level of the renal hilum, obtained by rotating the transducer with 90°. On the transverse section we determined the anterior-posterior diameter of the renal pelvis before and after hydration of the patient (fig 3), also expressed in millimeters.

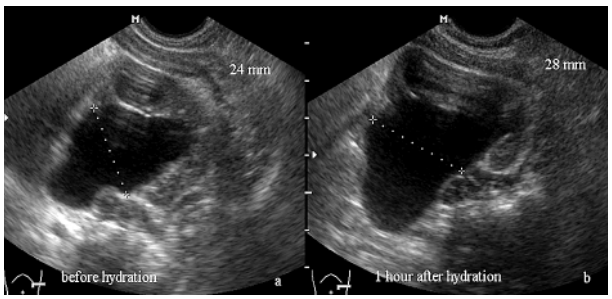


Fig 3 *a, b.* Transverse section at the level of the left kidney pelvis. Evaluation of the anterior-posterior pelvis diameter before and after hydration in infants from fig 1. There is an increase of the pelvis diameter after hydration.

Voiding cystourethrography was performed by introducing iodine based contrast media in the bladder (we used Ultravist diluted 1:1 with saline solution) through a 4 or 6 Fr catheter at low pressure. The filling of the bladder with contrast media was realized maximum 3 times. The presence of vesico-ureteric reflux at the first or second filling of the bladder allowed the termination of the procedure. If no reflux was found on the first two fillings of the bladder a third one was performed. If vesico-ureteric reflux was not detected during the third exam this pathology was excluded. Through the voiding urethrocystography the appearance of the bladder and urethra and the presence or absence of the vesico-ureteric reflux were evaluated. The patients who presented vesico-ureteric reflux were excluded from the study.

For the diuretic renal scintigraphy, the Tc 99m DTPA radionuclide was used and furosemide was administered as a diuretic (1-2 mg/kg). Furosemide was introduced after 20 minutes following the administration of the radionuclide. The scintigraphic examination evaluated the aspect of the evacuation curves before and after furosemide administration and the presence and the severity of the ureteropelvic junction obstruction. Differential renal function was also calculated.

Indication for pyeloplasty was established based on the following criteria: alteration of the renal function, progession of hydronephrosis, high degree hydronephrosis, sympthomatic hydronephrosis. Pyeloplasty was performed using the Hynes-Andersen method.

The anterior-posterior diameters of the renal pelvis were represented in a graph. The first value was measured at the first examination and the other values were taken during the follow-up, at a minimum of 3 months distance. For the patients who had had pyeloplasty after the age of 3, the Wilcoxon test was applied to evaluate the evolution of the pelvic diameter and of the parenchyma thickness.

Results

The study group was selected from a larger group of 56 patients with ages between 4 days and 13 years, based on the including and excluding criteria presented in methodology. Therefore, a number of 36 patients with IInd–IVth degree unilateral congenital hydronephrosis were included in the study. The group was evaluated in regard to the therapy that was applied to the different patients. In 13 patients a conservative management was applied, the remainder of the 23 patients benefited from surgery. Pyeloplasty was performed during infancy in 6 patients, between the ages of 2 and 3 in another 6 patients and in 11 patients after the age of 3. The demographic data of the study group patients are presented in the following table (tab I).

Table 1. Demographic data of the study group and the side of the affected hydronephrotic kidney

Treatment	Patients no	Sex ratio (Male/ Female)	Hydro-nephrosis (Left/Right)	Mean age ± SD
Conservative management	13	10/3	7/6	2ys2mo ±3ys4mo
Pyeloplasty < 1 year	6	4/2	3/3	4,3mo ±3mo
Pyeloplasy 2-3 years	6	2/4	1/5	2ys6mo ±6mo
Pyeloplasty > 3 years	11	7/4	8/3	9ys6mo ±3ys
Total	***36***	***23/13***	***19/17***	

From the patients who did not undergo pyeloplasty 10 presented IInd degree hydronephrosis and 3 had IIIrd degree hydronephrosis. In 2 cases with IIIrd degree hydronephrosis surgery was refused by the patients' parents

even though the procedure was indicated. The following graphs present a favorable evolution in 11 patients and an unfavorable one in the 2 patients who refused pyeloplasty (fig 4, fig 5). In the 2 patients mentioned, a progression of the dilation of the renal pelvis and a significant thinning of the renal parenchyma (over 10%) were observed.

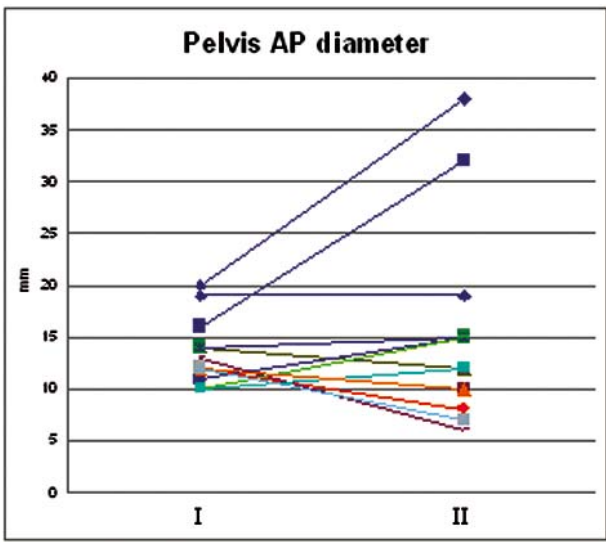


Fig 4. The evolution of the anterior-posterior pelvic diameter in patients with conservative management. There is a significant increase of the hydronephrosis in 2 patients with severe hydronephrosis (IIIrd grade).

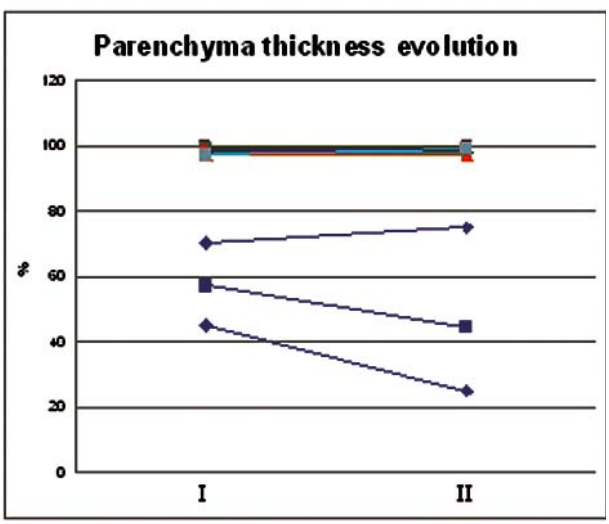


Fig 5. Renal parenchyma evolution in patients with conservative management. Significant deterioration of the renal parenchyma in 2 patients (parents declined surgery).

Table II presents the natural favorable evolution of the pelvic diameter and renal parenchyma thickness in one patient who benefited from conservative management.

Table 2. The evolution of the pelvis diameter (diam) before and after hydration and the evolution of the parenchyma thickness in an infant with right congenital hydronephrosis which was included in the conservative management program.

NN, male, birth date 29. 12. 2007

Date of US exam	Pelvis diam before/after hydration	Parenchima thickness	
		on the right side	on the left side
09.01.08	10/12 mm	8 mm	9 mm
27.02.08	8/20 mm	7 mm	10 mm
09.05.08	15/16 mm	7 mm	10 mm
09.07.08	14/18 mm	7 mm	10 mm
23.09.08	11/17 mm	7 mm	10 mm
09.12.08	10/13 mm	9 mm	11 mm
09.07.09	5/6 mm	11 mm	12 mm

Renal ultrasonography and diuretic renal scintigraphy also revealed a favorable evolution of the patient presented in table II (fig 6, fig 7, fig 8).

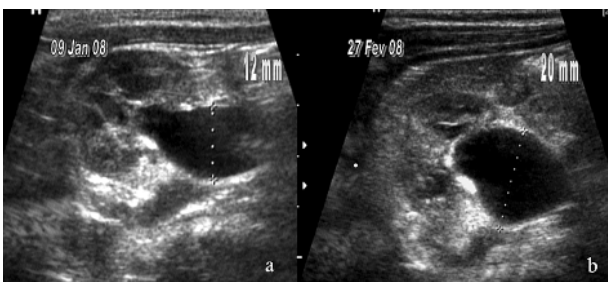


Fig 6. *a,b.* Initial evolution of the anterior-posterior renal pelvis diameter in table number 2 patient.

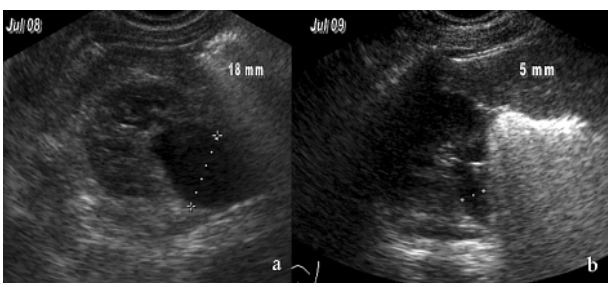


Fig 7. *a,b.* Spontaneously favorable outcome of hydronephrosis in fig 6 patient. At the age of 1 year and 8 months the pelvis diameter was almost normal and the patient presented normal parenchyma thickness.

All the patients who underwent pyeloplasty presented IIIrd and IVth degree hydronephrosis. In all of the 6 cases where pyeloplasty was performed in the first year of life, a decrease of the anterior-posterior diameter of the renal pelvis was observed (fig 9). The renal parenchyma thick-

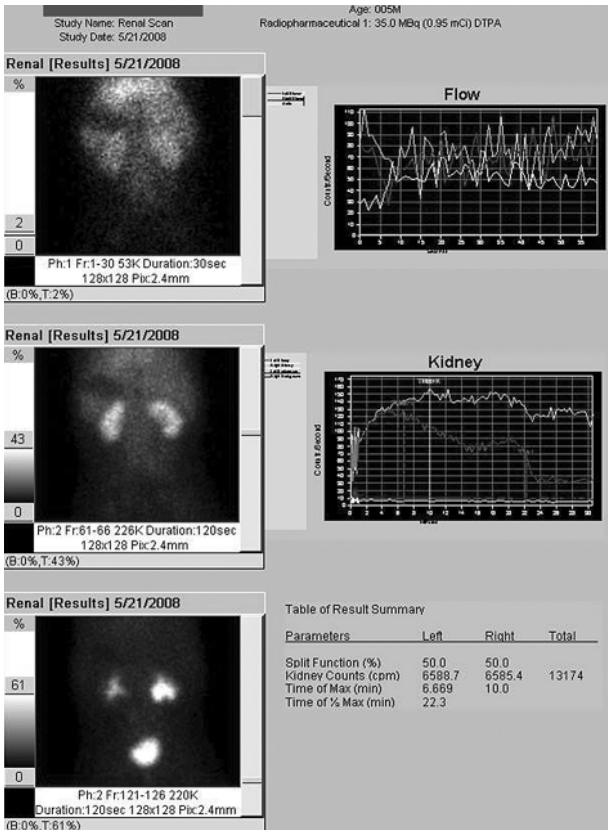


Fig 8. Diuretic renal scintigraphy in table 2 patient reveals favorable evolution.

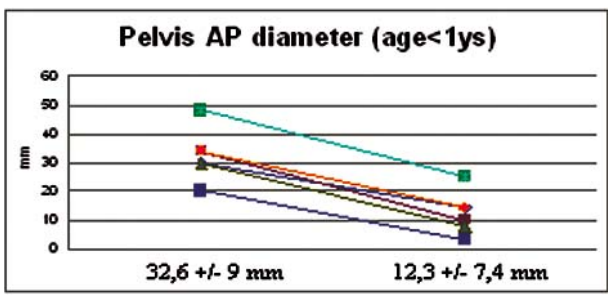


Fig 9. The evolution of the anterior-posterior pelvis diameter in patients operated under 1 year of age. There is a decrease of the pelvic dilatation in all patients.vorable evolution.

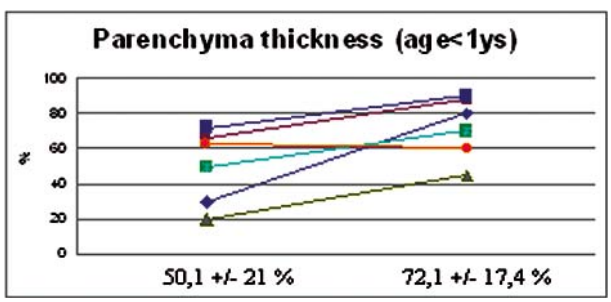


Fig 10. Parenchyma thickness was improved in 5 out 6 patients operated in the first year of life.

ness improved in 5 out 6 patients following the pyeloplasty (fig 10).

The evolution of the pelvic diameter and of the renal parenchyma thickness in a patient with IIIrd degree hydronephrosis who underwent pyeloplasty is represented in table III.

Table 3. The evolution of the pelvis diameter (diam) before and after hydration and the evolution of the parenchyma thickness in an infant with left congenital hydronephrosis with surgical treatment

CA, male, birth date 06.11.2008

Date of US exam	Pelvis diam before/after hydration	Parenchima thickness	
		on the left side	on the right side
11.11.08	11/12 mm	4,5 mm	8 mm
03.12.08	13,5/14 mm	5 mm	9 mm
23.12.08	11/17 mm	4 mm	11 mm
26.02.09	19/21 mm	3,5 mm	11 mm
18.03 09	*Surgery (pyeloplasty)*		
24.06.09 (3 months after surgery)	< 4 mm Large calices	5 mm	11 mm

The progression of the hydronephrosis in the patient presented in table 3 is displayed in fig 11. Renal ultrasonography demonstrated the aggravation of hydronephrosis one hour after hydration compared with the *a jeun* measurements (fig 12). The diuretic renal scintigraphy revealed an inadequate response after Furosemid administration (fig 13). Pyeloplasty was performed at the age of 5 months and the post-surgical evolution was favourable (fig 14).

Pyeloplasty was performed in 6 cases, patients aged 2 to 3. The procedure was unsuccessful in a 2 year old patient. In 4 out 5 of the remaining patients a decrease of the renal pelvis diameter (fig 15) and an improvement of the renal parenchyma were observed (fig 16).

In 11 cases pyeloplasty was performed after the age of 3. The anterior-posterior diameter of the renal pelvis had a significantly favourable evolution (p=0,0016) in all the patients (fig 17). But a deterioration of the renal parenchyma thickness in 3 of the 11 cases was noticed, 2 of these patients showing a decrease of over 10 % (fig 18).

As complications among the study group, we mention the failure of one of the 23 pyeloplasties in a 2 year old patient, a perinephric abscess after a nephrostomy in an 11 year old patient and a mycotic infection in a 2 and a half year old patient.

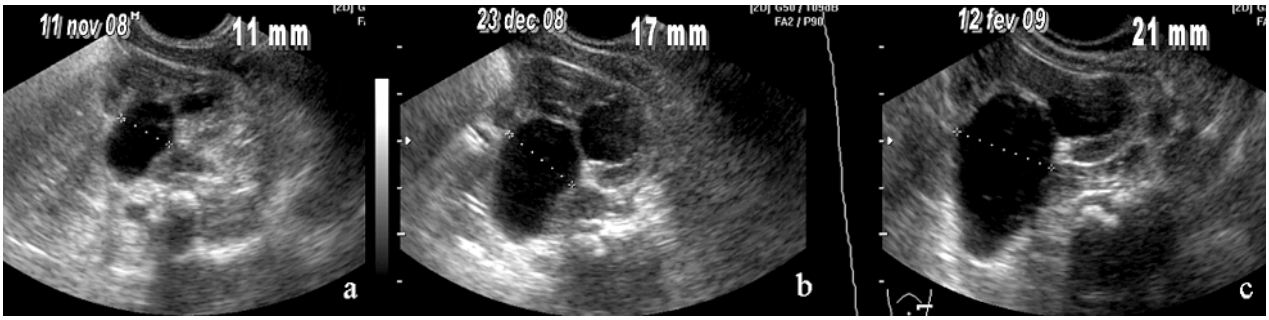


Fig 11. *a,b,c.* Anterior-posterior pelvic diameter evolution of the patient presented in table 3. Hydronephrosis progression has been observed.

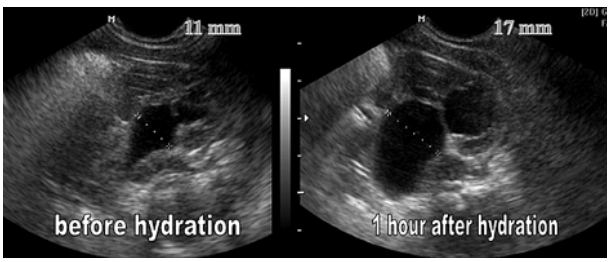


Fig 12. *a,b.* Increase of the pelvis dilatation 1 hour after hydration in table 3 patient.

Discussions

Urinary tract anomalies are the most common prenatal detected anomalies [9,10,11]. In a prospective cohort study performed between 1999-2003, compared with an earlier cohort (1989-1993), the incidence of renal anomalies was 7.6/1000 vs 3/1000 [4].

The meta-analysis realized by Lee *et al* aimed to establish a relationship between the degree of prenatal diagnosed

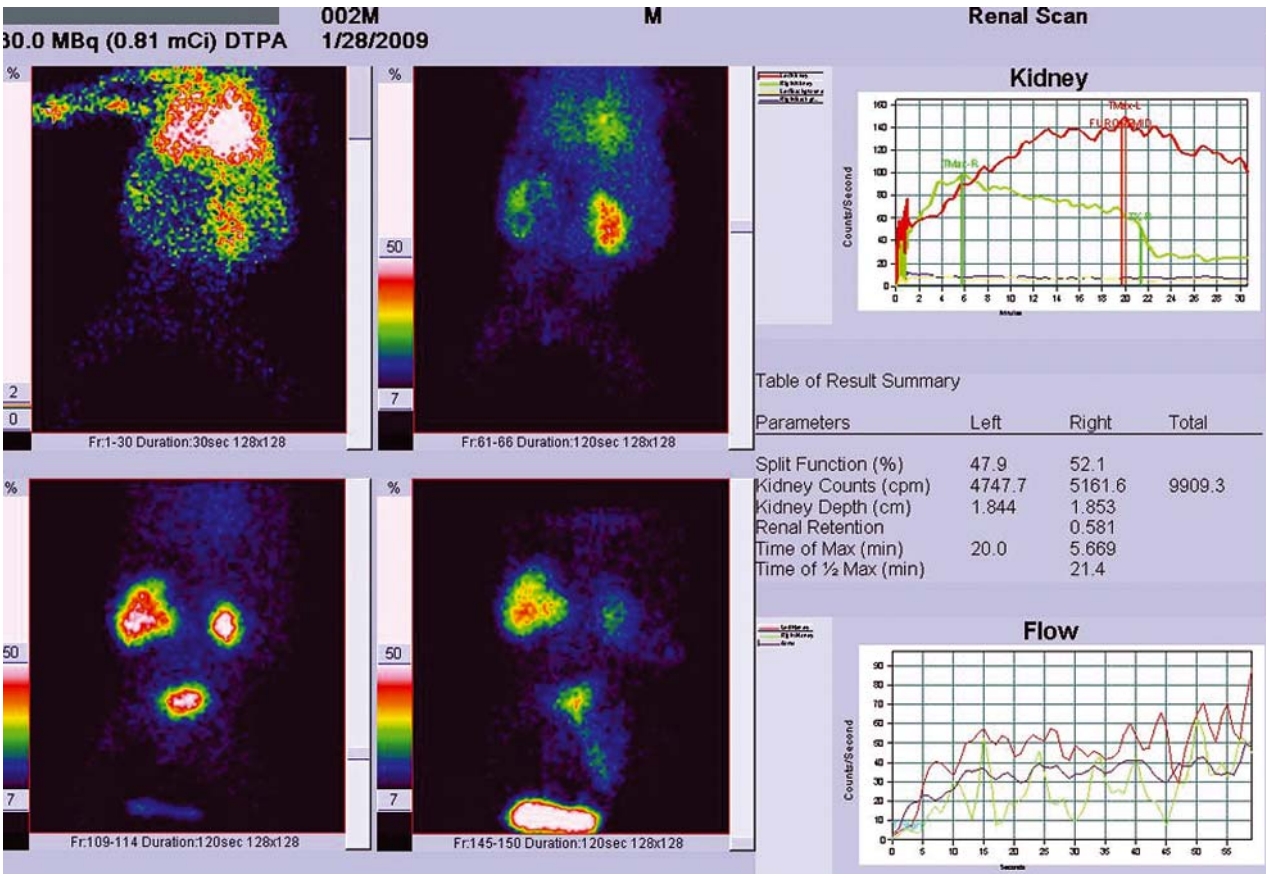


Fig 13. Diuretic renal scintigraphy in table 3 patient. This exam revealed obstruction of pelviureteric junction without spontaneous radionuclide excretion and with unfavorable answer after Furosemide administration.

hydronephrosis and its postnatal evolution. The authors selected 17 articles out of 1645 citations and demonstrated that the risk of developing a postnatal reno-urinary pathology certainly depends on the prenatal degree of the hydronephrosis. Therefore, the risk turned out to be 11.9% in mild hydronephrosis, 45.1 % in moderate hydronephrosis and 88.3 % in severe hydronephrosis [12].

Literature data revealed that patients with mild renal pelvis dilatation do not require invasive diagnosis procedures but need strict surveillance for urinary tract infec-

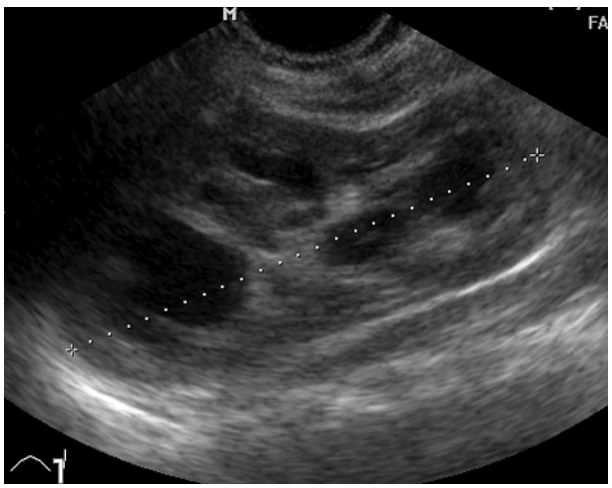


Fig 14. Three months after pieloplasty there is a decrease of the hydronephrosis and a mild improvement of the renal parenchyma thickness in table 3 patient.

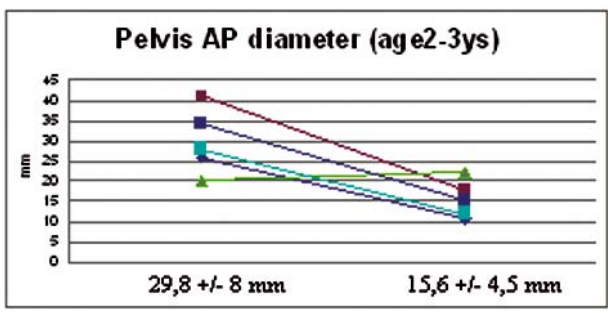


Fig 15. The evolution of the anterior-posterior pelvis diameter in patients operated between 2 and 3 years of age. There is a decrease of pelvis dilatation in 4 from 5 patients. The patient with unsuccessful pyeloplasty is not represented in the diagram.

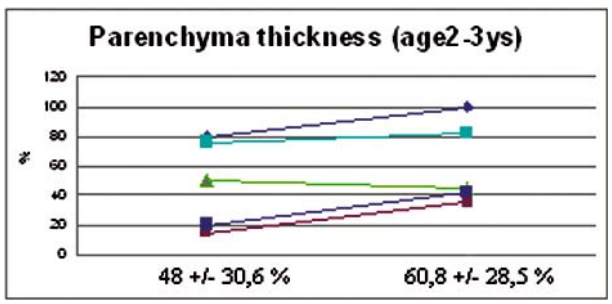


Fig 16. Parenchyma thickness evolution in patients operated between 2 and 3 years of age. The parenchyma thickness improved in 4 out of 5 patients. The patient with unsuccessful pyeloplasty is not represented in the diagram.

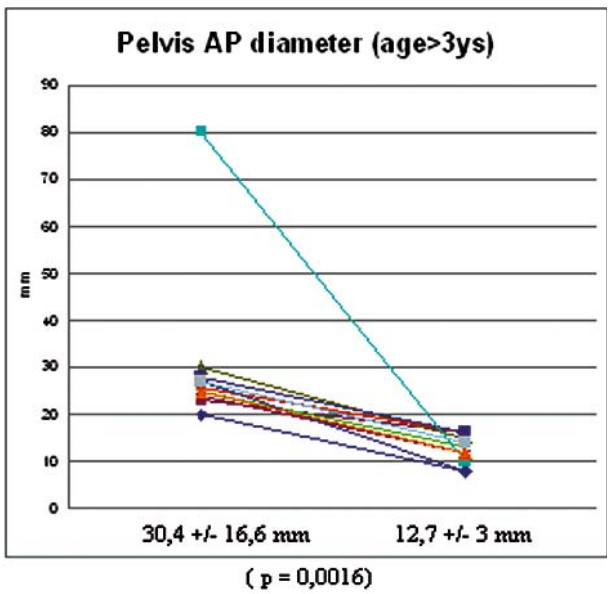


Fig 17. The evolution of the anterior-posterior pelvis diameter in patients operated after 3 years of age. There is a significant decrease of the pelvis dilatation in all patients (p = 0.0016).

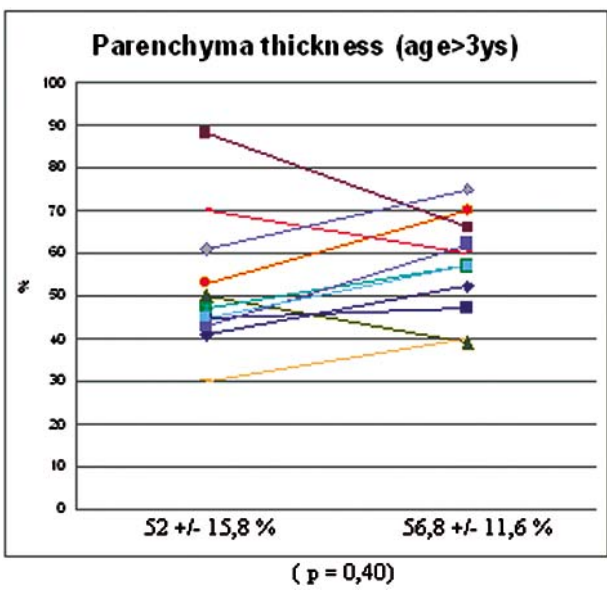


Fig 18. Parenchyma thickness evolution in patients operated after 3 years of age. There is no improvement of the parenchyma thickness after pieloplasty performed at children older than three years (p = 0.40). The deterioration of the parenchyma was present in 3 out 11 patients.

tion and for progression of renal pelvis dilatation [13].

Pyeloureteral junction obstruction is one of the most frequently encountered urinary tract anomalies, being the number one obstructive urinary anomaly. The prospective study realized by Mallik et al regarding the frequency of the prenatal diagnosed urinary anomalies reported pyeloureteral junction obstruction in 10.6%, thus representing the second reno-urinary anomaly after vesio-ureteric reflux, which was found in 12% cases [4].

Prenatal diagnosed hydronephrosis require strict imaging surveillance in order to appreciate their evolution in time. Renal ultrasonography represents the most available and non-invasive monitoring technique. At present, ultrasound exam is considered a very important tool in congenital hydronephrosis management [14]. Lately, more and more importance has been granted to the role of tri-dimensional ultrasonography quantifying the evolution of hydronephrotic kidney, especially in the assessment of renal parenchyma impairment [5].

There are more and more studies in the literature that propose a non-surgical management of patients suffering from congenital hydronephrosis, on the condition that these patients are adequately monitored [15,16,17]. A study published in 2002, performed on 19 patients with bilateral hydronephrosis, indicated pyeloplasty only if a progression of the hydronephrosis was observed. Therefore, surgery was performed only on 35% affected; renal units and conservative management and intensive monitoring over a period of two years was applied in the other cases [15]. A study on 104 newborns with severe unilateral hydronephrosis also revealed the importance of non-surgical management accompanied by a thorough follow-up of the patients. Pyeloplasty was applied in just 22% of the cases [16]. In a retrospective study, performed on two different groups classified upon the moment of diagnosis (early and late diagnosed hydronephrosis), it was shown that the moment of diagnosis and the timing of the surgery did not have a significant influence on the renal function [17]. Other studies that applied a conservative management of the pyeloureteral junction obstruction demonstrated that the delay of pyeloplasty does not significantly influence the recovery of the renal function [18].

The study published by Thorup et al [19] was realized on a group of 100 patients with hydronephrosis and showed that intensive follow-up and conservative management of hydronephrosis allows the prevention of surgery in over 50% of the cases. But in spite of the intensive surveillance of the patients, a deterioration of the renal function occurred in 5% of the studied cases [19].

There are also studies that demonstrated a significant loss of renal function in situations where pyeloplasty was done after a period of waiting compared with other situations where the intervention was early [20].

The present study revealed that early pyeloplasty allows for better improvement of the renal parenchyma, in contrast with cases when it was performed after the age of 3, when no significant improvement was noticed. The study also showed that monitoring of mild hydronephrosis did not lead to the alteration of the renal parenchyma. On the other hand, in cases where the surgical intervention was delayed (parent's refusal), a significant impairment of the renal parenchyma was observed.

Hefez AT *et al.* [21] demonstrated the role of renal ultrasonography in the management of hydronephrosis in a study published in 2002 in which they showed that the progression of hydronephrosis at two consecutive ultrasonographic exams represents an early sign of urinary obstruction. This study also demonstrated the use of the ultrasonographic technique in the management of congenital hydronephrosis.

Conclusions

In conclusion, the authors were able to show a decrease of the pelvic dilatation after pyeloplasty in all age groups. An improvement of renal parenchyma thickness was observed in patients who underwent surgery before the age of 3. Monitoring of mild hydronephrosis did not lead to renal parenchyma deterioration or to the increase of pelvic dilatations.

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