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Post-natal ultrasound morpho-dynamic evaluation of mild fetal hydronephrosis: a new management

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Abstract. – BACKGROUND: Fetal hydronephrosis is the most common anomaly detected on antenatal ultrasound examination, affecting 1-5% pregnancies.

AIM: A new management in mild antenatal renal pelvis dilatation (ARPD), using a technique based on both morphological and dynamical evaluation.

MATERIALS AND METHODS: Prospective study conducted during a 36-months period in 180 consecutive newborns referred as having mild ARPD. Examinations consisted in a morphological ultra-sound (US) scan evaluating antero-posterior diameter, renal parenchyma, ureteral evidence and pelvis morphology and, subsequently, a dynamic evaluation to analyze any change of the urinary tract during bladder voiding. All children were evaluated both at 3rd day and 1 month after birth. They were divided among those with negative examinations and those with at least one positive scan, trying to discriminate within the latter, children suspected for transient pyelectasis from those suspected for organic pathology.

RESULTS: 108 patients had normal US findings both at birth and at 1 month. The remaining 72 babies had at least one abnormal US examination: 54 were suspected for transient pyelectasis, while 18 suspected for organic pathology. At the end of the study, 61 babies (33.9%) had final diagnosis of transient pyelectasis and 11 cases (6.1%) of organic pathology. At one month the dynamic pattern of US findings had the highest negative predictive value, while renal parenchyma evaluation has the highest accuracy.

CONCLUSIONS: a dynamic US approach allowed to better select among infants suspected for transient pyelectasis from those suspected for organic pathology, avoiding unnecessary and invasive examinations in healthy babies.

Key Words:

Fetal hydronephrosis, Kidney disease, Vesicoureteral reflux, Ultrasonography, Megaureter.

Introduction

The introduction of routine fetal ultrasonographic examinations has increased the detection rate of fetal anomalies. This has led to the discovery of many fetal anomalies. Among them, fetal hydronephrosis is the most common anomaly detected on antenatal ultrasound examination, affecting 1-5% of pregnancies[1-6]. However, the choice of the diagnostic technique in these patients remains controversial as either the significance of mild antenatal renal pelvis dilatation (ARPD) detected by ultrasound in neonates and infants, and the need for postnatal imaging study are discussed options[7]. Many approaches in the management of these mild hydronephrosis are described in literature, underlining the lack of consensus among clinicians. Some recommend ultrasound, voiding cysto-urethrogram (VCUG) and renogram for all, without differentiating between mild to severe cases[7], whereas others reserve invasive postnatal investigations only in selected cases[8-11].

Prenatal hydronephrosis may represent a transient condition that frequently resolves spontaneously with tubular function maturation, increasing reabsorption ability, and ureteropelvic junction maturational process[12-19]. Lee at al[20] in a large meta-analysis demonstrated that the risk of any postnatal pathology in mild hydronephrosis was 11.9% and the risk of vesicoureteral reflux (VUR) was not significantly different among all severity. Moreover, the VUR has an high rate of spontaneous resolution during the first years of life, thus the question if it is useful to detect VUR in these children[21-22].

The aim of our study is to propose a new management using a US technique based both on a morphological and dynamical evaluation, to better differentiate babies with transient pyelectasis from those suspected for organic pathology, reserving to the latter further invasive investigations.

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Materials and Methods

Study Population Design

This prospective study was conducted in newborns over a 36-months period between March 2007 and March 2010 in Catholic University, Polyclinic A. Gemelli of Rome, Italy. Newborns were referred as having unilateral or bilateral mild ARPD, revealed according to parameters proposed by Lee et al[20] based on anterior-posterior diameter (APD) in the 2nd and 3rd trimester of pregnancy.

Patients with history of premature birth were excluded from the study.

All babies had two consecutive US examinations of the urinary tract 3 days and 1 month after birth. In babies who had at least one positive US scan, further examinations were performed until the complete resolution of radiological and clinical findings. We consider complete radiological resolution if there are at least two negative subsequent examinations in absence of clinical symptoms.

In case of postnatal bilateral pyelectasis, we considered the patient as one unit.

All the postnatal US examinations were performed by the same pediatric radiology team, with at least 15 years of experience in pediatric radiology. They performed the examination with a TOSHIBA Aplio XV machine (Milan, Italy), using a microconvex transducer and a linear transducer (7.5 MHz) with pediatric setting.

Verbal informed consent was provided by patients' parents. The study was performed in accordance with the Helsinki Declaration.

US Technique

All examinations were performed in a way that we propose and, to our knowledge, a similar approach was recently described only by Riccabona et al[23].

We first performed a classical morphological US scan in a well hydratated patient (full bladder), evaluating pelvic APD, renal parenchyma (thickness and symmetry), pelvis and ureteral morphology and possible ureteral dilatation. In a second phase, we proceeded with a dynamic evaluation considering pelvis changing during bladder emptying. The above criteria are listed in Tables I and II.

According to literature[23-25], an exam was considered abnormal if APD was ≥ 7 mm.

We referred to parenchymal thickness as the distance between the cortex perirenal fat interface (capsule) and the sinus-pyramidal apex interface. It was measured at the middle third portion of the kidney in the sagittal view in the controlateral decubitus position. All measurements have been obtained prospectively on static original ultrasound images using electronic calipers at the time of scanning and then reviewed at a PACS system during reporting.

Table I. Morphological US findings.

Finding	Normal	Abnormal
Renal parenchyma:		
– Thickness	9 ± 1 mm	< 8 mm
– Symmetry	Yes	No
Ureteral dilatation	No	Yes
Pelvic morphology	"V" shape	"O" shape
APD diameter	< 7 mm	≥ 7 mm

We considered as the normal value for the parenchymal thickness 9±1 mm[26]. We evaluated the symmetry between left and right kidney cortex: asymmetry and reduction of parenchymal thickness were considered suspected for pathology.

The evidence of the ureteral dilatation in its distal portion or in all its length was considered as abnormal finding.

The analysis of the pelvis morphology was conducted evaluating the "V" shape and the "O" shape pattern, thus considering the former as a normal finding and latter as suggesting for pathology. The "O" shape is defined as a round pelvis with sudden stop at the pyeloureteral junction, while the "V" shape is the normal shape with a smooth passage from the pelvis to the proximal ureter.

In the dynamic phase of the study, we considered the APD changes. If it reduced during/after the bladder emptying, it was considered as a normal finding (Dinamic Pattern 1-DP1). Otherwise, if the APD grew up, it was considered pathological (Dinamic Pattern 2-DP2). Finally, if the AP diameter was unchanged, it was considered suspected for pathology (DP2) only if associated to

Table II. Dynamic US findings.

Dynamic pattern 1 (DP1)
- APD reduced during bladder emptying
- APD unchanged during bladder emptying, without other abnormal morphological findings

Dynamic pattern 2 (DP2)
- APD increased during bladder emptying
- APD unchanged during bladder emptying, with other abnormal morphological findings

at least one among the above mentioned morphological criteria (Table II). The mean duration of the examination was 25 minutes.

Based on the above criteria, after the second exam (at 1 month after birth), all babies were divided in different groups:

1. Infants who had both normal US examinations, with normal morphological findings and DP1;
2. Infants with APD ≥ 7 were further divided in two subgroups:
   – Infants with DP1 without other abnormal morphological findings, suspected for transient pyelectasis, condition that resolves without intervention;
   – Infants with DP2 or with at least one abnormal US morphological criteria, suspected for organic pathology.

Further assessment with VCUG and/or ^{99m}Tc-angioscintigraphy were performed in all babies included in group 2b. In particular, VCUG was performed in suspicion of VUR and ^{99m}Tc-angioscintigraphy in suspicion of pyeloureteral junction (PUJ) obstruction.

Clinical Follow-up

All children had at least 1 year of clinical follow-up or until the complete resolution of clinical symptoms or radiological findings. The clinical follow-up was performed at "Spina Bifida and congenital uropathies outpatients Center" of Catholic University of Rome, Italy. Only in case of clinical suspicious, children were tested for urinary tract infections (UTI).

Statistical Analysis

Statistical analysis were performed with SAS 9.1 (SAS Institute, Inc, Cary, NC).

We performed a univariate analysis of all morphological and dynamical US findings above mentioned using a poisson regression model with a log link function. The Chi-squared test was used to determine whether there was an association between each US-sign and organic pathology. A *p value* of 0.05 or less was considered statistically significant.

Results

From March 2007 to March 2010, 10,225 neonates at term were born in Catholic University of Rome, Italy (50.3% male). A prenatal diagnosis of fetal mild renal pyelectasis was made in 190 (1.8%) of all. Ten cases (10/190; 5.2%) were not included in the analysis because they did not attend all the appointments. The remaining 180 newborns (122 boys and 58 girls, male to female ratio 2.1:1) were analyzed in this prospective study. In 119 cases (66.1%) prenatal diagnosis was bilateral, while in 61 (33.9%) was unilateral. After birth, only one case was bilateral at one month US examination.

108/180 patients (60%) had normal morphological and dynamic US findings both at birth and at 1 month, so they were included in group 1. This group had 1 year clinical follow-up with normal clinical outcome in 107 cases and only 1 case had a mild urinary tract infection at 4 months after birth.

The remaining 72 babies (40%) had at least one abnormal US examination, and so they were included in group 2. Among them, 56 had normal US findings at birth, while 16 had abnormal US examinations. All of them had abnormal US scan (APD ≥ 7 mm) at one month. 54 were included in group 2a (suspected for transient pyelectasis), while 18 in group 2b (suspected for organic pathology). A total of 10 VCUG and 15 ^{99m}Tc-angioscintigraphy were performed in group 2b (8 had only ^{99m}Tc-angioscintigraphy, 3 had only VCUG, 7 had both examinations). At the end of the study, 61 babies (33.9%) had final diagnosis of transient pyelectasis (Figure 1) and 11 cases (6.1%) of organic pathology: 4 PUJ, 3 megaureter, 2 ureterocele and 2 VUR (Figure 2). All the children with final diagnosis of organic pathology were included in group 2b.

Table III shows the statistical analysis of morphological and dynamical findings at one month US examination in group 2. Dynamic pattern is the finding with highest NPV (98.2%), while renal parenchymal evaluation is the one with the highest overall accuracy (94.4%). The morphology of the pelvis has the lowest sensitivity (36.4%) and NPV (89.1%).

Discussion

In the last twenty-five years, the systematic use of obstetric US examination has increased the detection of fetal uropathies that must be evaluated at birth. However, the significance of mild hydronephrosis detected by US in neonates and infants, the need of post-natal imaging study and the technique of choice in these patients remain controversial[7].

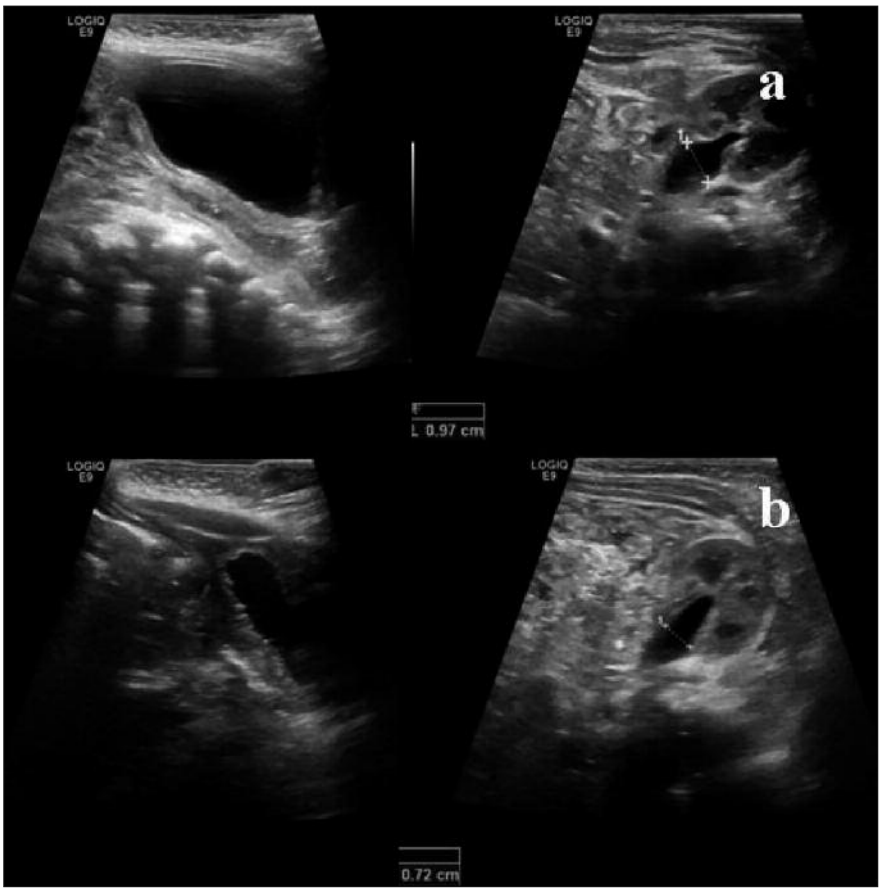

Figure 1. US exam performed 1 month after birth. ***a,*** Morphological evaluation with full bladder showed an APD = 10 mm. ***b,*** The dynamic evaluation during bladder emptying showed a reducing APD (7 mm). The US follow-up showed complete resolution of the pyelectasis.

This prospective study demonstrates, in patients with antenatal mild renal pelvis dilatation, a low prevalence of organic pathology (6.1%), in accordance with the literature[20], versus a high prevalence of transient pyelectasis (33.9%) and newborns with normal postnatal US findings (60%) after birth. These results reflect the need of a very accurate selection of babies that really deserves further invasive examinations (VCUG, ^{99m}Tc-angioscintigraphy), as proposed by the ALARA principle "as low as reasonably achievable".

Neonatal US imaging is an attractive screening procedure because it provides many advantages: noninvasive technique, lack of ionizing radiations, wide feasibility, excellent anatomic resolution, low patients discomfort and low costs[27]. It can also provide functional data if it is properly stressed. The apperance of new US equipments with higher accuracy the influence of US operator is becoming less significative.

In our report the US examination at day 3 has got a low accuracy in differentiating group 1 from group 2. In fact, 56 cases that had a normal US examination at day 3 (72 h after birth), had an abnormal US examination at one month of life. This can be due to the para-physiological dehydratation with reduced urine output during the first 24-48 hours[28]. Among them (56), 51 cases (91%) resulted to have a final diagnosis of transient pyelectasis (group 2a), thus this negativity at day 3 US evaluation didn't have any implication on outcome of these patients. The other 5/56 had a final diagnosis of organic pathology (2 ureterocele, 2 megaureter, 1 VUR), while the remaining 6 of 11 babies with final diagnosis of organic pathology had abnormal US examination at day 3.

Even if several authors[23,29] suggest to perform the first examination around day 5, we scanned the patients before (around 72 h after birth) because, in our Hospital, they are normally discharged at day 3. This kind of management, however, permitted us to avoid families to come back to the hospital two/three days after discharge and reduce parental anxiety starting an earlier counseling.

According to Thomas et al[30], in our report 60% of babies had normal US examinations both at day 3 and at one month after birth. Only in 1 case, we

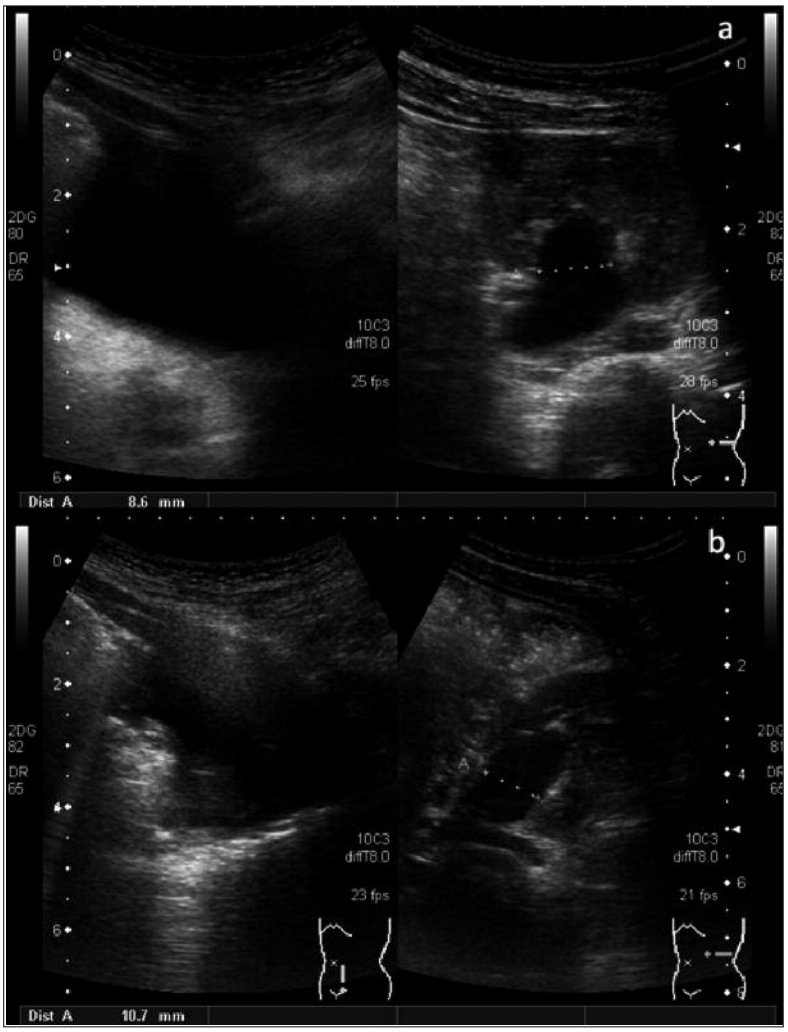

Figure 2. US exam performed 1 month after birth. ***a,*** Morphological evaluation with full bladder showed an APD = 8 mm. ***b,*** The dynamic evaluation during bladder emptying showed an increasing APD (11 mm). The VCUG showed III grade left VUR.

incidentally found the presence of a duplex kidney in a baby at 7 months of age during an US examination, performed because of repeated low UTI. VCUG excluded presence of RVU. However, an earlier diagnosis of duplex kidney wouldn't change the prognosis of this child because in this case it was a normal variant, not associated with other significant pathologies[31]. Remaining 107 cases (99% of Group 1) had normal clinical outcome after one year follow-up.

The real challenge of our investigation was to discriminate patients with APD ≥ 7 (group 2), between those suspected for transient pyelectasis (group 2a) from those suspected for organic pathology (group 2b), reserving only to the latter further invasive studies. No consensus was found concerning the application of VCUG. Most authors recommend VCUG in children with an AP diameter of > 5 mm on postnatal US[22]. Other authors recommend its application

Table III. Univariate analysis of morphological and dynamical US findings

US finding	Sensibility	Specificity	PPV	NPV	Accuracy	Relative 95% CI			Test Chi^2
						Risk	Min	Max	
Dynamic pattern	90.9%	88.5%	58.8%	98.2%	88.9%	32.4	4.1	252.7	< .0001
Renal parenchyma	81.8%	96.7%	81.8%	96.7%	94.4%	24.9	5.3	115.5	< .0001
Pelvis morphology	36.4%	93.4%	50.0%	89.1%	84.7%	4.5	1.3	15.6	0.0153
Ureteral dilatation	54.5%	98.4%	85.7%	92.3%	91.7%	11.1	3.4	36.5	< .0001

only with an AP of > 10 mm[16]. However, Tiballs and De Bruyn [28] proposed to investigate every child with a history of ARPD. Ismaili et al[21] concluded in their report that screening for VUR is not necessary in children who have two consecutive normal renal US (defined as pelviectasis of < 7 mm), no calyceal or ureteral dilatation, pelvic or ureteral wall thickening or signs of renal dysplasia.

We analyzed the 1month examination, about its ability to discriminate among group 2a and group 2b. We had 7 false positive cases and no false negative. Among the false positive (7), in 4 cases we suspected UPJ, because the pelvis had "O" shape morphology and the APD didn't change during the bladder emptying (DP2). On this suspicion, we suggested to perform a further ^{99m}Tc-angioscintigraphy, that showed simple marked renal stasis on the basic renogram that was washed-out after intravenous injection of furosemide, which increases urine flow. This excluded the organic etiology of the obstruction. In 1 case there was evidence of ureter dilatation with unchanged pelvis APD during the dynamic phase (DP2). In suspicion of organic pathology (VUR versus megaureter), we performed a VCUG that excluded a RVU. Therefore, following US examinations didn't detect abnormal ureteral dilatation anymore. In another case the US examination revealed reduction of parenchymal thickness (7 mm vs 9 mm of the controlateral kidney) with unchanged pelvis APD during the dynamic phase (DP2). In suspicion of organic pathology we performed ^{99m}Tc-angioscintigraphy. In the last case the APD increased during the bladder emptying (DP2). In suspicion of organic pathology (RVU), we performed a VCUG. It excluded the presence of RVU. The following US examinations showed, however, unchanged pelvis APD without any abnormal morphological finding (DP1). This was an isolated case and no more are reported in our study.

We didn't have any false negative case. In fact in all cases with final diagnosis of organic pathology we identified at least one abnormal US finding. However, in the suspicion of organic pathology, we were not always able to distinguish between the different diseases (e.g. RVU versus megaureter).

We also analyzed all the morphological and dynamical US findings in 1 month examination in group 2. The most sensitive sign in our statistical analysis was the newly described dynamic pattern. The sign showed 90.9% sensitivity and 98.2% of NPV, with a low PPV (58.8%) that increases the number of false-positives and an overall accuracy 88.9%. This is acceptable in the setting of a screening test, because it allows to identify all patients who might have the disease. Those patients so identified must then be addressed to further investigations which are more specific. Only one case with final diagnosis of organic pathology (megaureter), had a DP1 (APD reducing), while the remaining cases had DP2. The major limitation of this sign is that it must be always correlated with the morphological findings in case of unchanging APD. Thus the need of both the morphological and the dynamic evaluation.

Riccabona et al[23] proposed a pre-void (in well-hydrated patients) and a post-void US examination in ESPR guidelines. Our approach is more similar to Anderson et al[32] and differentiates from the one proposed by Riccabona et al. for having online monitoring during patient's voiding.

With this new approach (Figure 3), we could avoid unnecessary VCUG in 54 case, in which, according to the literature, because of their APD (≥ 7 mm), VCUG was indicated. The use of VCUG as a screening tool has been questioned[23]. In fact, even if VCUG remains the gold standard examination for bladder imaging, the urethra and the VUR, however, it is an invasive test, requiring urethral catheterization, and involving exposure to ionizing radiation. Moreover, US scan is a cheaper examination, when compared to VCUG.

A limit of this study is that we do not have a comparison of our data with the gold standard (in this case VCUG). Therefore, we cannot exclude that some of the children could had a missed low grade VUR. The clinical outcome and radiological follow-up were normal, thus no relevant pathology was missed. However, further prospective investigations should be carried out in this controversial field.

Conclusions

Renal pelvis dilatation is the commonest criterion used to confirm an abnormality; it is an important finding that permitted to discriminate among children that have no postnatal evidence of pyelectasis from that who need follow-up. Although 7 mm of APD diameter is the most widely accepted upper limit of normal in the literature, other findings must be considered.

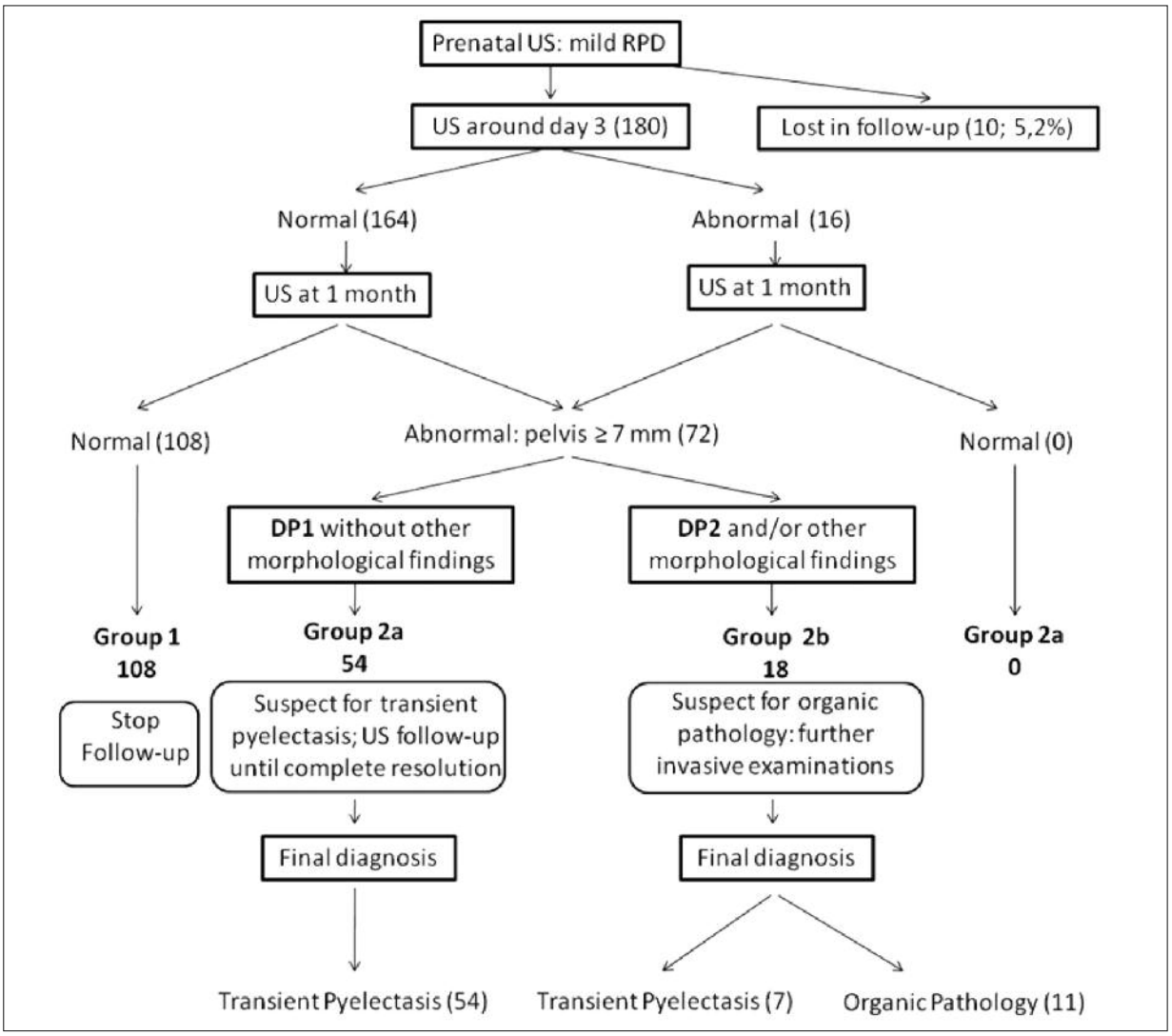

Figure 3. Imaging algorithm in newborns with mild ARPD and our results.

The introduction of a new US approach, including both a morphological and dynamic evaluation, allowed us to better select among infants suspected for transient pyelectasis from those suspected for organic pathology. While occasional cases of VUR could be missed by this longer and meticulous approach, it seems reasonable to consider that the risk of missing low grade VUR would be outweighed by the benefit of avoiding useless and invasive examinations in healthy babies[31].

Conflict of Interest

The Authors declare that they have no conflict of interests.

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