Renal Ultrasonography in Neonates.

Mahmoud Adel Abdel-Moneim, Mahmoud Mohi-Eldin El-Kersh, Mohamed Alaa Thabet, Magdy Abdel-Fattah Ramadan and Hossam H. Zeid.
From Department of Pediatrics, Faculty of Medicine, University of Alexandria, Egypt.

Abstract:

Ultrasound (US) is a safe and accurate imaging method in the evaluation of urinary tract and its anomalies in neonates. It is helpful in establishing correct diagnosis in the majority of cases and facilitates precise measurement of kidney length. We conducted this work to study the prevalence and types of renal anomalies in Egyptian neonates and to identify their normal renal length. Our study was conducted on 500 Egyptian neonates, at Alexandria University Maternity and Children’s Hospitals. Ultrasonographic examination and measurement of both kidneys were done in all neonates. Abnormal renal ultrasonographic findings were found in 15 neonates, with a prevalence of 3%. The abnormalities encountered were severe bilateral hydronephrosis in 8 cases (1.6%), moderate bilateral hydronephrosis in 3 cases (0.6%). Horseshoe kidney, bilateral hyperechoic renal medulla, polycystic kidney disease (ARPKD), and unilateral renal tumor were detected in equal frequencies of 0.2% each. Further evaluation of the cases with severe hydronephrosis revealed: posterior urethral valve (PUV) in 5 cases, bilateral primary vesicouretral reflux (VUR) in 2 cases, bilateral pelviureteric junction obstruction (PUJO) in one case. Cases with moderate hydronephrosis resolved on follow-up. Sonographic renal appearance in normal neonates was different from that seen in older children. They showed a pattern of increased corticomedullary differentiation with markedly sonolucent medullary pyramids. The mean renal length in normal newborns was 4.7± 0.7cm. There was a positive correlation between renal length and each of body length and weight than with age and head circumference. The high prevalence of renal anomalies in Egyptian neonates justifies early postnatal renal US examination of all neonates; especially those who had abnormal antenatal ultrasonographic findings. Early diagnosis of such anomalies will lead to proper early management and prevention of chronic renal failure.

Abbreviations:

Introduction:

Postnatal imaging is a necessity for evaluation of suspected or proven urinary tract abnormalities detected during gestation. Ultrasound examination is a safe and accurate imaging method in the evaluation of urinary system and its anomalies in neonates.1,3 It is helpful in establishing correct diagnosis and selecting cases requiring further investigations or urological treatment.2 There are specific conditions that prompt US imaging in the early neonatal period; as the presence of oligohydramnios, single umbilical artery, low set ears, abdominal mass, failure to void, poor urinary stream, hypertension, RTA, UTI, hematuria or proteinuria.3,5 Although diagnostic accuracy of prenatal US may be far from perfect, at least, prenatal detection of urinary tract abnormalities mandates careful postnatal examination.5,7 Enthusiasm for the use of prenatal US to maximize decisions regarding the time and mode of delivery and to allow counseling of parents regarding their infant’s diagnosis, prognosis, and possible treatment modalities must be tempered by the knowledge that errors in diagnosis may occur in 4% to 61% of cases.6,9 When used as a screening procedure, US examination of the fetal urinary tract seldom leads
to beneficial interventions. There is also a cost in terms of parental anxiety and unnecessary investigation. A formal screening program would therefore be unjustified. However, screening of women for obstetric purposes will continue to reveal fetal abnormalities, and a strategy for dealing with these is needed.

The aim of this work was to study prevalence and types of renal anomalies in Egyptian neonates and to identify their normal renal length and sonographic findings, as revealed by postnatal US screening.

**Subjects and Methods:**

This study was conducted on 500 Egyptian neonates. They were recruited from neonates delivered at Alexandria University Maternity Hospital, and those attending the newborn clinic of Alexandria University Children’s Hospital. There were no inclusion or exclusion criteria.

All neonates were subjected to:

1. Thorough history taking and clinical examination.
2. Renal ultrasonography by real-time scanner (linear and sector) using a 5 MHz transducer (Aloka-626 apparatus).
3. A follow-up ultrasound was done, 7-10 days latter, if the first examination was performed during the first 2 days of life.
4. All neonates with normal renal sonographic pattern were examined to determine renal length of both kidneys.
5. If any renal abnormality was detected, further investigations were done as needed. These investigations included blood urea, creatinine, VCUG, follow-up US and others.
6. Ultrasound evidence of hydronephrosis was defined as dilation in the antero-posterior renal pelvic diameter (APRPD) of > or = 5 mm. Hydronephrosis was divided according to APRPD into: mild if it was 5-10 mm, moderate if it was 11-15 mm and sever if > 15 mm or there was associated calyceal dilation. Histopathological examination of the excised renal tumor mass in one neonate revealed Wilms’ tumor. None of 6 kidneys 15 mm or smaller in APRPD had obstruction; All of 16 kidneys with APRPD larger than 15 mm were obstructed or demonstrated VUR.

**Statistical Methods:**

- Statistical analysis was done by SPSS computer program version 8 using student’s t test, correlation coefficient (r) and Chi square test whenever needed. Values were expressed as percentage or mean±SD. The level of statistical significance was at p < 0.05.
- Prevalence of renal anomalies was calculated as follows:

\[
\text{Prevalence} = \frac{\text{No. of neonates having renal anomalies}}{\text{Total No. of neonates in the study}} \times 1000
\]

**Results:**

Our study was conducted on 500 Egyptian neonates, their age varied between few hours to 30 days with a mean of 13.8 ± 11 days. The male to female ratio was 1.6:1. Out of the five-hundred scanned neonates, fifteen were found to have abnormal renal ultrasonographic findings with a prevalence of 30 per 1000 neonates (3%). Three neonates (0.6%) had moderate hydronephrosis and another eight neonates (1.6%) had severe dilation of APRPD. Bilateral hyperechoic renal medulla, ARPKD, horseshoe kidney and unilateral renal tumour occurred in equal frequencies of 0.2% each. On further evaluation of the eight cases with severe hydronephrosis by VCUG; five of them proved to have PUV, two had bilateral primary VUR grade V and the last one had bilateral PUJO (table I). Histopathological examination of the excised renal tumor mass in one neonate revealed Wilms’ tumor. None of 6 kidneys 15 mm or smaller in APRPD had obstruction; All of 16 kidneys with APRPD larger than 15 mm were obstructed or demonstrated VUR. No statistically significant differences were observed as regards the mean age or anthropometric measurements between the normal neonates and those with renal abnormalities (table II). Most of neonates with renal abnormalities were males (93.3%), versus 60.2% in normal neonates. Even after exclusion of the neonates with PUV, the males were still predominant with male to female ratio 9:1. It is worth mentioning that the consanguinity, family history and perinatal history were comparable in normal neonates and neonates with renal abnormalities so that we cannot consider any of them as risk factors.

Sonographic appearance of the kidney in normal neonates was different from that seen in older children. We noticed that echogenicity of the renal cortex approximate or even exceed that of the liver or spleen. Moreover, the medullary pyramids were hypoechoic and prominent, providing striking contrast with the adjacent echogenic cortex. There was paucity of the hyperechoic central renal sinus. In normal neonates, there was no statistically significant difference between the mean length of the left and the right kidney (Table III). Moreover, there was no statistically significant difference in the mean kidney length between male and female neonates. The left kidney was longer than the right kidney in 42% of neonates, while the right was the longer in 22%. The right and left kidneys were of equal length in 36% of neonates. There was a positive correlation between the renal length and
each of the age, weight, body length and head circumference. Renal length correlated more with body length and weight than with age and head circumference (Fig 3, 4). The right kidney correlated more with these anthropometric measurements than the left.

Table I: Types of renal anomalies and their frequencies

<table>
<thead>
<tr>
<th>Type of anomaly</th>
<th>No.</th>
<th>% of cases with anomalies</th>
<th>% of total neonates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe hydronephrosis:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• PUV</td>
<td>8</td>
<td>53.33</td>
<td>1.6</td>
</tr>
<tr>
<td>• Bilateral primary VUR</td>
<td>5</td>
<td>33.33</td>
<td>1.0</td>
</tr>
<tr>
<td>• Bilateral PUJO</td>
<td>2</td>
<td>13.33</td>
<td>0.4</td>
</tr>
<tr>
<td>Moderate hydronephrosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Transient hydronephrosis”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horseshoe kidney</td>
<td>1</td>
<td>6.67</td>
<td>0.2</td>
</tr>
<tr>
<td>Hyperechoic renal medulla</td>
<td>1</td>
<td>6.67</td>
<td>0.2</td>
</tr>
<tr>
<td>ARPKD</td>
<td>1</td>
<td>6.67</td>
<td>0.2</td>
</tr>
<tr>
<td>Renal tumour (Wilms’ tumor)</td>
<td>1</td>
<td>6.67</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>100%</td>
<td>3%</td>
</tr>
</tbody>
</table>

Table II: Gestational age, age at examination, anthropometric measures and male:female ratio of studied neonates.

<table>
<thead>
<tr>
<th>Neonates</th>
<th>GA (weeks)</th>
<th>Age (days)</th>
<th>Weight (kg)</th>
<th>Length (cm)</th>
<th>Head Circ. (cm)</th>
<th>M:F Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (n=500)</td>
<td>37±1.8</td>
<td>13.8±11</td>
<td>3.6±0.8</td>
<td>50.86±3.5</td>
<td>35±2.4</td>
<td>1.6:1</td>
</tr>
<tr>
<td>Normal (n=485)</td>
<td>37±2</td>
<td>13.7±11</td>
<td>3.6±0.8</td>
<td>50.88±3.5</td>
<td>35.4±2.4</td>
<td>1.5:1</td>
</tr>
<tr>
<td>with Anomalies (n=15)</td>
<td>37±1.6</td>
<td>15.4±11</td>
<td>3.8±0.8</td>
<td>50.53±2.2</td>
<td>34.8±2</td>
<td>14 :1</td>
</tr>
<tr>
<td>p</td>
<td>0.53</td>
<td>0.57</td>
<td>0.90</td>
<td>0.70</td>
<td>0.35</td>
<td></td>
</tr>
</tbody>
</table>

Table III: Comparison between the length of the left and the right kidney in normal neonates

<table>
<thead>
<tr>
<th></th>
<th>Left Kidney</th>
<th>Right Kidney</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range</strong></td>
<td>3 – 7.2 cm</td>
<td>3 – 7.3 cm</td>
</tr>
<tr>
<td><strong>Mean + SD</strong></td>
<td>4.70 ± 0.77 cm</td>
<td>4.69 ± 0.65 cm</td>
</tr>
<tr>
<td><strong>p</strong></td>
<td>0.82</td>
<td></td>
</tr>
</tbody>
</table>

Fig.1: Ultrasound of the right kidney of a 12-days old female neonate showing severe hydronephrosis due to primary VUR

Fig.2: Ultrasound of the right kidney of a 19-days old male neonate showing ARPKD
Discussion:

Early diagnosis of urinary tract malformations allows realizing the best medical and/or surgical treatment as fast as possible, thus preventing or at least slowing down the evolution of CRF.\textsuperscript{1,3} Postnatal US screening can easily identify congenital urinary tract abnormalities, especially obstructive ones.\textsuperscript{3,5} The present study was conducted on 500 Egyptian neonates, their ages ranged between few hours and 30 days, with a male to female ratio of 1.6:1. The prevalence of renal anomalies was found to be 30 per 1000 neonates (3%). Male predominance was evident among the neonates with renal anomalies even after exclusion of those with PUV. This may be an indicator that male sex is a risk factor for occurrence of renal anomalies.

In the European countries, the incidence of urinary tract congenital anomalies varied between 1.6% and 4.4%. Our results lie within this spectrum. Jojart and Nagy,\textsuperscript{14} Jelen,\textsuperscript{2} Leonhardi and Reither,\textsuperscript{15} from Hungary, Poland and Germany respectively found the incidence of congenital renal anomalies to be 1.6%, 2.1%, 4.4% respectively. These variations may be due to demographic causes or difference in ethnic groups, methodology or timing of detecting anomalies between the various studies. In Italy, Ricciopettoni et al\textsuperscript{16} performed US screening on 3,454 neonates in the first week of life and reported pronounced anomalies in (1.04%) and mild renal pelvis dilation in (4.60%). On the other hand, Kim and Song\textsuperscript{17} in Korea reported lower incidence of urinary tract anomalies 0.9% (8.8/1,000 births). This may be due to interplay of multiple genetic and environmental factors. Another possible reason is the wide application of therapeutic abortions in that country.

The anomalies detected in the present study were more uropathies than nephropathies. Hydronephrosis was the commonest renal anomaly detected, it was found in 73.33% of cases with renal anomalies. Further radiological investigations of them revealed PUV to be the main underlying etiology. Horseshoe kidney, bilateral hyperechoic renal medulla, ARPKD and Wilms’ tumor occurred in similar frequencies, 0.2% each. Similarly, Kim and Song\textsuperscript{17} found that the most common renal anomaly detected by US was hydronephrosis. In contrast to our study, they did not encounter any case with PUV and reported PUJO as the commonest cause of hydronephrosis. In accord with us, Jelen\textsuperscript{2} found mild hydronephrosis, renal mass and hyperechoic renal medulla, with nearly the same frequencies as in our study (0.6%, 0.1%, and 0.3% respectively). In addition, he found unilateral multicystic renal dysplasia, solitary kidney and renal duplication in 0.2%, 0.2%, and 0.4% respectively.

Follow-up US helped us to avoid unnecessary uroradiological investigations; cases with moderate hydronephrosis proved to be transient and resolved after few weeks. They probably represented the group with physiological renal pelvic dilation; which is a common prenatal finding.\textsuperscript{6,7} Moreover the hyperechoic renal pyramids detected in one neonate with transient ARF returned to normal hypoechoic appearance within few days. This hyperechoic medulla could be explained by the reversible tubular blockade by Tamm-Horsfall proteins in ARF.\textsuperscript{18} In addition, US facilitated the selection of cases that required further evaluation. All kidneys with APRPD >15mm demonstrated obstruction or VUR and required uroradiological investigations. Voiding cystourethrography was an indispensable complement to US in these cases; it delineated their
lower urinary tract anatomy and differentiated VUR from obstruction as a cause of sonographically detected hydronephrosis. Cases with moderate hydronephrosis (< or = 15mm) were associated with an excellent prognosis. The majority of renal anomalies diagnosed in this survey were clinically unsuspected. Out of the 15 neonates with renal abnormalities, only five (one third) presented with manifestations related to the urinary tract. Two neonates presented with abdominal mass, two neonates presented by signs and symptoms of sepsis and the last one presented with ARF. This point clarifies the importance of US as a postnatal screening test in all neonates. Ultrasound facilitates precise measurement of renal length. We used this advantage to identify the normal renal length in Egyptian neonates. We did not find any significant difference between the length of the left kidney and that of the right kidney. The right and left kidneys were of equal length in 36% of neonates. Renal length correlated more with body length and weight than with age. In accord with us, Han and Babcock, Blane et al, and Dinkel et al reported similar observations. Thus when looking for renal diseases evidenced by overall renal length, the best correlate of one kidney is the other kidney. This works well for unilateral renal disease. On the other hand, when looking for bilateral renal disease affecting renal size, renal length is better predicted by a body measurement such as length and/or weight rather than age. In our study and relevant studies, no sex-related differences were found in renal length. There was a close similarity between our study and that of Blane et al, as regard the range and mean of renal length. Accordingly, the renal length of Egyptian neonates can be interpreted or predicted by body length and/or weight using the nomogram designed by Blane et al.

Conclusion:

The prevalence of congenital renal anomalies was 30 per 1000 neonates in our community. The most common renal anomaly detected was hydronephrosis. Renal pelvic diameter served as a prognostic factor and indicator for the need of further investigations. Posterior urethral valve was the main underlying etiology of hydronephrosis. Male sex was proved to be a risk factor for occurrence of renal anomalies. The sonographic renal length of the Egyptian neonate could be safely predicted by body length and/or weight using the western nomogram. We believe, following our study, that the screening for renal malformations of all the neonatal population is a goal to pursue and to achieve as soon as possible for its high sensitivity and specificity.

References: