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Original Article (Pages: 12235-12242)

Ultrasound Measurement of Kidney Dimensions in Premature Neonates

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Abstract

Background
Ultrasonography is a non-invasive and accurate diagnostic method to evaluate urinary system and its anomalies in the neonates. Kidney sonographic measurement can be used as an alternative method to estimate gestational age. The aim of this study was to measure kidney size in preterm neonates and to provide a guide reference for gestational age.

Materials and Methods: Four hundred kidneys (in both sides) of 200 preterm neonates born with gestational age less than 37 weeks were evaluated in the present cross sectional study. Newborns with intrauterine growth retardation (IUGR), asphyxia, high grade hydronephrosis, single kidney, polycystic kidney, duplex kidney, dysplastic kidney and hydroureteronephrosis were excluded. Ultrasound investigations were performed in supine and lateral decubitus positions. Birth weight, gestational age, height and sex were recorded. Data were analyzed using SPSS software version 16.0.

Results: The mean gestational age of patients was 33.8±2.2 weeks. Mean kidney length, width, and thickness were 38.8±3.8 mm, 18.9±2.6 mm, and 21.3±2.6 mm, respectively. In addition, the kidney volume was 84037±2533.4 mm3. Mean diameter of the kidney and its volume were significantly higher in male neonates ($p<0.05$). Kidneys length and volume had a strong correlation with neonatal birth weight ($r=0.608$, $p<0.001$, $r=0.663$, $p<0.001$, respectively).

Conclusion
A significant positive correlation was observed between renal dimensions and birth weight, gestational age, and height of patients. The results of this study showed that the trend of kidney growth can be used as a reference guide for gestational age in premature neonates.

Key Words: Newborn, Premature, Kidney size, Ultrasound.

*Please cite this article as: Esmaeili M, Keshaki M, Younesi L, Karimani A, Otoukesh H, Esmaeili M. Ultrasound Measurement of Kidney Dimensions in Premature Neonates. Int J Pediatr 2020; 8(10): 12235-242. DOI: **10.22038/ijp.2020.39892.3392**

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Received date: Feb.23, 2020; Accepted date: Mar. 22, 2020

1- INTRODUCTION

Although improvement in medical care in pregnant women and premature births is increasing, premature born and low birth weight infants are prone to kidney damage and its associated complications in future (1-3). In certain pathologies, such as polycystic kidney disease, changes in kidney size may occur even before echogenicity alterations. Hence, knowing the size of normal kidneys in pre-term infants and fetuses is essential to determine abnormal renal size and urinary tract anomalies (4-6). Ultrasonography as a safe and non-invasive, widely accessible, and cost-efficient imaging technique is essential for the diagnosis of urinary tract anomalies in the children and newborns. Sonographic assessment of renal dimensions during fetal course can be used as an alternative method to determine the gestational age (7, 8).

Although several studies have been conducted on kidney size in various populations and pediatric age groups, very few studies with some limitations have been performed on preterm infants, which have led to a lack of sufficient data to provide optimal nomogram standards and their relation to anthropometric indices (9-14). However, racial factors and maternal feeding in different parts of the world can be an important factor in the development of fetal organs. To our knowledge, no study has been performed on premature infants about the size of kidneys in our country (Iran). The aim of this study was to investigate the size of kidneys in premature infants by ultrasonography and introduce the kidney size as a reference guide for gestational age.

2- MATERIALS AND METHODS

2-1. Study design and population

This prospective cross-sectional study was performed in 2015-2016 in Akbarabadi hospital, one of the maternity hospitals in Tehran, Iran. The study population was preterm infants with gestational age less than 37 weeks who were consecutively admitted to the newborn ward over a period of two years. A sample size of 138 was calculated by using the MedCalc statistical software. To increase the accuracy of the study and the possibility of eliminating inaccurate data, the sample size was increased to 200 people.

2-2. Inclusion and exclusion criteria

All newborns with intrauterine growth restriction (IUGR), apparent congenital anomalies, asphyxia, hydronephrosis grade II and higher (based on Society of Fetal Urology grading system), all dysplastic, multicystic, polycystic, single and duplex and hydroureteronephrosis kidneys were excluded. Finally, 200 preterm infants with gestational age less than 37 weeks (based on the mother's last menstrual date (LMP) or the New Ballard scoring in the absence of LMP) were assessed by the ultrasound imaging of the kidneys and urinary tract in supine position in the first three days of life.

2-3. Ethical consideration

Written informed consent was obtained from all the mothers of the infants. The project was approved by ethics committee of Iran University of Medical Sciences (ID- code 954176). All kidney dimensions were measured by one radiologist with 5 years of experience in the field of obstetrics and gynecology and newborns sonography.

2-4. Measuring tool

Ezoate Ultrasound scanner device with 11 MHz transducer was used. The kidney dimensions included the length diameter (upper pole to lower pole), width (mediolateral diameter), and thickness (anteroposterior diameter) were reported based on millimeters (mm). Kidney volume was calculated using the following formula: Volume = length × width × thickness × 0.5232 (15).

2-5. Data Analyses

The data were analyzed using SPSS software version 16.0. T-test, Mann-Whitney, and Wilcoxon test were used to compare the means and Spearman's rho test was utilized to find the relationship between data. P-value less than 0.05 was considered as significant. Normalization of data was confirmed by Kolmogorov-Smirnov test.

3- RESULTS

A total of four hundred kidneys (in both sides) in 200 premature neonates with mean gestational age 33.8±2.2 weeks were evaluated by ultrasound method. The mean ± standard deviation of gestational age (weeks) in male and female neonates was 34.01±2.4 and 33.7±1.8 (P=0.388), respectively. Body weight (g) in male and female neonates was 2190±608 and 1953±514 (P=0.032), respectively. In addition, the height (cm) in male and female neonates was 45.2±3.7 and 44.02±4.05 (P=0.004), respectively. Mean kidney length, width, and thickness were 38.8±3.8 mm, 18.9±2.6mm, and 21.3±2.6 mm, respectively. Moreover, kidney volume was 84037±2533.4 mm3. No significant difference in renal dimensions was observed between the right and left kidneys. Mean renal dimensions were significantly higher in male neonates. The average renal length in the boys and girls was 39.4 ± 3.9 mm and 37.9 ± 3.3 mm, respectively and the difference was statistically significant (P = 0.006). The mean width of kidney in the male and female neonates was 19.3 ± 2.4 mm and 18.4 ± 2.5 mm, respectively and the difference was statistically significant (P =0.02). The average renal thickness in the boys and girls was 21.7 ± 2.7 mm and 20.7 ± 2.3 mm, respectively and the difference was statistically significant (P =0.008). The mean renal volume in the boys and girls was 88722.3 ± 2661 mm^3 and 77286.1 ± 2174 mm^3, respectively and the difference was statistically significant (P=0.002). The average kidney dimensions in both genders are shown in **Table.1**.

Findings showed that there was correlation between height and length of kidneys (r=0.375, P<0.001), and moderate correlation between gestational age and renal length (r =0.461, P <0.001), but a strong correlation was found between birth weight and kidney length (r =0.608, P<0.001) (**Figure.1**). There was a moderate correlation between gestational age and kidney volume (r =0.462, P=0.003), and between height and kidney volume (r =0.403, P <0.001). In addition, a good correlation was found between birth weight and kidney volume (r =0.663, P<0.001) (**Figure.2**). The average renal size as well as height and weight of neonates in different gestational weeks, are shown in **Tables 2-4**.

Table-1: The average dimensions and volume of the kidneys in 200 premature neonates.

Kidney dimensions	Boy (mean ± SD)	Girl (mean ± SD)	P-value
Length(mm) left kidney	39.3±4.2	37.6±3.5	0.004
Length(mm) right kidney	39.4±4.2	38.1±3.8	0.029
Width(mm) left kidney	19.4±2.8	18.5±3.2	0.035
Width(mm) right kidney	19.1±3.02	18.3±3.08	0.053
Thickness(mm) left kidney	21.9±2.9	20.7±2.8	0.002
Thickness(mm) right kidney	21.4±3.2	20.7±2.8	0.095
Volume(mm^3) left kidney	87554.4±311	77397±240	0.014
Volume(mm^3) right kidney	89903.4±266	77174.3±240	<0.001

SD: Standard deviation.

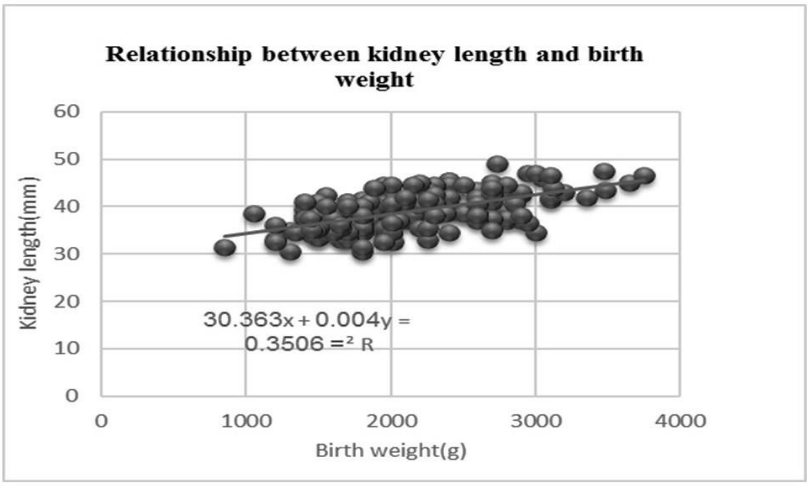

Fig. 1: Relationship between kidney length and birth weight in premature neonates.

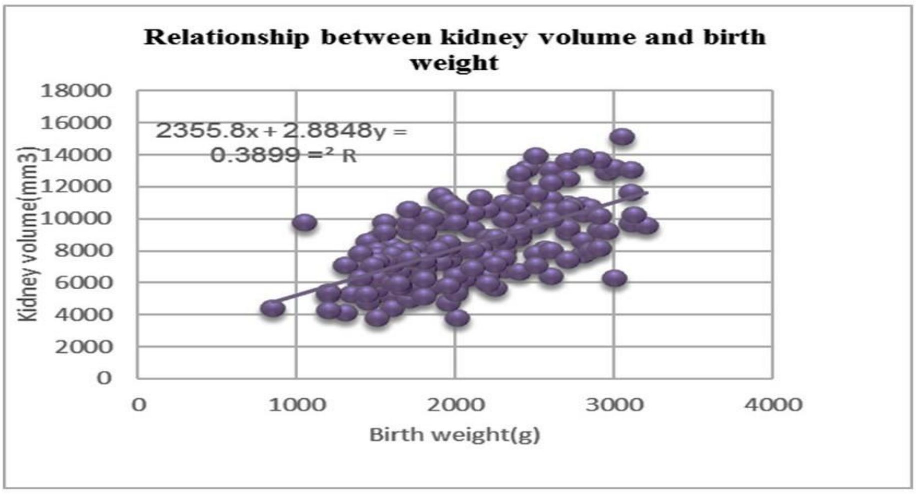

Fig.2: Relationship between kidney volume and birth weight in premature neonates.

Table-2: The average dimensions and volume of kidney in 200 premature neonates according to gestational age.

Gestational weeks	Length(mm) (Mean±SD)	Width(mm) (Mean±SD)	Thickness(mm) (Mean±SD)	Volume (mm^3) (Mean±SD)
27-30 weeks	35.6±4.4	18.5±3.1	18.9±2.7	68035.9±2793.5
31-32 weeks	37.0±2.3	17.8±1.9	20.6±2.6	71951.6±1433.0
33-34 weeks	37.9±3.3	18.4±2.3	21.0±2.3	78983.0±2201.1
35-36 weeks	40.7± 3.5	19.5±2.7	21.9±2.7	92861.9±2444.2
37 weeks	42.4±3.9	22.4±2.2	23.9±2.8	120314.9±2578.1
P- value	<0.001	<0.001	<0.001	<0.001

SD: Standard deviation.

Table-3: The average dimensions and volume of kidney in 200 premature neonates according to birth height.

Neonate height	Length(mm) (Mean±SD)	Width(mm) (Mean±SD)	Thickness(mm) (Mean±SD)	Volume (mm^3) (Mean±SD)
32-34 cm	35.8±2.5	16.3±2.4	19.7±7.4	62141.1±1544.9
34.1-36 cm	36.0±1.4	17.9±1.6	20.1±2.4	75282.7±4396.3
36.1-38 cm	37.1±2.1	18.1±3.3	20.5±2.1	75615.7±6936.7
38.1-40 cm	37.3±4.2	18.2±1.9	20.2±2	75750.7±1674.8
40.1-42 cm	37.7±8.8	18.5±6.3	20.7±0.3	75819.1±2543.7
42.1-44 cm	37.7±2.9	19.5±0.7	20.7±2.2	76423±3856.1
44.1-46 cm	39.2±3.6	19.0±2.4	21.1±3.0	82622.7±2190.6
46.1-48 cm	40.0±3.6	20.2±2.8	22.3±2.4	96186.3±2499.1
48.1-50 cm	40.9±3.6	20.9±2.7	22.6±2.3	103200.6±2820.2
P- value	<0.001	<0.001	<0.001	<0.001

SD: Standard deviation.

Table-4: The average dimensions and volume of kidney in 200 premature neonates according to birth weight.

Neonate weight (g)	Length(mm) (Mean±SD)	Width(mm) (Mean±SD)	Thickness(mm) (Mean±SD)	Volume (mm^3) (Mean±SD)
<1000 g	31±1.08	16.0±1.3	14.5±2.6	44195.1
1001-1250 g	35.0±2.7	16.7±2.5	19.4±2.8	62023.4±2455.5
1251-1500 g	36.5±2.4	16.8±2.2	20.1±2.2	65397.1±1307.9
1501-1750 g	36.6±2.3	17.8±1.8	20.2±2.1	70319.1±1495.7
1751-2000 g	38.0±2.5	18.8±2.0	21.1±2.0	77003.4±1826.8
2001-2250 g	39.2±2.6	18.1±2.4	20.4±2.0	80343.2±1857.9
2251-2500 g	40.9±2.6	20.2±2.0	22.3±2.4	97770.3±1956.8
>2500 g	41.8±3.7	21.1±2.6	23.2±2.7	109300.2±2659.9
P-value	<0.001	<0.001	<0.001	<0.001

SD: Standard deviation.

4- DISCUSSION

Every premature and low weight newborn is prone to kidney damage, knowing the size of normal kidneys in premature neonates is necessary to determine the kidney and urinary tract anomalies. Ultrasonography is a non-invasive and accurate diagnostic method to evaluate urinary system and its anomalies in the neonates. The aim of this study was to measure kidney size in preterm neonates and to provide a reference guide for gestational age. The mean gestational age of patients was 33.8±2.2 weeks. Mean kidney length, width, and thickness were 38.8±3.8 mm, 18.9±2.6 mm, and 21.3±2.6 mm, respectively. In addition, the kidney volume was 84037±2533.4 mm3. Mean diameter of the kidney and its volume were significantly higher in male neonates (P<0.05). Kidneys' length and volume had a strong correlation with neonatal birth weight (r =0.608, p <0.001, r =0.663, p <0.001, respectively). Failure in the filtration of waste products, inability to produce concentrated urine by the immature kidneys, birth problems such as asphyxia and frequent exposure to nephrotoxic medications may lead to higher risk of renal disease in premature infants. Measurement of kidney dimensions is important in identifying the problem, treatment and follow-up in this age group. Ultrasound is a simple, non-invasive, and relatively inexpensive diagnostic tool to assess kidney size. Although several studies have been performed about the sonographic assessment of the kidneys in pediatric age group in various populations, so far few studies have been performed on the size of the kidneys in newborns, especially premature infants. To our knowledge, so far no similar research has been conducted in Iran (4). Daud and his colleagues determined the size of kidneys in preterm neonates. They found a positive correlation between the size of kidneys and weight, height, head circumference and gestational age (14). Similar to our study, there was a strong correlation between weight and kidney size, although the number of their investigated newborns was too small. Erdemir et al. in 2013 investigated renal dimensions in premature infants.

The results of their study showed there are significant differences between male and female newborns regarding all dimensions of the kidneys. Length and thickness of the kidneys showed high correlation with weight, height and gestational age in both genders. Right kidney thickness was also larger than left one (16). The result of our study in some aspects was similar to their finding, whereas in our study as a positive point, determination of gestational age was based on mother's last menstrual date or New Ballard scoring.

In addition, we assessed correlation of kidney volumes and newborns anthropometric factors. Soyupak et al. in 2002 studied liver, spleen and kidneys size in 99 premature infants. The relationship between length and width of the kidneys with birth height and weight was confirmed. They found that the weight showed the best correlation with any one of the renal dimensions against age and height. Small for gestational age (SGA) infants in this study were not excluded, which could count as a confounding factor in the judgment (17). In a study in 2010, van Venrooij et al. investigated renal dimensions in 30 premature infants. In this study, infants aged less than 31 weeks and less than 1500 g were enrolled. Kidneys growth over a three-month period was studied. This study showed that there was not a significant difference between left and right kidneys but the best correlation was found between weight and renal dimensions (7). Chiara et al. and Schlesinger et al. studied the kidneys length in small numbers of newborns. Only the correlation of renal length and weight was reported in these studies. The number of newborns in their studies were too low and were not able to provide a nomogram and the reference standard (18, 19). In the United States, Chen and colleagues examined the size of the kidneys in children aged one week to 18 years. The kidney length was reported larger in boys than girls, and the left kidney was larger than the right one in the study population (20).

In a study managed by Konus et al. in Turkey, dimensions of the kidney were measured in children, and no significant difference was found between girls and boys. They reported that the length of left kidney was longer than right one.The highest correlation was observed between height and kidney size (21). A report by Dinkel et al. showed that there is a correlation between kidney volume and weight. They reported that the length of left kidney is longer than the right kidney (22). Although many studies have been previously performed on the size of the kidneys in premature and term infants in the years prior to 2000 (15, 24, 25), with technological advancement in ultrasound instruments, the accuracy of these studies is not comparable with the current researches.

Sultana et al. in 2012 investigated renal dimensions in 100 term newborns. There was no significant difference in kidney dimensions between both sides and genders. There were correlations between renal dimensions and volume with gestational age, weight, length, body mass index (BMI) and body surface area (BSA) (26). Nandini et al. reported birth weight and neonatal length were independent predictors of renal length (27). But, according to our knowledge, determination of BSA and BMI may be associated with error and may not be practical. In the present study, kidney dimensions on both sides were not significantly different in the two sexes. Contrary to a study on Saudi children (28), similar results were obtained in the Erdemir et al. study (16); Chen et al. (20), Konus et al. (21), and Dinkel et al. showed that the left kidney dimensions were larger than the right kidney (22). This difference may also be due to different age distribution. In Erdemir et al.'s study and our study, only premature infants were enrolled, while in other studies pediatric age group was considered.

Our study showed the highest correlation between birth weight and renal length and volume. The results of our study are consistent with some previous studies and it seems that indicators such as weight have the highest correlation with the size of the kidneys. The present study is unique to express kidney dimensions according gender, based on different gestational ages and different weight and height in premature neonates, which can be used as a reference guide. One drawback of our study is that the kidneys dimensions were only determined once and perhaps independent measurement done twice would make it more accurate.

5- CONCLUSION

The results of the present study indicate that renal dimensions in all different gestational ages, as well as different height and weight in premature infants can be used as a guide and reference in this age group. This study confirmed the good correlation between gestational age, weight, and height with kidney dimensions in premature infants.

6- CONFLICT OF INTEREST: None.

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