Assessment of kidney size in newborns

Abstract:

Introduction: Ultrasonographic assessment of renal size in newborns is important for diagnosis of renal disease in neonatal period. It is well known that changes in renal dimensions may precede kidney echotexture changes in certain renal pathologies. The aim of this study is to conduct a systematic review to evaluate kidney dimensions in premature and full term newborns.

Method: We search all English language studies and the articles related to kidney dimension in neonate and children in Google scholar, PubMed and Scopus website and selected those due to premature and term newborns. We identified 74 retrieved studies from electronic database. After studying the titles and abstracts we selected 10 included articles that were mach with aim of this study and reviewed articles full text.

Result: The studies on kidney dimension of newborns had been reported among various populations. Some studies had been conducted regarding the comparison of renal diameters with body weight and length at first days of birth. Some others have compared the gestational age with renal size, but without any conclusive results. There were numerous studies about kidney size in childhood and fetal period but limited investigation in neonatal period. In this paper the kidney dimensions correlation with gestational age, length, weight, and body surface area was analyzed by reviewing the literature.

Conclusion: although kidney volume is regarded as the most precise index of kidney size, kidney length is the easiest practically indicator of kidney dimensions that is correlated to anthropometric and gestational age of neonates.

Keywords: Infant, Newborn, Ultrasonography, Reference values, Premature

Introduction:

The assessment of kidney dimension is an important and integral part of evaluation, identification, management and follow up for renal disease in newborn period.

In neonatal period renal dimension is changing with age, when kidney and urinary tract abnormalities are common and when it is the best time for diagnosis and workup of renal abnormalities. This is true particularly for preterm and/or low birth weight newborns that are thought to be risk factors for kidney diseases.

Ultrasound is an important and valuable imaging modality for evaluating kidney size and congenital renal and urinary tract abnormalities. It is well known that some conditions to affect the changes in kidney dimensions prior to any changes of kidney echotexture in certain kidney lesions (1).

Ultrasonography as a tool is widely available, free of ionizing radiation, noninvasive, inexpensive which can be performed at bed side. We know that the kidney size was accurately measured on intra venous urography in non infant ages previously which had its own disadvantages (2). Whereas there were numerous studies about renal size in childhood and fetal periods but there was a limited investigation about kidney diameters in neonates. The aim of this study is to provide a review of all English articles about kidney size in neonates.

Methods:

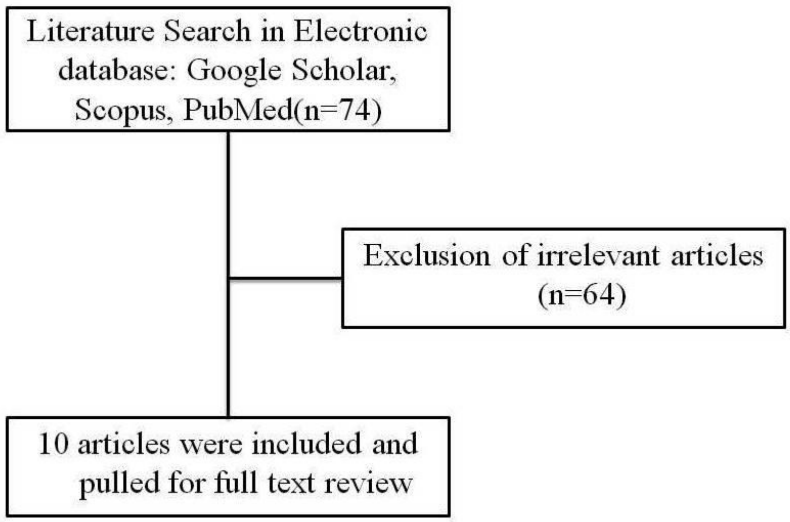
Our search strategy was to review any English language articles including the abstracts about kidney dimensions in newborns and children and to select full text articles about renal size in premature and full term neonates, the search terms in this article was "kidney size" and newborns.

We search all English language studies that were related to kidney dimension in neonate and children in Google scholar, PubMed and Scopus website and selected those due to premature and term newborns. After studying the titles and abstracts we selected those articles that were matched with aim of our study and reviewed full text of themes.

Results:

We found 74 articles were retrieved according to our search strategy after reviewing the title and abstracts. We included 10 articles that fulfill our inclusion criteria after reviewing the articles full text.

Figure 1: PRISMA flowchart diagram of reviewed articles



The studies a kidney dimension of newborns had been reported among various population some studies had been conducted regarding the comparison of renal diameters with body weight and length at first days of birth. Some others have compared the gestational age with renal size, but without any conclusive results.

We found beneficial results from data and information derived from articles about kidney dimensions in neonatal period. Applicable information and data of one relevant articles that were included in our study is summarized in table 1.

Table 1: The extracted data of included articles

Author Year Reference	No. of Neonates	Gestational age (GA) Week (wk)	Weight (WT) g	Renal Length (mm)	Difference between Right (R) and Left (L) Kidney	Difference between Sexes Boy (B), Girls (G)	Correlation with GA, WT, Length, BSA
DeVries 1983 (5)	100	26-42	-	25-45	R=L	B=g	Positive correlation with WT, Length
Scott 1990 (4)	560	33-42	3291±517	38-48	R<L	B=g	Best Correlation with Head circumference
Gupta 1992 (1)	71 Preterm 29 Term	26.1-37 wk 33.9±4.4 wk	540-3250 1623±685	27.9±7.4	R=L	B=g	Best Correlation with BSA*
Soyupak 2002 (6)	99 Preterm 154 Term	24±4 36.8±3.8	2872±834	36.4±5 41±4	R=L	B=g	Best Correlation with WT
Daud 2006 (14)	128	71 SGA**, 57 AGA***	1100-4200	35±5	R<L	B=g	Best Correlation with WT
Adeyekun 2007 (15)	150	Term	1900-4100	44.4±44.9	R=L	B=g	Positive correlation with WT, Length
Natalie 2010 (19)	30	<31 wk	<1500	26±35	R=L	B=g	Best Correlation with GA
Otiv 2012 (16)	71	Term	2500±40	43±6	R=L	B=g	Best Correlation with Length
Erdemir 2013 (3)	498	30.6±3.3	1595±628	29.8-43.7	R=L	B>g	Best Correlation with WT
Erdemir 2013 (18)	385	39.7±0.7	3266±391	38-47.3	R<L	B>g	Best Correlation with WT

* BSA: Body surface aria
** SGA: Small for Gestational Age
***AGA: Appropriate for Gestational Age

Discussion

Gupta et al reported the result of kidney sonography in 100 healthy newborns that comprised of 71 premature and 29 term neonates, appropriate for gestational age (AGA). The gestational ages were from 26.1 to 41.3 weeks with mean ± standard deviation (SD) (33.9±4), weight 540 to 3260 grams with mean 1623 grams (SD=685.5).

This study showed no significant difference in mean of renal volume between right and left renal length. It is found no statistically difference between renal dimensions in boys and girls. On statistical analysis a significant correlation was observed between renal dimensions and gestational age, length, weight and body surface area (BSA) (1).

In order to assessment of kidney size in newborns Erdemir et al determine the reference ranges of kidney dimensions in preterm newborns and to provide a chart to use easily in daily practice. They evaluated renal dimensions in 498 preterm infants (226 girls and 272 boys) with a gestational age of <37 weeks using sonography within the first week of life. Infants with congenital anomalies and those who were small for gestational age were excluded from the study. Infants with abnormal sonography such as hydronephrosis, dysplastic kidneys or duplex kidneys were also excluded. . All dimensions of the kidneys were statistically different in boys and girls ($P<0.05$). Both length and thickness dimensions of the right and left kidneys showed high correlation with gestational age, weight and height in girls and boys. Weight correlated best with dimensions No statistically significant differences were found between the length dimensions of the right and left kidneys but thickness dimensions of the right kidney were higher in both genders (3).

In report of Scott et al (Newcastle, 1986) between 48 and 72 hours after delivery renal measurements were made by ultrasonography in 560 healthy newborn infants. Three dependent variables (renal length, renal depth, and renal area) were measured, together with three independent variables (birth weight, head circumference, and gestational age). There was a significant difference between right and left kidneys in length and depth for each independent variable. Renal thickness and area in boys were significantly larger than in girls. The data showed a consistent significant difference in shape between the two kidneys; as the babies became larger the left kidney became comparatively longer and thinner, and the right shorter and fatter. It seems likely that the changing shape was caused by the liver, which in the newborn is larger in proportion to the volume of the abdominal cavity than in later life (4).

In study of DeVries one hundred unselected infants ranging from 26 to 42 weeks' gestational age. The first Urinary tract ultrasonography was performed within the first 3 days of life, 82% of them within 48 hours.

The ratio of kidney length to newborns height made in 20 infants. The ratio was from 0.70 to 0.85 with a mean of 0.78. In infants who were either small or large for gestational age the renal size was in proportion with the length of the newborn. There was no significant difference in the length between the right and left kidneys (5).

One study was conducted by Su¨reyya K. in order to assess normal liver, spleen and renal dimensions in premature and term neonates and presents the acceptable range. A total of 253 (99 preterm and 154 term) healthy newborns were evaluated within the first week of life by sonography. Gestational age ranged from 24 to 41 weeks, weight was from 638 to 4800 g. they showed that weight was the best correlation with any one of the mentioned organ dimensions. There was no significant difference in organ dimensions with respect to gender (P_0.05). Difference of organ dimensions between preterm and term infants were significant (P_0.005) and increased as gestational age increased (P_0.001) (6).

SULTANA et al reported the kidney dimensions in one hundred inborn, healthy, appropriate for gestational ages, term infants that were examined by sonography within 72 hours of birth. In 52 boys and 48 girls body weight (BW), supine length (SL), occipito-frontal circumference(OFC) were extracted from delivery room records, and body surface area (BSA) was calculated using the formula BSA=BW(kg)0.425 ×BL(cm)0.725×0.007184 and BMI=Weight(kg)/height(m)2. There were no significant differences in mean renal length and volume between right (39.22±4.32 mm, 9.79±2.80cc) and left (38.36±4.30 mm, 9.82±2.24cc) and kidneys in boys (right kidney 39.77±4.28mm, 10.30±2.69cc, left kidney38.62±3.68mm, 9.91±2.06cc) and girls (right kidney 38.63±4.32mm, 9.23±2.83cc left kidney 38.09±4.91mm, 9.73±2.43cc). Kidney length was correlated better with BMI (<0.001), BW (<0.01) and BSA. (<0.05). Renal volume was also correlated with BW (<0.05), BMI (<0.05) and BSA (<0.05). No correlation found with gestational age, length and OFC (7).

In the literature, there are few detailed studies to interpret the renal dimensions in newborns. However, sonography is one of the most common imaging methods used in routine practice. During the neonatal period, ultrasonography (US) mostly represents the primary imaging modality of choice. This technique provides a quick assessment of visceral organ dimensions without any risk of radiation. Ultrasonography (US) is appropriate for the evaluation of renal pathology in newborns because it lacks ionizing radiation, can be performed bed-side and is inexpensive and widely available. The examination is real time, tridimensional, independent of organ function and phase of respiration. Neonatal kidneys can be clearly visualized with real time ultrasound .The portability of the equipment allows rapid scanning of most infants-including those on mechanical ventilators or those undergoing other forms of intensive care-and with little handling or disturbance. Although the technique is simple, some experience is necessary

Before repeatable measurements are obtained. The best visualisation of the kidneys is obtained during the first few days of life before the child is established on gastric feeds. Once the bowel becomes full of gas total reflection of sound from the gas or tissue interface occurs, making precise measurement of the kidneys more difficult. The assessment of renal size is an integral part of evaluation of renal diseases the normal range of renal dimensions at a given age must be known before an abnormality can be diagnosed. Renal dimensions have been investigated by many authors for pediatric age groups but studies about renal dimensions in newborns are limited. Limited data are available on normative standards of renal dimensions in preterm and term newborns.

Soyupak et al. (8) have reported the kidney dimensions of 99 preterm newborns and van Venrooij et al. (9) determined renal lengths in 30 preterm newborns. The study of Chiara et al. (10) included 121 newborns that were preterm and also full-term newborns. Schlesinger et al. (11) studied kidney lengths in 52 preterm newborns.

There is no consensus on which measurement parameter is most sensitive for investigating the normal limits of renal dimensions. In 1983; the kidney lengths of 100 newborn infants, ranging in gestational age from 26-42 weeks were measured. In 20 of these infants, the ratio of kidney length to crown-to-heel measurement was calculated. It was found that kidney length remained in proportion to the length of infant, Irrespective of whether the infant was small or appropriate for gestational age (5).

In the same year, in another study of 36 newborn infants, no correlation of kidney length with crown-to heel measurement was found (12).

In another study in 1987 a poor correlation was found between kidney length and body length measured in 52 pre-term, appropriate for gestational age (AGA) infants (11).

It was thought that body length measurements are inaccurate in the newborn period because of the infant's flexed posture and this may be the reason of this poor correlation. It is not practical to use the volumes of the kidneys.

The renal volume is calculated by the formula: Volume=0.5233×length×width× thickness. Total body surface area (BSA) is determined by BSA= $weight^{0.425}\times length^{0.725}\times$ 71.84. BMI is calculated as weight (kg)/height (m2) (1, 13).

Scot et al had very interesting observations regarding to the kidney size in males and females. They found that the kidneys of male babies are longer than female ones in all dimensions, but their rate of increase differs. Kidney length of males increased faster with increasing birth weights and head circumferences than females, but the kidney depth increased at similar rate in both males and females (4).

The babies included in Daud et al study were limited to infants of less than 72 hours age, because gestational age was one of the independent variable they were studying and gestational age can be assessed reliably only during the first 72 hours of life. Furthermore, there is a normal initial loss of weight in the newborn babies which returns to the birth weight (14).

Adeykun AA and collegue showed significant correlation with renal length and renal volume with neonatal weight and length (15).

Although the renal length correlated best with body height and body surface area, the calculation of body surface area is cumbersome and requires multiple measurements. In clinical practice, the body height and weight can be quickly recorded to compare the actual renal length with the renal norm. Similarly, since the estimation of renal volume requires measurement of three dimensions of the kidney, the error associated with renal volume increases in geometric proportion. Hence it is simpler to use renal length as a yardstick for comparing renal growth with body growth (16).

Fitzsimons RB also found significant correlation between kidney length and birth weight (17).

Assessment of kidney dimensions in 385 term neonates showed the kidney length of right kidney was larger than the left one and the birth weight had the best correlation with the length of kidney (18).

Natalie A evaluated renal length and growth in 30 premature newborns and showed a positive correlation of kidney size and growth with weight and gestational age (19).

Conclusion:

although kidney volume is regarded as the most precise index of kidney size, kidney length is the easiest practically indicator of kidney dimensions that is correlated to anthropometric and gestational age of neonates.In the present article reviewed the neonatal renal size which correlated well with most commonly used parameters of overall body size including age, body weight, body height, body surface area and gestational age. We hope this study contributes to daily practice in neonates and radiology clinics

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Conflict of interest

The authors declare no conflict of interest

References:

1- Gupta AK, Anand MK, Lamba IS. Ultrasound evaluation of kidney dimensions in neonates. Indian Pediatr. 1993; 30:319-24.

2- Hodson CJ, Drewe JA, Karn MN, et al. Renal size in normal children: a radiographic study during life. Arch Dis Child. 1962; 37:616-22.

3- Aydin Erdemir, Zelal Kahramaner, Ebru Cicek, et al. Reference ranges for sonographic renal dimensions in preterm infants. Pediatr Radiol (2013) 43:1475–1484.

4- Scott JES, Hunter EW, Lee REJ, et al. Ultrasound measurement of renal size in newborn infants. Arch Dis Child 1990; 65: 361-65.

5- 5-DeVries, Levene MI. Measurement of renal size in preterm and term infants by real time ultrasounds. Arch Dis Child. 1983; 58: 145-47

6- Su¨reyya K. Soyupak a, Nejat Narli, et al. Sonographic measurements of the liver, spleen and kidney dimensions in the healthy term and preterm newborns. European Journal of Radiology 43 (2002) 73–78

7- Sabina Sultana, Shafiqur Rahman, Biplob Kumar Basak, et al. determination of kidney length and volume by ultrasound in 100 term Bangladeshi newborn. Bangladesh J Child Health 2012; Vol 36(1):26-29.

8- Soyupak SK, Narli N, Yapicioğlu H, et al. Sonographic measurements of the liver, spleen and kidney dimensions in the healthy term and preterm newborns. Eur J Radiol 2002; 43:73–78.

9- Van Venrooij NA, Junewick JJ, Gelfand SL, et al. Sonographic assessment of renal size and growth in premature infants. Pediatr Radiol 2010; 40:1505–1508.

10- Chiara A, Chirico G, BarbariniM, et al. Ultrasonic evaluation of kidney volume in term and preterm infants.AmJ Perinatol 1993;10:109–111

11- Schlesinger AE, Hedlund GL, Pierson WP, et al. Normal standards for kidney length in premature infants: Determinations with ultrasound. Radiology 1987; 164: 127-29.

12-Holloway H, Jones TB, Robinson AE, et al. Sonographic determination of renal volumes in normal neonates. Paediatric Radiol 1983; 13: 212-4.
13-Han BK, Babcock DS. Sonographic measurements and appearance of normal kidneys in children. AJR Am J Roentgenol 1985; 145:611-6.
14-Aamir Daud, Ashraf Achakzai, Habib-ur-Rehman, et al. A comparative study of renal size in newborn babies. Gomal Journal of Medical Sciences July–Dec 2006; Vol. 4, No. 2.
15-Adeyekun AA, IbadinMO, Omoigberale AI. Ultrasound assessment of Renal size in healthy term neonates; A report from Benin City, Nigeria. Saudi J Kidney Dis Transplant 2007; 18(2): 277-81.
16-A otiv, k mehta, u ali, et al. Sonographic Measurement of Renal Size in Normal Indian Children. Indian pediatrics 2012; volume 49.
17-Fitzsimons RB. Kidney length in the newborn measured by ultrasound. Acta paediatric sound, 1983; 72(6): 885-7.
18-Aydin Erdemir, Zelal Kahramaner, Bilal Arik, et al. Reference ranges of kidney dimensions in term newborns: sonographic measurements. Pediatr Radiol (2014) 44:1388–1392.
19-Van Venrooij NA1, Junewick JJ, Gelfand SL, et al. Sonographic assessment of renal size and growth in premature infants. Pediatr Radiol. 2010 Sep;40(9):1505-8.