



Assessment of the Kidney Size in Newborns

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ABSTRACT

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Introduction: Ultrasonographic assessment of the kidney size in newborns is essential to the diagnosis of renal diseases during the neonatal period. According to the literature, altered renal dimensions may lead to changes in the kidney echotexture in certain renal pathologies. This systematic review aimed to evaluate the renal dimensions in premature and term neonates.

Methods: This systematic review was conducted to identify the English articles on the renal dimensions of children and premature/term neonates via searching in databases such as PubMed, Google Scholar, and Scopus. In total, 74 studies were retrieved from the electronic databases. After reviewing the titles and abstracts, 10 articles that were in line with the study objectives were selected in full text and evaluated.

Result: The studies on the renal dimensions of newborns had been performed on various populations. Some studies had compared kidney diameters with the body weight and length of the neonates within the first days of birth, while some others had compared the gestational age of neonates with their kidney size. However, no conclusive results were proposed. In addition, several studies were found on kidney size during the fetal period and childhood, while limited investigation was available regarding the neonatal period. In the present study, we analyzed the correlations between the renal dimensions of neonates and their gestational age, length, weight, and body surface area by reviewing the current literature.

Conclusion: Although renal volume is considered to be the most precise index of the kidney size, renal length is evidently the most practical indicator of renal dimensions, which is correlated with the anthropometric indices and gestational age of neonates.

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Introduction

Assessment of renal dimensions is an integral part of the evaluation, identification, management, and follow-up of renal diseases in newborns. In the neonatal period, the renal dimensions change with age. Since kidney and urinary tract abnormalities are relatively prevalent among newborns, the neonatal period is considered to be the best time for the diagnosis and workup of renal abnormalities, particularly in the preterm and/or low-

birth-weight neonates that are high-risk for renal diseases.

Ultrasound is a valuable imaging modality for evaluating the kidney size, as well as congenital renal and urinary tract abnormalities. According to the literature, altered renal dimensions lead to changes in the renal echotexture of certain kidney lesions (1). As a widely available tool, ultrasonography is a noninvasive, cost-efficient tech-

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nique without ionizing radiation, which could be performed at the patient's bedside. Apart from infants, the kidney size could be measured accurately by intravenous urography in the other age groups, which may also have certain shortcomings (2).

Although numerous studies have been focused on the kidney size during childhood and the fetal period, there is limited investigation regarding the kidney diameters in neonates. The present study aimed to review all the English articles on the kidney size in neonates.

Methods

Literature Search methods

This systematic review was conducted to identify all the English articles on the renal dimensions in neonates and children via searching in databases such as PubMed, Google Scholar, and Scopus, and the studies focusing on premature and term newborns were selected for further evaluation. Some of the keywords used in the literature search were 'kidney size' and 'newborns'. After reviewing the titles and abstracts of the identified documents, the articles that were in line with the study objectives were retrieved in full text.

Renal volume was calculated based on the following formula:

$$\text{Volume} = 0.5233 \times \text{Length} \times \text{Width} \times \text{Thickness}$$

Total body surface area (BSA) was determined based on the following formula:

$$\text{BSA} = \text{Weight}^{0.425} \times \text{Length}^{0.725} \times 71.84$$

Finally, body mass index (BMI) was calculated, as follows:

$$\text{Weight (kg)} / \text{Height (m}^2\text{)} \text{ (1,3).}$$

Results

Literature search results

After reviewing the titles and abstracts, 74 articles were identified and retrieved in accordance with the objectives of the research. In total, 10 articles that met the inclusion criteria were included in the study after reviewing the full texts.

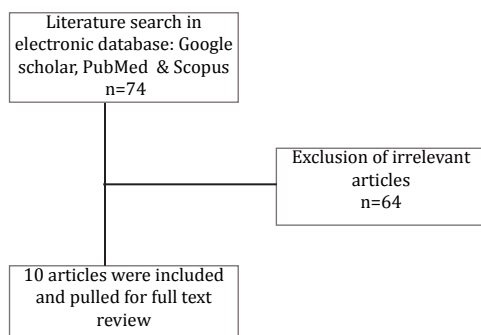


Figure 1. PRISMA Flowchart of Reviewed Articles

Studies evaluating the renal dimensions of newborns had been conducted on various populations. Some studies had compared the renal diameters with the body weight and length of the neonates within the first days of birth, while some others had compared the gestational age with the kidney size of the infants. However, no conclusive results were proposed.

In the current research, analysis of the data extracted from the retrieved articles yielded beneficial results regarding the renal dimensions in the neonatal period. Applicable data of the relevant articles included in the study are presented in Table 1.

In their research, Gupta et al. reported the results of kidney ultrasound in 100 healthy newborns, including 71 premature and 29 term neonates that were appropriate for gestational age (AGA). Gestational age of the neonates was within the range of 26.1-41.3 weeks (mean: 33.9±4 weeks), and their weight was within the range of 540-3,260 grams (mean: 1,623±685.5 grams). Findings of the mentioned study showed no significant difference in the mean renal volume between the length of the right and left kidneys. Furthermore, no statistically difference was reported in the renal dimensions of the male and female neonates. On the other hand, significant correlations were observed between renal dimensions and gestational age, length, weight, and BSA of the newborns (1).

In order to assess the kidney size in newborns, Erdemir et al. determined the reference ranges of renal dimensions in preterm infants to provide an easily applicable chart in daily practice. They evaluated renal dimensions in 498 preterm infants (226 girls and 272 boys), with the gestational age of <37 weeks via ultrasound within the first week of life. The exclusion criteria in the mentioned research were congenital anomalies, small-for-gestational-age infants, and abnormal ultrasound (e.g., hydronephrosis, dysplastic kidneys or duplex kidneys). According to the findings, there were statistically significant differences in the renal dimensions of boys and girls. In addition, a significant correlation was reported between the dimensions of length and thickness in the right and left kidneys and gestational age, weight and height in girls and boys. Another major finding of the research indicated that the body weight of the neonates had the most significant correlation with their renal dimensions. However, no statistically significant differences were reported between the length of the right and left kidneys, while the thickness of the right kidney was higher in male and female infants (4).

In the study by Scott et al. (1986) in Newcastle,

Table 1. Extracted data of reviewed articles.

No	Author Year Reference	Neonates (N)	Gestational Age (GA) (week)	Weight (WT) (g)	Renal Length (mm)	Difference between Right (R) and Left (L) Kidneys	Difference between Boy (B) and Girls (G)	Correlation with GA, WT, Length, and BSA
1	DeVries 1983 (6)	100	26-42	-	25-45	R=L	B=g	Positive Correlation with WT and Length
2	Scott, 1990 (5)	560	33-42	3291±517	38-48	R<L	B=g	Best Correlation with Head Circumference
3	Gupta 1992 (1)	71 Preterm 29 Term	26.1-37 weeks 33.9±4.4 weeks	540-3250 1623±685	27.9±7.4	R=L	B=g	Best Correlation with BSA*
4	Soyupak 2002 (7)	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
5	Daud 2006 (14)	128	71 SGA** 57 AGA***	1100- 4200	35±5	R<L	B=g	Best Correlation with WT
6	Adeyekun 2007 (15)	150	Term	1900- 4100	44.4±44.9	R=L	B=g	Positive Correlation with WT and Length
7	Van Venrooij 2010 (10)	30	<31 weeks	<1500	26±35	R=L	B=g	Best Correlation with GA
8	Otiv 2012 (16)	71	Term	2500±40	43±6	R=L	B=g	Best Correlation with Length
9	Erdemir 2013 (4)	498	30.6±3.3	1595±628	29.8-43.7	R=L	B>g	Best Correlation with WT
10	Erdemir 2013 (18)	385	39.7±0.7	3266±391	38-47.3	R<L	B>g	Best Correlation with WT

*BSA: body surface area; ** SGA: small-for-gestational-age; ***AGA: appropriate-for-gestational-age

renal measurements were performed via ultrasonography in 560 healthy newborns within 48-72 hours after birth. The researchers measured three dependent variables (length, depth, and area of the kidneys), as well as three independent variables (birth weight, head circumference, and gestational age). According to the obtained results, there were significant differences between the right and left kidneys in terms of the length and depth for each independent variable. Moreover, thickness and area of the kidneys were significantly larger in boys compared to girls. Findings of the mentioned study were indicative of a significant difference in the shape of the two kidneys; accordingly, as the neonates became larger, the left kidney became comparatively longer and thinner, while the right kidney became shorter and thicker. It seems likely that the changing shape might have been caused by the liver, which is often larger in proportion to the volume of the abdominal cavity during the neonatal period than the later life stages (5).

Another research by DeVries was conducted on 100 infants with the gestational age of 26-42 weeks. The first urinary tract ultrasonography

was performed within the first three days of life, while it was carried out within 47 hours after birth in 82% of the cases. Additionally, the ratio of kidney length to the height of the neonates was calculated in 20 infants and estimated to be within the range of 0.70-0.85 (mean: 0.78). In the infants who were small or large for the gestational age, the kidney size was in proportion with the length of the newborn. However, no significant difference was reported in the length of the right and left kidneys (6).

In this regard, Sureyya et al. assessed normal liver, spleen, and renal dimensions in premature and term neonates. In total, 253 healthy newborns (99 preterm and 154 term neonates) were examined during the first week of life via ultrasound. Gestational age of the infants was within the range of 24-41 weeks, and their weight was within the range of 638-4,800 grams. According to findings, weight had the most significant correlation with the other organ dimensions of the neonates. In addition, no significant difference was observed in the organ dimensions in terms of gender (P=0.05). Meanwhile, the differences in the organ

dimensions between preterm and term infants were considered significant ($P=0.005$) and higher with the increased gestational age ($P=0.001$) (7).

In their study, Sultana et al. examined renal dimensions in healthy, AGA, term infants via ultrasound within 72 hours after birth. Body weight, supine length, occipitofrontal circumference, and BSA were recorded in 52 boys and 48 girls. No significant differences were reported in the mean renal length and volume between the right and left kidneys in male and female neonates. Results of the study indicated that the kidney length had better correlations with BMI ($P<0.001$), body weight ($P<0.01$), and BSA ($P<0.05$). Furthermore, kidney volume was observed to be correlated with the body weight ($P<0.05$), BMI ($P<0.05$), and BSA ($P<0.05$). However, no correlations were reported between the gestational age, fetal length, and occipitofrontal circumference and kidney size of the neonates (8).

In the literature review, a few detailed studies interpreted the renal dimensions in newborns. Sonography was among the most common imaging modalities used in the routine practice in this regard.

During the neonatal period, ultrasonography commonly represents the primary imaging modality of choice, which provides a quick assessment of the visceral organ dimensions without the risk of radiation. Moreover, ultrasonography is considered appropriate for the evaluation of renal pathology in newborns since it has no ionizing radiation, could be performed at the patient's bedside, and is cost-efficient and widely available. Among the other benefits of ultrasonography are the real-time, tridimensional examination, which is independent of organ function and phase of respiration. Neonatal kidneys could be clearly visualized via real-time ultrasound, and the portability of the equipment allows the rapid scanning of most infants, including those on mechanical ventilation or undergoing other forms of intensive care, with the least disturbance. Despite the simplicity of this technique, it might require further experimentation in some cases.

In newborns, the best visualization of the kidneys is obtained during the first few days of life before the neonate is established on gastric feeding. Once the bowel becomes full of gas, the total reflection of sound from the gas or tissue interface makes it difficult to accurately measure the kidneys. Assessment of the kidney size is essential to the evaluation of renal diseases. In this regard, the normal range of renal dimensions at a given age must be determined prior to the diagnosis of an abnormality. Several studies have investigated the renal dimensions in pediatric age groups, while

studies focusing on the renal dimensions in newborns are limited. Moreover, evidence is scarce on the normative standards of renal dimensions in preterm and term neonates.

Different parameters have been used to evaluate renal dimensions and function in various studies (9-12). However, there is no consensus on the most sensitive measurement parameters for investigating the normal limits of these dimensions. In a study in this regard, the kidney length of 100 newborns with the gestational age of 26-42 weeks was measured, and the ratio of kidney length to crown-to-heel measurement was calculated as well. According to the results, kidney length remained in proportion to the length of the infant, irrespective of whether the infant was appropriate or small for gestational age (6). In another research conducted on 36 neonates, no correlation was reported between the kidney length and crown-to-heel measurement (13). In another study performed in 1987, a poor correlation was reported between the kidney length and body length in 52 preterm, AGA infants (12). This finding could have stemmed from the assumption that the body length measurements are inaccurate in the neonatal period due to the flexed posture of the infant.

According to the literature, using the kidney volume may not be practical. For instance, Scot et al. have claimed that the kidneys are longer in male infants compared to female ones in all dimensions, while the rate of increased length differs in this regard. Kidney length increases faster in male infants with the increased birth weight and head circumference compared to females, while the kidney depth increases at a similar rate in both males and females (5).

In a research, Daud et al. evaluated infants aged less than 72 hours since the gestational age could be assessed reliably only during the first 72 hours of life, thereby removing the normal initial weight loss in newborns, which returns to the birth weight (14).

Findings of Adeykun et al. confirmed the significant correlation of kidney length and kidney volume with the weight and length of neonates (15). Although the kidney length has the most significant correlation with height and BSA, the calculation of BSA is cumbersome and requires multiple measurements. In clinical practice, the height and weight could be recorded quickly in order to compare the actual kidney length with the normal limits. Similarly, since estimating the kidney volume requires the measurement of three renal dimensions, the error associated with the kidney volume increases in geometric proportion. Therefore, it is simpler to use kidney length as a yard-

stick for comparing the renal growth with body growth (16).

In another research, Fitzsimons reported a significant correlation between the kidney length and birth weight of neonates (17). In this regard, the assessment of renal dimensions in 385 term neonates indicated that the length of the right kidney was larger than the left kidney, and birth weight had the most significant correlation with the length of the kidneys (18). Furthermore, Van Venrooij evaluated the kidney length and growth in 30 premature infants, reporting a positive correlation between the kidney size and growth with the birth weight and gestational age of infants (9).

Conclusion

Although kidney volume is considered to be the most accurate index of kidney size, kidney length is the easiest practical indicator of the renal dimensions, which is correlated with the anthropometric indices and gestational age of neonates. According to the results of the present review, the kidney size in neonates is well correlated with the most commonly used parameters of overall body size, including age, body weight, body length, BSA, and gestational age. It is hoped that our findings contribute to the daily practices in pediatric and radiology clinics.

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Conflict of Interest

The authors declare no conflict of interest.

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