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Ogbe P
Ocheke IE
Bode-Thomas F

Renal sizes in healthy term newborns in Jos, Nigeria

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Ocheke IE (✉)
Ogbe P
Bode-Thomas F
Department of Paediatrics,
University of Jos/ Jos University Teaching Hospital
Email: ieocheke@yahoo.com

Abstract*: Introduction*
Knowledge of the range of normal measurements of body organs including the kidneys in the healthy population is essential. Such reference values provide a quick guide for prompt and accurate evaluation of the abnormal. This study sought to determine renal size by ultrasound measurement in term neonates at the Jos University Teaching Hospital (JUTH).
Materials and Methods: Healthy term neonates aged 12 to 72 hours were consecutively enrolled. Ultrasound measurements of their renal sizes were determined. Mean renal dimensions and their 95% confidence intervals (CI) were computed. The renal sizes were correlated with the infants' anthropometric parameters and gestational ages using Pearson's correlation coefficient. Sizes of left and right kidneys and of male and female subjects were compared using student's t-test.
Results: Two hundred term newborns consisting of 105 (52.50 %) females and 95 (47.50%) males were enrolled. Their mean renal length was 4.09(95% CI, 3.72, 4.46) cm and 4.08 (95% CI, 3.72, 4.44)cm for right and left kidneys; width2.11 (95% CI, 1.89, 2.33) cm and 2.08 (95% CI, 1.85, 2.31) cm for right and left kidneys, and volume9.66(95% CI, 7.49, 9.87) $cm^3$and 9.41 (95% CI, 7.23, 11.59) cm^3 for right and left kidneys respectively. Renal dimensions increased consistently with birth weight. No significant difference in renal dimensions between the right and left kidneys was found.
Conclusion: The mean renal dimensions for right and left were similar and correlated with birth weight.

Key Words: Healthy, Term, Newborn, Ultrasound, Renal Size,

Introduction

Physical parameters at birth such as weight, length and head circumference vary from one baby to another and from one population to another. They are influenced by factors such as gestational age, genetics, environment and socioeconomic imperatives. These factors may also influence the sizes of body organs.[1,2]
Kidney sizes have been shown to increase throughout foetal life as the neonate grows bigger.[3]Preterm and small for gestational age babies have small sized kidneys concurrent with their age and size.[4-7] These findings support the notion of proportionate growth of body organs with gestational age and other factors such as body weight, surface area and length.

Reference values on physical and biochemical parameters serve as quick standards for comparison so that deviation from the normal can easily be identified.[8- 11] Ultrasound assessment of the kidney is an important step in the evaluation of patients with renal pathology and its use for prognostic purposes in certain conditions.[12] Therefore, knowledge of the normal range of renal dimensions (length, width, thickness and volume) is essential for such evaluation. [8, 13, 14]
Normal mean renal lengths reported for term neonates range from 3.83 to 4.70 cm.[7, 11, 13, 15, 16] There are limited reports on kidney size from developing countries, including Nigeria. This study was thus designed to describe the renal size in healthy Nigerian term neonates within the first 72 hours of life and to provide reference values for the evaluation of this age group so that deviation from the normal size can easily be identified.

Methods

This was a prospective, cross-sectional and descriptive study carried out at the Jos University Teaching Hospital (JUTH) Jos, a tertiary health care facility in central Nigeria. Ethical approval for the study was obtained from the Ethics Committee of the hospital. Informed oral consents were obtained from mothers after they had been given information about the study. Apparently healthy babies whose maternal records showed no evidence of hypertension, diabetes or obesity and who had completed 37but did not exceed 42 completed weeks of gestation were recruited. All the babies were appropriate for gestational age. A complete clinical examination was

done for each baby, including birth anthropometry and their body surface areas calculated using the Du Bois formula.[17]Neonates with obvious congenital malformation (s), detectable by physical examination or organ abnormality detected by ultrasound assessment, sick neonates, and those with birth weight greater than 4kg or less than 2.5kgwere excluded. All babies recruited into the study were subsequently re-evaluated between 12 and 72 hours of age and their weights, lengths and BSAre-measured and recorded.

Each baby then had real time ultrasound scanning of the abdomen with a 7.5MHz linear probe (AlokaProsound SSD 3500 sv). Scanning was done in both the supine and lateral decubitus positions.[18,19] Each kidney was examined in its longitudinal and transverse axis from which the bipolar length and width were determined in centimeters (cm). At the same point with the transducer now transversely oriented, a third measurement was taken to obtain the anterior- posterior diameter or thickness. The dimensions of each kidney were taken twice and the average of the two readings was recorded. The ultrasound machine automatically calculated the volume (cm^3) using the formula for an ellipsoid.[20]
All babies were scanned after the first 12 and within 72 hours of birth when the transient hydronephrosis present usually at birth would have resolved.[13,21,22] More so, the kidneys are best visualized in the first few days of life before enteral feeding is well established as gas in the gut makes precise measurements of renal images difficult.[4]

The data was analysed using SPSS (Statistical Product and Service Solutions, formerly known as Statistical Package for the Social Sciences) VERSION 16 (SPSS, Chicago, IL). Sizes of left and right kidneys and renal sizes of male and female subjects were compared using student's t-test. Recommended reference ranges of renal size for term newborns were derived from the 95% confidence intervals.[23]Renal dimensions were correlated with the infants' anthropometric parameters and gestational age using Pearson's correlation coefficient. Linear regression analysis to determine the strength of correlation of anthropometric factors with renal dimensions was done. Statistical significance was set at a p-value of <0.05.

Results

Two hundred (200)neonates were enrolled for the study, comprising 95 (47.5%) males and 105 (52.5%) females. The mean age at ultrasound scanning was 20.84±13.16 hours (range 12 - 72 hours). Seventy (35%) of the 200 babies were born at 38 weeks of gestation, 60 (30%) at 39 weeks and 41(20.5%) at 40 weeks. Twenty three (11.5%) and 6 (3%) babies were born at 41 and 42 weeks respectively. The socio-demographic characteristics of the study population are shown in Table 1. A history of parental consanguinity was found in 9 (4.5%) subjects (Table 1).

Table 1: Socio-demographic and physical characteristics of study population

Variables	Frequency (n=200)	Percentage
Gestational age (weeks)		
38	70	35.0
39	60	30.0
40	41	20.5
41	23	11.5
42	6	3.0
Birth weight (kg)		
2.5-2.9	61	30.5
3.0-3.4	104	52.0
3.5-4.0	35	17.5
Socio-economic class		
Lower	21	10.5
Middle	46	2.0
Upper	133	66.5
Family history of kidney disease		
Absent	194	97.0
Present	6	3.0
Parental consanguinity		
Absent	191	95.5
Present	9	4.5

Anthropometric indices of the study population

The overall mean birth weight was 3.15±0.35 kg, length 49.33±2.48cm and body surface area (BSA) 0.193±0.014 m^2. Male infants significantly had bigger weights and larger BSA than females (Table 2). The anthropometric measurements at enrollment were as follows: weight, 3.10±0.35kg; length, 49.34±2.48cm; BSA, 0.19±0.01m^2. There was a statistically significant difference between the birth weight and BSA at enrollment.

Table 2: Anthropometric indices at birth and at enrollment

	Birth Mean (95% CI)	Enrollment Mean (95%CI)	t-test	p-value
All subjects				
Weight (kg)	3.15 (2.80-3.50)	3.10 (2.75-3.45)	9.517	<0.001*
Length (cm)	49.33 (46.85-51.58)	49.34 (46.86-51.82)	0.576	0.565
BSA (m^2)	0.19 (0.179±0.207)	0.19 (0.18-0.20)	5.010	<0.001*
Males				
Weight (cm)	3.22 (2.87-3.57)	3.17 (2-82-3.52)	7.093	<0.001*
Length (cm)	49.61 (47.02-52.20)	49.61 (47.04-52.18)	1.000	0.320
BSA (m^2)	0.20 (0.181-0.211)	0.20 (0.18-0.22)	3.680	<0.001*
Females				
Weight (kg)	3.08 (2.75-3.41)	3.04 (2.69-3.39)	6.371	<0.001*
Length (cm)	49.07 (46.72-51.44)	49.07 (46.71-51.43)	0.000	1.000
BSA (m^2)	0.19 (0.179-0.203)	0.19 (0.18-0.20)	3.544	0.001*

*statistically significant, BSA- body surface area, CI- Confidence Interval

Renal Dimensions

The mean renal length was 4.09±0.37 cm(95% CI, 3.72, 4.46) and 4.08±0.36 cm (95% CI, 3.72, 4.44) for right

and left respectively. The mean renal width was 2.11±0.22 cm (95% CI, 1.89, 2.33) and 2.08±0.23 cm (95% CI, 1.85, 2.31)also for right and left kidneys in that order. Renal thickness was 2.10±0.29 cm and 2.22±0.22 cm on the right and on the left, while the mean renal volume was 9.65±2.21 cm^3 on the right and 9.4±2.18 cm^3 on the left. There was no significant difference in these parameters between the genders. There was also no significant difference in the renal dimensions between the right and the left sides. (Table 3).

The renal dimensions did not vary significantly with gestational age between 37 and 42 weeks (Table 4) but did with increasing birth weight and not with birth length (Table 5).

Table 3: Renal dimensions of study population according to gender

Variable	All subjects Mean (95% CI)	Male Mean±SD	Female Mean±SD	t-test	p-value
Right Length (cm)	4.09 (3.72-4.46)	4.10±0.37	4.08±0.37	0.372	0.710
Left length (cm)	4.08 (3.72-4.44)	4.08±0.31	4.09±0.40	0.218	0.828
Right Width (cm)	2.11 (1.89-2.33)	2.13±0.21	2.10±0.23	0.755	0.451
Left Width (cm)	2.08 (1.85-2.31	2.08±0.24	2.08±0.23	0.037	0.971
Right Thickness (cm)	2.10 (1.82-2.39)	2.09±0.31	2.10±0.27	0.323	0.747
Left Thickness (cm)	2.11 (1.89-2.33)	2.12±0.22	2.09±0.23	1.105	0.271
Right Volume (cm^3)	9.66 (7.49-9.87)	9.72±2.22	9.59±2.20	0.397	0.692
Left Volume (cm^3)	9.41(7.23-11.59)	9.40±2.13	9.37±2.24	0.225	0.822

CI- Confidence Interval

Table 4: Renal dimensions of study population according to gestational age

Gestational age (weeks)	38(n=70) Mean (95% CI)	39(n=60) Mean (95% CI)	40 (n=41) Mean (95% CI)	41(n=23) Mean (95%CI)	42(n=6) Mean (95%CI)	f-test	p-value
Right length (cm)	4.14 (3.75-4.53)	4.09 (3.75-4.43)	4.07 (3.72-4.42)	4.02 (3.63-4.41)	3.91 (3.58-4.24)	0.956	0.433
Left length (cm)	4.08 (3.67-4.49)	4.09 (3.71-4.47)	4.08 (3.81-4.35)	4.08 (3.74-4.42.0)	3.98 (3.66-4.30)	0.139	0.968
Right width (cm)	2.11 (1.87-2.35)	2.12 (1.92-2.32)	2.08 (1.88-2.28)	2.20 (1.91-2.49)	2.03 (1.89-2.17)	1.310	0.268
Left width (cm)	2.08 (1.82-2.34)	2.09 (1.86-2.32)	2.08 (1.87-2.29)	2.08 (1.86-2.30)	1.99 (1.83-2.15)	0.233	0.920
Right thickness (cm)	2.03 c(1.66-2.40)	2.12 (1.89-2.350	2.12 (1.90-2.340	2.15 (1.93-2.37)	2.12 (1.85-2.39)	0.980	0.420
Left thickness (cm)	2.10 (1.87-2.33)	2.09 (1.86-2.32)	2.11 (1.92-2.30)	2.20 (1.98-2.42)	2.05 (2.02-2.08)	1.252	0.290
Right volume (cm^3)	9.68 (7.28- 12.08)	9.66 (7.70-11.62)	9.45 (7.20-11.70)	10.07 (7.66-12.48)	8.90 (7.12-10.68)	0.465	0.761
Left volume (cm^3)	9.37 (6.82-11.92)	9.38 (8.28-10.48)	9.37 (7.20-10.98)	9.83 (7.39-12.27)	8.65 (6.43-10.87)	0.404	0.806

CI- Confidence Interval

Table 5: Renal dimensions of 200 term newborns according to birth weight

Birth weight (kg)	2.50-<3.00(n=61) Mean (95%CI)	3.00-<3.50 (n=104) Mean (95%CI)	3.50-4.00(n=35) Mean (95%CI)	F-test	p-value
Right length (cm)	4.05(3.69-4.41)	4.06(3.71-4.41)	4.25(3.88-4.62)	4.280	0.015*
Left length (cm)	4.01(3.60-4.42)	4.08(3.77-4.39)	4.22(3.85-4.59)	3.667	0.027*
Right width (cm)	2.08(1.84-2.32)	2.12(1.90-2.34)	2.16(1.96-2.36)	1.664	0.102
Left width (cm)	1.99(1.76-2.22)	2.11(1.87-2.35)	2.14(1.96-2.32)	6.412	0.002*
Rt.thickness (cm)	1.99(1.65-2.33)	2.13(1.91-2.35)	2.21(1.97-2.45)	8.192	<0.001*
Left thickness (cm)	2.03(1.81-2.25)	2.13(1.91-2.35)	2.17(1.95-2.39)	5.659	0.004*
Right volume (cm^3)	9.08(6.89-11.27)	9.7(7.53-11.87)	10.58(8.50-12.66)	5.393	0.005*
Left volume (cm^3)	8.51(6.42-10.60)	9.7(8.3-11.1)	10.15(8.15-12.15)	8.816	<0.001*

*statistically significant**;** CI= confidence interval; Rt. =right

Correlation of renal dimensions with anthropometric variables

There was a significant positive correlation between all the renal dimensions and the weight and BSA of the subjects at birth and at enrollment. No significant correlation was observed between the renal dimensions and the subjects' length and gestational ages and at enrollment (Tables 6,7). On multiple linear regression analysis however, the strength of association was strongest with birth weight therefore the anthropometric measurements at birth were subsequently used for analysis.

Table 6: correlation of renal dimensions with anthropometric indices at birth

	Weight		Length		BSA		Gestational age	
Renal dimensions	r	p-value	R	p-value	r	p-value	r	p-value
Right length (cm)	0.180	0.011*	0.094	0.186	0.178	0.012*	-0.133	0.060
Left length (cm)	0.224	0.001*	0.084	0.238	0.206	0.003*	-0.018	0.795
Right width (cm)	0.168	0.018*	0.000	0.995	0.140	0.049*	0.014	0.841
Left width (cm)	0.280	<0.001*	0.638	0.498	0.229	0.001*	-0.019	0.792
Right thickness (cm)	0.248	<0.001*	0.034	0.630	0.219	0.002*	0.116	0.102
Left thickness (cm)	0.237	0.001*	-0.015	0.835	0.142	0.045*	0.082	0.250
Right volume (cm^3)	0.252	<0.001*	0.058	0.412	0.242	0.001*	-0.010	0.887
Left volume (cm^3)	0.322	<0.001*	0.047	0.511	0.257	<0.001*	-0.014	0.845

*statistically significant; r-Pearson's correlation coefficient

Table 7: correlation of renal dimensions with anthropometric indices at enrollment

	Weight		Length		BSA	
Renal dimensions	R	p-value	r	p-value	r	p-value
Right length (cm)	0.169	0.0170 *	0.96	0.178	0.170	0.016*
Left length (cm)	0.222	0. .002*	0.802	0.251	0.206	0.003*
Right width (cm)	0.154	0.030*	0.003	0.966	0.137	0.053*
Left width (cm)	0.245	<0.001*	0.047	0.505	0.206	0.003*
Right thickness (cm)	0.222	0.002*	0.037	0.604	0.205	0.004*
Left thickness (cm)	0.209	0.003*	-0.010	0.890	0.127	0.073
Right volume (cm3)	0.231	0.001*	0.061	0.391	0.232	0.001*
Left volume (cm3)	0.297	<0.001*	0.048	0.502	0.238	0.001*

*statistically significant**,** r-Pearson correlation coefficient, BSA- body surface area

Discussion

Our study showed that the mean renal length of term newborn babies in Jos, Nigeria is 4.09cm and 4.08 cm for the right and left kidneys respectively. This finding is similar to the 3.92 cm and 3.83 cm for right and left kidneys reported by Sultana et al[15] among term Bangladeshi newborns. However, our figure differs from that reported by Adeyekun et al[24] in Benin, southern Nigeria, who noted greater mean renal lengths, of 4.49 and 4.44 cm for the right and left kidneys respectively. This difference may be attributable to geographic location. Whereas, Jos the capital city of Plateau state is situated at a higher altitude, Benin is situated in the lower region of Nigeria. It has been shown that babies born at higher altitudes have relatively smaller birth weight, and since renal size correlates with body weight, it may explain why this variation exist.[3,23,25-27] The mean birth weight of our study subjects was 3.15Kg, a value much lower than previously reported mean birth weight from Benin city.[28]

Among Caucasians, mean renal length range from 4.2 to 4.5cm, while mean length of4.7 cm has been reported among Arabs.[11,13,23,29] These variations most likely suggest that race could be a determinant of neonatal renal dimensions. Renal volumes in the present study were 9.65and 9.42 cm^3 for right and left kidneys respectively. This finding is also similar to the 9.7and 9.8cm^3 for right and left kidneys respectively, reported in Bangladesh.[15] Holloway et al[20]on the other hand found a slightly larger renal volume of 10.0cm^3among Caucasians for both right and left kidneys, a value which is different from our study and that from Bangladesh, suggesting invariably the influence of race on overall renal size.

Renal dimensions in our study consistently increased with increasing birth weight, corroborating previous studies among different populations.[3,15,24,27] However, we found no significant increase in renal dimensions with gestational age, within the narrow gestational age range(38-42 weeks) studied. This is not surprising since Fitzsimons[30]noted that renal length does not increase significantly after 36 weeks' gestation. Gupta and colleagues[31] reported a positive correlation between renal length and gestational age, a finding that contrasts with ours, but their study evaluated renal parameters in both term and preterm babies. The inclusion of preterm neonates in their final analysis may have contributed to this finding.

We did not find any significant difference in size between the right and left kidneys, though the right was consistently larger. Several other studies have reported similar findings.[4,5,13,15,24,32] Some studies however, found the left to be longer than the right kidney.[2,7,11,23,33]It has been suggested that this could be due to a localized bulge that is present sometimes on the left kidney called the dromedary hump. It gives an increased convexity on the lateral aspect of the kidney. This hump might also be due to the adjoining spleen and its impression on the superolateral aspect of the left kidney or may be due to fetal lobulations or both.[34]

Our findings also did not show any gender variation as has been demonstrated in other studies.[2,24,25,35] However, in studies of adolescents and adults, kidney length has been found to be significantly bigger in males than females.[1, 36-38]This has been attributed to ultimate gender differences in body size, with the male gender having a larger body mass than the female counterpart.

Conclusion

In conclusion, the mean renal length was 4.09(95% CI, 3.72, 4.46) cm and 4.08 (95% CI, 3.72, 4.44)cm for right and left kidneys respectively. Our study also demonstrated that renal dimensions correlated significantly with birth weight but not with length and BSA in the early neonatal life. The gender of the child did not influence significantly the renal dimensions.

As much as possible, it is recommended that values should be determined and used for the race and locality in evaluating renal sizes in normal term newborns.

This study is not without limitation as only one observer measured the renal dimensions reported here. Even though multiple measurements were taken and only the mean was recorded, chances of human error is still possible. Independent measurements by two individuals would have overcome such possible error. On the whole however, the data presented here offers baseline guideline for quick assessment of renal dimensions among healthy term neonates in Nigeria.

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