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Original research article

Volumetric study of the fetal kidney at different weeks of gestational age and correlation with general parameters of the fetus

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Abstract

Background: One of the most important aspects of obstetric ultrasound is the evaluation of the fetal kidneys. To identify kidney disorders and monitor changes in embryonic kidney growth, accurate information regarding kidney size is essential. The renal volume, which represents the ideal kidney dimension, is regarded to be the most helpful parameter.

Objective: The main objective of this study is to correlate between volume of the fetal kidney at different weeks of gestation age with general parameters of the fetus.

Material and methods: This study was conducted on 246 (96 in 2nd trimester and 150 in 3rd trimester) normal sonography of pregnant women in and in the Department of Anatomy, in collaboration with Obstetrics & Gynecology and Radiology of Index Medical College Hospital & Research Centre, Malwanchal University, Indore.

Observation & Result: The mean and standard deviation of B.P.D. (in cm) is 6.89 ± 1.79 for total fetuses. The mean and standard deviation of H.C. of fetuses (in cm) is 25.57 ± 6.31 for total fetuses. The mean and standard deviation of A.C. (in cm) is 24.11 ± 7.76 for total fetuses. The mean and standard deviation of F.L. (in cm) is 5.29 ± 1.78 for total fetuses. The mean and standard deviation volume of the kidney (in cm^3) is 5.46 ± 4.20 for total fetuses.

Conclusion: From the current study, we can conclude that the Determination of gestational age by using Ultrasonographic parameters like BPD, HC, AC, FL, and fetal kidney volume is a more accurate and reliable method. So, can be used as a tool to assist in the assessment of gestational age.

Keywords: Biparietal diameter **(**BPD), Head circumference (HC), Abdominal circumference (AC), Femur length (FL), Fetal kidney volume (FKV), Fetal growth rate (FGR)

Introduction

One of the most important aspects of obstetric ultrasound is the evaluation of the fetal kidneys. To identify kidney disorders and monitor changes in embryonic kidney growth, accurate information regarding kidney size is essential. Assessing fetal kidney size, echotexture, and perfusion can be done safely, affordably, and broadly using ultrasound imaging. Numerous modern two-and three-dimensional ultrasound methods have been developed to assess kidney growth [1]. Environmental and genetic variables most likely have an impact on kidney size. Most likely, genetics determines the number of glomeruli present at birth. The size and number of nephrons dictate the size of the kidneys [2]. Biometric data, such as the femur length, head circumference, belly circumference, and biparietal diameter, have consistently provided the best estimations; but, as pregnancy advances, estimation precision and variability decrease [3]. One of the most crucial organs for fetal growth and health is the kidney, and the circulation of the kidneys during fetal development is a component of the peripheral system. The fetal kidney volume has been observed to decrease in fetuses with FGR [4]. Renal volume is a new screening tool that allows for the precise assessment of renal volume in children and gives doctors access to more accurate information. Renal volume accurately depicts the size of the kidney and has been considered a potential indication of renal function [5].

Timely amniotic fluid testing and maternal serum assays are beneficial to schedule throughout the second trimester. When fetal growth disorders are diagnosed in the third trimester, it is helpful to plan the timing of fetal interventional treatment. It also helps with high-risk pregnancies, such as those complicated by gestational hypertension, preeclampsia, central placenta previa, and sensitized Rh-negative mothers, when delivery is timed to occur as soon as the fetus becomes mature. Inaccurate gestational age estimation can result in iatrogenic prematurity, needless induction of labor, incorrect test interpretations,

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and surgical deliveries, all of which raise perinatal morbidity and mortality [6]. The renal volume, which represents the ideal kidney dimension, is regarded to be the most helpful parameter [7]. Using ultrasound technology, the diameter, volume, and crown-rump length (CRL) of the gestational sac can be measured in the first trimester to compute GA [8]. Measurement variables included numerous gestations, diabetes throughout pregnancy, intrauterine growth restriction (IUGR), maternal size, fetal lie, fluctuating engagement, and measurement variation between and among observers [9, 10]. Fetal kidney features offer the most accurate prediction of gestational age among all the biometric indices [11, 12].

Material and Method

This study was conducted on 246 (96 in 2nd trimester and 150 in 3rd trimester) normal sonographs of pregnant women in and in the Department of Anatomy, in collaboration with Obstetrics & Gynecology and Radiology of Index Medical College Hospital & Research Centre, Malwanchal University, Indore. This study was carried out for a period of 2 and a half years (from July 2021 to December 2023). The history of the patient was collected from the OBGY department of Index Medical College Hospital & Research Centre, Malwanchal University, Indore. After approval from the institutional ethical committee for biomedical and Health Research Index Medical College Indore. Patients were divided into six groups based on the gestation age of fetuses. In A (18-21), B (22-25), C (26-29), D (30-33), E (34-37), and F (30-41) groups respectively. The BPD, HC, AC, and FL of the fetuses and the volume of the kidney were recorded by USG. The Data was analyzed using SPSS software version 27. Statistical test of Significance (t-test will be applied wherever found necessary. (p<0.05 was considered statistically significant).

Observation and Result

Table 1: Showing Mean Values and Standard Deviation of BPD, HC, AC, FL, and FKV of Fetal at Different Gestational Weeks

Parameters/GA	BPD (cm)		H.C. (cm)		A.C. (cm)		F.L. (cm)		FKV (cm3)	
	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max	Mean ± SD	Min-Max
Group A (18-21) weeks	4.74±0.49	3.4-5.5	18.1±1.25	14.5-19.9	15.35±1.33	12.1-20.1	3.31±0.42	2.1-3.90	1.22±0.49	0.1-2.52
Group B (22-25)	5.29±0.38	4.4-6.2	19.43±1.3	17-23.6	16.58±1.49	14-20.8	3.56±0.41	3.1-4.8	1.82±0.47	0.84-3.84
Group C (26-29)	6.27±0.42	5.35-7.2	24.01±1.74	20.6-26.7	21.94±2.31	17.5-25.4	4.67±0.54	3.8-5.8	3.72±0.99	2.09-5.49
Group D (30-33)	7.44±0.44	6.3-8.5	28.11±2.02	25.1-32.5	26.32±2.09	23.1-30.4	5.91±0.55	5.1-6.90	6.09±2.11	2.15-10.62
Group E (34-37)	8.57±0.42	7.4-9.5	31.69±1.33	29.1-34.7	31.31±2.06	25.2-34.9	6.94±0.58	6.1-7.8	8.65±1.95	5.66-14.45
Group F (38-41)	9.22±0.33	8.1-9.6	33.36±0.96	31.3-35.8	34.37±1.78	32.1-40.1	7.6±0.25	7.1-7.9	11.39±2.52	6.93-20.73
Total	6.89±1.79	3.4-9.6	25.57±6.31	14.5-35.8	24.11±7.76	12.1-40.1	5.29±1.78	2.1-7.9	5.46±4.2	0.1-20.73

Table 2: Showing the Pearson's Correlation between Fetal General Parameters along with Fetal Kidney Volume

Parameters	BPD	HC	AC	FL	FKV
BPD	1	0.977	0.973	0.964	0.914
HC	0.977	1	0.984	0.972	0.915
AC	0.973	0.984	1	0.972	0.927
FL	0.964	0.972	0.972	1	0.919
FKV	0.914	0.915	0.927	0.933	1

Table 3: Showing R-Value, R^2 and P-Value of Different Parameters

Parameters	R-Value	R2	P- value
BPD	0.969	0.938	<0.0001
HC	0.965	0.931	
AC	0.964	0.929	
FL	0.956	0.913	
FKV	0.91	0.828	

The gestational age of the fetuses in this study ranged from 18 to 41 weeks. Patients were divided into six groups based on the gestation age of fetuses. Group A (18-21), Group B (22-25), Group C (26-29), Group D (30-33), Group E (34-37) and Group F (38-41). The mean and standard deviation of B.P.D. (in cm) are 6.89 ± 1.79 for total fetuses. The mean and standard deviation of BPD of fetuses (in cm) is 4.74±0.49, 5.29±0.38, 6.27±0.42, 7.44±0.44, 8.57±0.42 and 9.22±0.33 in group A, B, C, D, E and F respectively. The values of B.P.D. were calculated by the best-fit regression formula: Y = 0.11921 +

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0.243068 (GA of fetus in weeks). Pearson's correlation between the B.P.D. and the gestation age of the fetuses was r = 0.969 and p-values <0. 0001.
The mean and standard deviation of H.C. of fetuses (in cm) is 25.57 ± 6.31 for total fetuses. The H.C. is 18.10± 1.25, 19.43 ±1.30, 24.01± 1.74, 28.01 ±2.02, 31.69 ±1.33 and 33.36 ±0.96, at groups A, B, C, D, E and F respectively. The values of H.C. were calculated by the best-fit regression formula: Y =0.821976+ 0.8595 (GA of fetus in weeks). Pearson's correlation between the H.C and the gestation age of the fetuses was r = 0.965 and p-values <0. 0001.
The mean and standard deviation of A.C. (in cm) is 24.11 ± 7.76 for total fetuses. The A.C. is 15.35± 1.33, 16.58 ±1.49, 21.94± 2.31, 26.32 ±2.09, 31.31 ±2.06 and 34.37 ±1.78, at groups A, B, C, D, E and F respectively. The values of A.C. were calculated by the best-fit regression formula: Y =−6.32619+ 1.057269 (GA of fetus in weeks). Pearson's correlation between the A.C and the gestation age of the fetuses was r = 0.964 and p-values <0. 0001.
The mean and standard deviation of F.L. (in cm) is 5.29 ± 1.78 for total fetuses. The F.L. is 3.31± 0.42, 3.56 ±0.41, 4.67± 0.54, 5.91 ±0.55, 6.94 ±0.58 and 7.60 ±0.25, at groups A, B, C, D, E and F respectively. The values of F.L. were calculated by the best-fit regression formula: Y =−6.63674+ 0.240525(GA of fetus in weeks). Pearson's correlation between the F.L. and the gestation age of the fetuses was r = 0.956 and p-values <0. 0001.
The mean and standard deviation volume of the kidney (in cm^3) is 5.46 ± 4.20 for total fetuses. The volume of the kidney is 1.22± 0.49, 1.82 ±0.74, 3.72± 0.99, 6.09 ±2.11, 8.65 ±1.95 and 11.39 ±2.52, at groups A, B, C, D, E and F respectively. The values of the volume of the kidney were calculated by the best-fit regression formula: Y =−10.0353+ 0.538201(GA of fetus in weeks). Pearson's correlation between the volume of the kidney and the gestation age of the fetuses was r = 0.91 and p-values<0. 0001.

Discussion

In the present study, we found that the mean value of B.P.D. of fetuses is 4.7, 5.29, 6.27, 7.44, 8.57, and 9.22 (in cm) in A, B, C, D, E, and F groups respectively. In group A our finding is strongly similar to the study conducted by Mahima *et al.* 4.77cm [13]. In group B our finding is strongly similar to the study conducted by Shivalingaiah N *et al.* 5.74cm [14] and Mahima *et al.* 5.79cm [13]. In group C our finding is smaller than the study conducted by Mahima *et al.* 7.06cm [13] and Sonika Gupta *et al.* 7.03cm [15]. In group D our finding is strongly similar to the study conducted by Mahima *et al.* 7.94cm [13]. whereas our finding is smaller than the study conducted by Bharatnur S. *et al.* 8.48cm [16]. In group E our finding is strongly similar to the study conducted by Mahima *et al.* 8.59cm [13] and Bharatnur S. *et al.* 8.96cm [16]. In group F our finding is strongly similar to the study conducted by Bharatnur S. *et al.* 9.36cm [16].
The mean values of H.C. of fetuses are 18.10, 19.43, 24.01, 28.11, 31.69, and 33.36 (in cm) in A, B, C, D, E, and F groups respectively. In group A our finding is strongly similar to the study conducted by Mahima *et al.* 18.2cm. [13] In group B our finding is smaller than the study conducted by Mahima *et al.* 21.89cm [13] and Shivalingaiah N *et al.* 20.53cm. [14]. In group C our finding is smaller than the study conducted by Mahima *et al.* 26.42cm [13] and Sonika Gupta *et al.* 25.7cm [15]. In group D our finding is smaller than the study conducted by Mahima *et al.* 29.47cm [13] and Bharatnur S. *et al.* 29.65cm [16]. In group E our finding is strongly similar to the study conducted by Mahima *et al.* 31.66cm [13] and Sonika Gupta *et al.* 31.5cm [15]. In group F our finding is strongly similar to the study conducted by Bharatnur S. *et al.* 32.9cm [16].
The mean value of A.C. of fetuses is 15.35, 16.58, 21.94, 26.32, 31.31, and 34.37 (in cm) in the A, B, C, D, E, and F groups respectively. In group A our finding is strongly similar to the study conducted by Mahima *et al.* 15.81cm [13]. In group B our finding is smaller than the study conducted by Mahima *et al.* 19.09cm [13] and Shivalingaiah N *et al.* 18.31cm [14]. In group C our finding is smaller than the study conducted by Mahima *et al.* 23.84cm [13] and Shivalingaiah N. *et al.* 23.32cm [14]. In group D our finding is smaller than the study conducted by Mahima *et al.* 27.54cm [13] and Bharatnur S. *et al.* 27.86cm [16]. In group E our finding is strongly similar to the study conducted by Mahima *et al.* 31.27cm [13] and Bharatnur S. *et al.* 30.26cm [16]. In group F our finding is strongly similar to the study conducted by Bharatnur S. *et al.* 33.4cm [16].
The mean values of FL of the fetuses are 3.31, 3.56, 4.67, 5.91, 6.94, and 7.60 (in cm) in the A, B, C, D, E, and F groups respectively. In group A our finding is strongly similar to the study conducted by Mahima *et al.* 3.35cm [13]. In group B our finding is strongly similar to the study conducted by Shivalingaiah N *et al.* 3.75cm [14] and Sonika Gupta *et al.* 3.17cm [15]. In group C our finding is smaller than the study conducted by Mahima *et al.* 5.32cm [13] and Shivalingaiah N *et al.* 5.26cm [14]. In group D our finding is smaller than the study conducted by Mahima *et al.* 6.11cm [13] and Bharatnur S. *et al.* 6.04cm [16]. In group E our finding is strongly similar to the study conducted by Mahima *et al.* 6.78cm [13] and Sonika Gupta *et al.* 6.82cm [15] In group E our finding is strongly similar to the study conducted by Bharatnur S. *et al.* 7.08cm [16].
The mean values of fetal kidney volume of the fetuses are 1.22, 1.82, 3.72, 6.09, 8.65, and 11.39 (in cm^3) in the A, B, C, D, E, and F groups respectively. In group C our finding is smaller than the study conducted by Osho *et al.* 5.35cm^3 [17]. In group D our finding is smaller than the study conducted by

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Osho *et al*. 7.43 cm^3 [17]. In group E our finding is smaller than the study conducted by Osho *et al*. 11.06cm^3 [17]. In group F our finding is smaller than the study conducted by Osho *et al*. 16.37cm^3. [17].

Conclusion

In the present study, we conclude that qualitative and quantitative aspects of human renal development and analyzing the kidney's growth pattern in human fetuses may be helpful in more precisely defining fetal kidney diseases, such as agenesis, hypoplasia, multicystic kidney, polycystic kidney, etc., using contemporary and non-invasive imaging techniques. Therefore, from the current study, we can conclude that the Determination of gestational age by using Ultrasonographic parameters like BPD, HC, AC, FL, and fetal kidney volume is a more accurate and reliable method. So, can be used as a tool to assist in the assessment of gestational age.

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