Study of fetal kidney size by ultrasonography at different gestational age

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Abstract
Normal fetal kidney dimensions are necessary to diagnose fetal kidney abnormalities. The maximum fetal renal growth occurs during 26-34 weeks gestation. Fetal kidney length correlates well with gestational age. Aim of the present study is to measure fetal kidney size at 30 and 38 weeks of gestation in singleton pregnancy. No statistically significant difference was found in the mean parameters of right and left kidney at a particular gestational age (p≥0.05) in this study. The mean length in mm of fetal kidneys was slightly longer than the approximate gestational age in weeks.

Keywords: Fetal kidney, Ultrasound, Gestational age.

Introduction
The kidneys, one of the vital organs of body, are part of the urinary system. It excrete metabolic waste products, has role in maintaining blood pressure and blood glucose level and also act as endocrine tissue liberating Kinins, 1, 25-dihydroxycholecalciferol, erythropoietin and renin. Measurement of the kidney length, by sonography can diagnose renal abnormality. Kidney can be visualized early at 14 weeks of gestation. As the pregnancy progresses, the increase in the perinephric fat with increased echogenicity separate the kidney from its surrounding soft tissues & allow its visibility easier. During 26-34 weeks gestation the fetal renal growth is maximum. In the third trimester 60% of the nephrons develop and the increase in nephron numbers stops by 36 weeks of gestation. Accurate measurements also may be helpful in determination of gestational Age. An often quoted “Rule of Thumb” is that renal length in millimeters approximates gestational age in weeks from 24 to 40 weeks.

Materials and Methods
The present study was conducted after obtaining clearance from Ethical Committee of the Institution from October 2011 to August 2013 in the Department of Anatomy Kalinga Institute of Medical Sciences, KIIT University, Patia, Bhubaneswar, Odisha, India. It was done in collaboration with the Department of Radiodiagnosis, Pradyumna Bal Memorial Hospital, KIMS, KIIT campus-5. Singleton 172 antenatal cases from eastern Odisha were included for the study. Two gestational age, at 30 and 38 Weeks of Gestation were included for the study, as the “Rule of Thumb” includes 24 to 40 weeks of gestational age and most of the booked patients at antenatal clinics of gynae & obstetrics units were referred for ultrasonographic evaluation at these weeks. Gestational age of fetus was calculated from the last menstrual period as mentioned by the patient.

Fetal Renal Measurements: The measurements of both kidneys were performed in the phase of Fetal Apnea. Ill-defined Adrenal or renal borders, abnormal renal morphology, and renal pelvic dilatation greater than 4 mm in anteroposterior diameter were excluded.

For measurement of the kidney length, the fetuses was scanned in the transverse plane until the kidneys were visualized just below the stomach. The probe was then rotated through 90° to outline the longitudinal axis of the kidneys to take the length pole to pole (Fig 5 & 6). The transducer was then rotated 90° to the longitudinal axis and the Transverse Section was obtained at the level of the renal hilum. Thickness & Width were measured in axial plane perpendicular to each other from outer to outer margin of the frozen image. Maximum thickness (Antero-Posterior diameter) was measured from ventral to dorsal surface and Width (Transverse diameter) was measured from lateral to medial border of the kidney images (Fig 5 & 6). The renal volume (cm³) was calculated (ellipsoid formula) as: 0.523 × Length (in cm) × Width (in cm) × Depth (in cm)

Results
Statistical analysis of measurements fetal kidney parameters in172 singleton antenatal cases were taken. Out of which 56 cases were 30 weeks gestation and 116 cases were 38 weeks gestation.

The comparison of parameters of right and left kidneys between 30 and 38 weeks of gestation by Independent Sample’t test is furnished in Table 1. The mean values of different parameters of right and left kidney are plotted graphically in Fig. 1 and Fig. 2 respectively. It is clearly revealed that at 38 weeks the parameters were higher than parameters at 30 weeks and the difference was statistically significant. Further
analysis was done to see the difference between the parameters of right and left kidneys at a particular gestational age through paired sample ‘t’ test. The results are depicted in Table 2 and graphically represented in Fig. 3 and Fig. 4 for 30 weeks and 38 weeks of gestation respectively. It was revealed that at 30 weeks of gestation the mean length, breadth, thickness and volume of right kidney were 32.4 ± 5.2 mm, 17.8 ± 3 mm, 20.3 ± 4 mm and 6.3 ± 2.7 cm³ respectively. At 30 weeks of gestation the mean length, breadth, thickness and volume of left kidney were 33.3 ± 4 mm, 17.7 ± 2.9 mm, 19.8 ± 3.4 mm and 6.4 ± 2.3 cm³ respectively. At 38 weeks of gestation the mean length, breadth, thickness and volume of right kidney were 39.7 ± 4.9 mm, 21.1 ± 3.5 mm, 23.5 ± 4 mm and 11 ± 7.3 cm³ respectively. At 38 weeks of gestation the mean length, breadth, thickness and volume of left kidney were 39.1 ± 4.9 mm, 20.6 ± 3 mm, 22.7 ± 4.9 mm and 9.8 ± 2.8 cm³ respectively. The difference between the mean parameters of right and left fetal kidney at 30 weeks of gestation was not statistically significant (p ≥ 0.05). At 38 weeks of gestation the mean length, breadth, thickness and volume of right and left kidney were 39.7 ± 4.9 mm, 21.1 ± 3.5 mm, 23.5 ± 4 mm and 11 ± 7.3 cm³ respectively. At 38 weeks of gestation the mean length, breadth, thickness and volume of left kidney were 39.1 ± 4.9 mm, 20.6 ± 3 mm, 22.7 ± 4.9 mm and 9.8 ± 2.8 cm³ respectively. The difference between the mean parameters of right and left fetal kidney at 38 weeks of gestation was not statistically significant (p ≥ 0.05). Hence, there was no difference in the mean parameters of right and left kidney at a particular gestational age.

Table 1: Comparison of parameters of kidney between 30 weeks and 38 weeks

| Parameters        | Foetal Age | Mean | 95% Confidence Interval for Mean | Std. Deviation | t value | p value |
|-------------------|------------|------|---------------------------------|----------------|---------|---------|
|                   |            | Lower Bound | Upper Bound | Std. Error Mean |         |         |
| Length Right Kidney | 30 weeks   | 32.443  | 31.063 | 33.822 | 5.151 | -8.950 | 0.000 |
|                    | 38 weeks   | 39.743  | 33.834 | 40.653 | 4.946 | 0.000 |
| Breadth Right Kidney | 30 weeks   | 17.754  | 16.963 | 18.544 | 2.953 | -6.231 | 0.000 |
|                    | 38 weeks   | 21.113  | 20.474 | 21.752 | 3.473 | 0.000 |
| Thickness Right Kidney | 30 weeks   | 20.305  | 19.229 | 21.382 | 4.019 | -4.896 | 0.000 |
|                    | 38 weeks   | 23.511  | 22.771 | 24.252 | 4.027 | 0.000 |
| Volume Right Kidney | 30 weeks   | 6.271   | 5.549  | 6.993  | 2.696 | -4.683 | 0.000 |
|                    | 38 weeks   | 11.003  | 9.658  | 12.349 | 7.316 | 0.000 |
| Length Left Kidney | 30 weeks   | 33.307  | 32.226 | 34.388 | 4.038 | -7.726 | 0.000 |
|                    | 38 weeks   | 39.150  | 38.247 | 40.053 | 4.913 | 0.000 |
| Breadth Left Kidney | 30 weeks   | 17.689  | 16.895 | 18.484 | 2.967 | -6.018 | 0.000 |
|                    | 38 weeks   | 20.645  | 20.085 | 21.204 | 3.042 | 0.000 |
| Thickness Left Kidney | 30 weeks   | 19.770  | 18.855 | 20.684 | 3.415 | -4.071 | 0.000 |
|                    | 38 weeks   | 22.723  | 21.826 | 23.620 | 4.879 | 0.000 |
| Volume Left Kidney | 30 weeks   | 6.355   | 5.730  | 6.980  | 2.334 | -7.953 | 0.000 |
|                    | 38 weeks   | 9.768   | 9.258  | 10.277 | 2.770 | 0.000 |

Table 2. Comparison of parameters of left and right kidney at same gestational age (30 weeks and 38 weeks)

| Foetal Age | Pair | Parameters          | Mean   | N  | Std. Deviation | Std. Error Mean | t value | p value |
|------------|------|---------------------|--------|----|----------------|-----------------|---------|---------|
| 30 weeks   | Pair 1 | Length Right Kidney | 32.443 | 56 | 5.151           | 0.688           | -1.621  | 0.111  |
|            |       | Length Left Kidney  | 33.307 | 56 | 4.038           | 0.540           | 0.020   | 0.836  |
|            | Pair 2 | Breadth Right Kidney | 17.754 | 56 | 2.953           | 0.395           | 1.041   | 0.302  |
|            |       | Breadth Left Kidney | 17.689 | 56 | 2.967           | 0.396           | 1.048   | 0.302  |
|            | Pair 3 | Thickness Right Kidney | 20.305 | 56 | 4.019           | 0.537           | 1.041   | 0.302  |
|            |       | Thickness Left Kidney | 19.770 | 56 | 3.415           | 0.456           | 1.041   | 0.302  |
|            | Pair 4 | Volume Right Kidney | 6.271  | 56 | 2.696           | 0.360           | -0.433  | 0.667  |
|            |       | Volume Left Kidney  | 6.355  | 56 | 2.334           | 0.312           | 0.031   | 0.976  |
| 38 weeks   | Pair 1 | Length Right Kidney | 39.743 | 116 | 4.946           | 0.459           | 1.284   | 0.202  |
|            |       | Length Left Kidney  | 39.150 | 116 | 4.913           | 0.456           | 1.362   | 0.188  |
|            | Pair 2 | Breadth Right Kidney | 21.113 | 116 | 3.473           | 0.322           | 1.362   | 0.188  |
|            |       | Breadth Left Kidney | 20.645 | 116 | 3.042           | 0.282           | 1.362   | 0.188  |
|            | Pair 3 | Thickness Right Kidney | 23.511 | 116 | 4.027           | 0.374           | 1.627   | 0.107  |
|            |       | Thickness Left Kidney | 22.723 | 116 | 4.879           | 0.453           | 1.627   | 0.107  |
|            | Pair 4 | Volume Right Kidney | 11.003 | 116 | 7.316           | 0.679           | 1.822   | 0.071  |
|            |       | Volume Left Kidney  | 9.768  | 116 | 2.770           | 0.257           | 0.031   | 0.976  |
Table 3. Comparison of fetal kidney length in present study and other studies

|                        | Present Study | J.J. Kansaria (2009) | Nahid Yusuf (2007) | J.C. Konje (2002) | S.M. Ansari (1997) |
|------------------------|---------------|-----------------------|---------------------|-------------------|---------------------|
|                        | Right kidney  | Left kidney           |                     |                   |                     |
| Kidney length at 30 weeks (mm) | 32.44±5.2    | 33.30±4.0             | 29.03±1.32          | 31.4±1.4          | 30.9±3.2            |
| Kidney length at 38 weeks (mm) | 39.74±4.9    | 39.15±4.9             | 36.25±1.70          | 37±1.4            | 40.1±2.4            |

Fig. 1: Parameters (USG) of right kidney by fetal age

Fig. 2: Parameters (USG) of left kidney by fetal age
Fig. 3: Comparison between mean parameters of foetal right and left kidney at 30 weeks by USG

Fig. 4: Comparison between mean parameters of foetal right and left kidney at 38 weeks by USG

Fig. 5: Showing ultrasonographic measurements of fetal right kidney at 30 weeks
Discussion

Normal dimensions of fetal kidneys is helpful in order to diagnose abnormalities. Measurement of the kidney length, by sonography can diagnose renal abnormality as early as 14 weeks of gestation. As the pregnancy progresses, the increase in the perinephric fat with increased echogenicity separate the kidney from its surrounding soft tissues & allow its visibility easier. By 30 weeks, the sufficient perirenal fat surrounding and accentuating the normal sonolucent renal parenchyma make identification relatively simple.

Gestation of 26-34 weeks is the period during which maximum fetal renal growth occurred. Major increase in kidney length, i.e. 26.2 mm has been noticed in second trimester while the measurement in 13 week was 6.3 mm and 9.6 mm in last trimester and at 37 week of gestation, the length of kidney was 42.1 mm. Sixty per cent of the nephrons develop in the third trimester and that increase in nephron numbers stops by 36 weeks of gestation. The renal length does not change significantly from 35 weeks of gestational age until term.

According to the study by Dinkel et al (1986), pathology of kidney is better expressed in its volume than in its length. Renal pelvic dilatation is a common sonographic finding in early pregnancy to diagnosis fetal kidney’s anomalies. Along with this measuring their size can help in determination of gestational age, especially in cases where the date of the mother’s last menstruation is unknown, and routine methods show contradictory results.

In the present study there was no statistically significant difference between the measurements of the left and right kidneys (p≥0.05) (Fig 1 & Fig 2). Similar result is also reported by many authors. The mean length of fetal kidneys in the present study was 32.9mm at 30 weeks and 39.5mm at 38 weeks which was similar to the study by Ansari SM et al (1997), Nahid Yusuf et al (2007), Konje J. C. et al (2002), but greater than those reported by J. J. Kansaria et al (2009) (Table 3). The mean length of fetal kidneys in this study was smaller than that reported by Cohen et al (1991), H.A.M. Damen – Elias (2005).

Konje et al (2002) mentioned that kidney length between 24 and 38 weeks of pregnancy was a more accurate technique for determining GA than other fetal biometric parameters such as BPD, HC, FL and AC. Kidney length can estimate the age of pregnancy, when the fetal head is too low and BPD and/or HC measurements are unfeasible. As the differences between the left and right kidney length is insignificant, measuring only one kidney in difficult cases does not affect the GA estimation.

Another study in India by Kansaria et al (2009) demonstrated that by measuring kidney length, pregnancies could be dated within 9.17 days. Many authors, in their study did not find significant difference in kidney length between normal and growth restricted fetuses, but they observed decreased kidney volume (29% less) in foetuses with intrauterine growth restriction than that of normally grown foetuses, which may be due to impaired nephrogenesis as a result of decreased renal perfusion.

But Indu Kaul et al (2012) found in their study the mean Left fetal kidney length was slightly but significantly longer than the mean Right at each gestational period, which was also observed by Fitzsimons RB et al, Duval JM et al and Sampaio FJ et al, as mentioned by Indu Kaul et al.

The left kidney volume is more than the right one from VI to IX lunar month. Nevertheless, in X lunar month the right fetal kidney has bigger average volume than left one. In this study also the volume of left kidney is more than right at 30 weeks of gestation and...
the volume of right kidney is more than left at 38 weeks of gestation. Philippe Jeanty et al (1982) also found the mean difference in both kidney volumes was 17%. 20

Many studies have found a very strong correlation between Fetal Kidney Length and Gestation Age.1,10,12,13,16 B O Verburg et al (2007) found all fetal growth parameters were positively associated with Fetal Kidney Volume.13

Conclusion
In this study, the observed mean dimensions of right kidney at 30 weeks of gestation were length 32.4± 5.2 mm, breadth 17.8± 2.9mm, thickness 20.3± 4 mm and volume 6.3± 2.7 cm³ and that of left kidney were length 33.3± 4 mm, breadth 17.7± 2.9mm, thickness 19.8±3.4 mm and volume 6.4± 2.3 cm³. At 38 weeks of gestation, the mean measurements of right kidney were length 39.7± 4.9 mm, breadth 21.1± 3.5mm, thickness 23.5± 4 mm and volume 11± 7.3 cm³ and the mean measurements of left kidney were length 39.2± 4.9 mm, breadth 20.7± 3 mm, thickness 22.7± 4.9 mm and volume 9.8± 2.8 cm³. An often quoted rule-of thumb is that “renal length in mm approximates gestational age in weeks”. In this study the mean length in mm of fetal kidneys were slightly longer than the approximate gestational age in weeks. No difference in measurements between right and left kidney was found.

Interest of Conflict: None

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