ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

ULTRASOUND MEASUREMENTS OF FETAL KIDNEY LENGTH IN NORMAL PREGNANCY AND CORRELATION WITH GESTATIONAL AGE

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ABSTRACT

Due of its non-invasive nature, ultrasound has quickly become an essential component of prenatal treatment. This study delves into the association between gestational age and the use of ultrasound measures to assess the length of the fetal kidneys during normal pregnancies. Women who participated in the research had normal pregnancies and had regular ultrasounds at certain points in the journey. Fetal kidney length is positively correlated with gestational age, and the size of the kidneys grows steadily larger as the pregnancy progresses, according to the results. This study confirms the reproducibility of ultrasound measurements for embryonic kidney size, since it demonstrated negligible interobserver variability. In order to detect anomalies or variations from predicted growth patterns, which might suggest underlying foetal developmental difficulties, it is crucial to know the typical range of foetal kidney length at different gestational ages. The results of this study will improve antenatal care procedures and help doctors make more accurate assessments of fetal kidney development using ultrasonography. Prenatal detection of renal abnormalities and prediction of neonatal outcomes may be possible with more investigation into the value of measuring the length of the fetal kidneys.

Keywords: Ultrasound Measurements, Fetal Kidney Length, Normal Pregnancy, Gestational Age, Fetal Development

INTRODUCTION

Ultrasound imaging has changed the way obstetrics is practiced because it allows doctors to evaluate the fetus's growth without intrusive procedures. Fetal kidney length is one of the many measures assessed during prenatal ultrasound exams that is of special relevance because of its possible consequences for detecting renal problems and tracking fetal growth. Ultrasound measures of the length of the fetal kidneys and their relationship to gestational age are crucial in normal pregnancies, and this introduction seeks to explain why.[1] In order to monitor the health of the fetus and find congenital abnormalities early on, prenatal ultrasonography has become an essential technique for evaluating the fetal anatomy and development. Conditions including renal agenesis, hydronephrosis, and polycystic kidney

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

disease require early discovery in order to be appropriately managed; these abnormalities make up a substantial fraction of congenital malformations. Fetal kidney ultrasounds reveal important details on the kidneys’ size, shape, echogenicity, and the existence of any anomalies in their structural makeup.[2]

It is essential to have a solid understanding of the normal development of the kidneys in a fetus in order to appropriately interpret the findings of an ultrasound. The embryonic kidneys go through a period of fast development and maturation over the course of pregnancy.[3] This results in the formation of unique structures such as the renal cortex, the medulla, and the collecting system. It is possible to evaluate the kidneys' size in connection to the gestational age due to the fact that they are well-defined and may be measured by the time the pregnancy reaches the middle pregnancy.

Ultrasound measurements of the length of the fetal kidneys during a normal pregnancy and how they correlate with gestational age are important because they have the ability to improve prenatal diagnosis and care. Medical personnel will be able to evaluate the development of a fetus more precisely if a standard range for the length of the kidneys at various points in the gestational period is defined. As a result, problems with development or anomalies may be more easily identified and treated in a timely manner. Further, improving the precision of fetal age estimation during ultrasounds can be achieved by comparing kidney length with gestational age. In the long run, this research has the potential to increase maternal-fetal healthcare outcomes, refine prenatal screening techniques, and better manage high-risk pregnancies.

MATERIALS AND METHODS

This is a prospective cross-sectional study conducted in Postgraduate Department of Anatomy in collaboration with Postgraduate Department of Radiodiagnosis and Imaging, Government Medical College, Srinagar during the period from Mat to October 2023. Women who met the following criteria were eligible to participate: they were pregnant, they were in the latter half of their second or third trimesters, they had a regular 28-day menstrual cycle, they knew their last menstrual period (LMP), and they had an obstetric scan in the first trimester of their index pregnancy that was dated using the CRL. The following conditions were used to exclude mothers from the study: a history of diabetes or hypertension during pregnancy, a lack of clarity on the index pregnancy's LMP, a history of cigarette smoking, and a discrepancy of more than two weeks between GA determined by LMP and composite GA (CGA) according to Hadlock's chart. Exclusion criteria included indications of intrauterine growth restriction, polyhydramnios, ambiguous adrenal or renal limits, aberrant renal morphology, apparent fetal hydronephrosis, and morphological anomalies in the fetus. The present research is comprised of a sample size of 150 individuals in this study.

Ultrasound machine was used to measure all fetal biometric parameters with a real-time, grayscale, 3.5-5.0 MHz curvilinear array transducer. Participants were asked to fill out a standardized questionnaire that would record their sociodemographic information as well as any pertinent medical records. We measured the mother's weight and height in kilos and meters, respectively.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

When scanning the foetus, it was common practice to begin at the level of the four heart chambers to establish an acceptable transverse plane. From there, the scans continued in a cephalocaudal direction until the foetal kidneys were visible, which was usually at or slightly below the stomach level. After that, the longitudinal axis of both kidneys on each side of the midline tubular anechoic abdominal aorta was obtained by rotating the probe through 90 degrees. It was a laborious process to acquire and freeze on screen the greatest longitudinal picture that showed the outer poles of both the right and left kidney. From the top to the bottom, we used computerized calipers to measure the kidneys' length. To reduce the possibility of bias among the observers, we measured each kidney three times and averaged the results (in millimeters) in a spreadsheet. Figure 1 shows that the adrenal glands (AGs) were carefully excluded from the measurements.

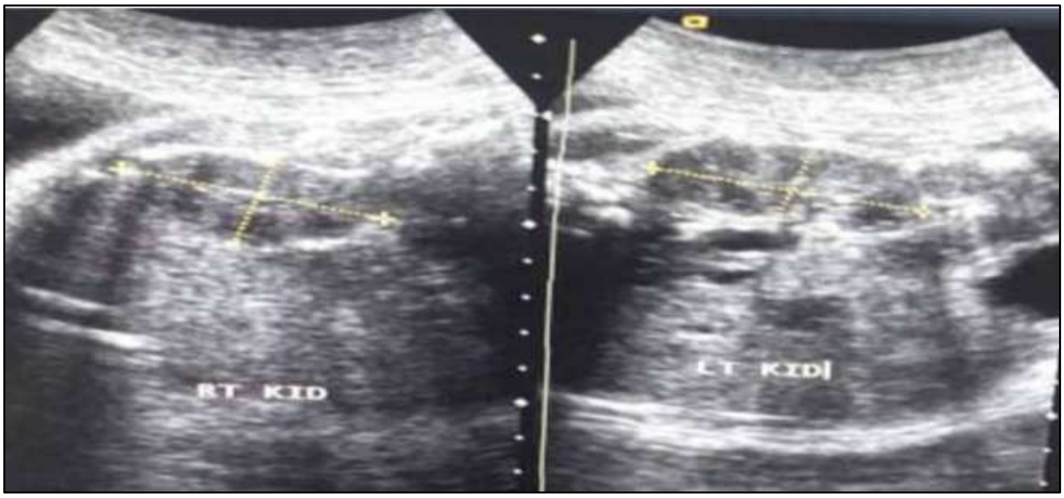

Figure 1: Yellow dotted lines indicate fetal kidney lengths and widths at 39 weeks gestation. Right kidney: 4.76 cm, width: 2.42 cm; left kidney: 4.45 cm, width: 2.20 cm

Using Naegele's rule, the patient's menstrual age (MA) in weeks was calculated from their LMP, which represents GA by LMP. The estimated GA, on the other hand, was calculated from Hadlock's chart of predicted fetal measurements at specific menstrual weeks for BPD, HC, FL, and AC, using well-defined reference points. Just like that, the CGA in weeks was recorded in the spreadsheet. This was calculated by averaging the measured biometric indices (BPD, HC, FL, and AC). The mean value was obtained by averaging the results of each measurement, which was done three times.

An analysis of the data was performed using SPSS 22.0, which was employed for the analysis. A 95% confidence interval, Student's t-test, analysis of variance, and Pearson's correlation coefficient were used to statistically analyze the significance of the hypotheses at a significance level of $P < 0.05$. In addition, we compared the results of regression analysis on the biometric factors. We used regression equations that were both univariate and multivariate.

RESULTS

The study looked at 300 fetal kidneys and 150 pregnant women overall. The majority of the participants were in the third trimester 72%, whereas a small percentage were in the late second trimester 28.5%. Participants' ages ranged from 18 to 44 years, with an average

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

age of 29.90 ± 0.22 years. In Table 1, we can see the nomograms for foetal kidney length (FKL) in this study, which include the mean RKL, LKL, and MKL along with their standard deviations at distinct GAs starting from the 20th week. As the GA climbed in weeks, RKL, LKL, and MKL all increased in millimeters. At 20 weeks of gestation, the MKL was 20.87 ± 0.75 mm, and at 41 weeks of gestation, it was 41.41 ± 0.07 mm.

Table 1:
Comparison of mean right, left, and combined kidney lengths with menstrual age

Menstrual age (weeks)	Number of patients (n)	RKL+SD (mm)	LKL+SD (mm)	Difference (mm)	MKL+SD (mm)
20	6	20.70±0.91	21.04±0.63	0.34	20.87±0.75
21	4	20.86±0.43	21.05±0.45	0.19	20.96±0.41
22	7	22.06±0.60	22.49±0.46	0.43	22.27±0.44
23	7	23.59±0.85	23.99±1.13	0.40	23.79±0.94
24	5	25.13±1.36	25.53±1.32	0.40	25.33±1.32
25	7	25.83±1.28	26.11±1.43	0.28	25.97±1.31
26	4	26.90±0.67	28.04±0.71	1.14	27.47±0.68
27	3	27.31±1.28	27.77±1.09	0.46	27.54±1.17
28	5	29.36±0.62	29.56±0.74	0.20	29.46±0.63
29	5	30.00±0.96	30.69±1.19	0.69	30.34±1.02
30	7	31.59±0.89	32.07±0.77	0.48	31.83±0.74
31	9	31.66±0.99	32.08±1.07	0.42	31.87±1.00
32	7	33.51±0.97	33.69±1.02	0.18	33.60±0.88
33	10	34.13±1.34	34.48±1.30	0.35	34.31±1.26
34	7	34.92+0.84	35.21±1.02	0.29	35.06±0.86
35	11	35.76+1.34	35.96±1.16	0.20	35.86±1.19
36	16	36.52±1.04	37.20±1.03	0.68	36.86±0.99
37	13	38.15±1.41	38.21±1.08	0.06	38.18±1.14
38	9	38.58±1.14	38.96±1.15	0.38	38.77±1.05
39	4	39.35±1.14	39.45±0.92	0.09	39.40±0.99
40	2	39.80±0.68	40.83±1.75	1.03	40.32±0.54
41	2	40.80±0.63	42.02±0.76	1.22	41.41±0.07
Total	150	31.99±5.98	32.38±5.98		32.18±5.96

LKL was considerably greater than RKL during gestational weeks (P = 0.000) (Table 1). RKL, LKL, and MKL (mm) had a substantial positive connection with MA in weeks (r = 0.983, P = 0.000, r = 0.985, P = 0.000). The connection between maternal height and RKL, LKL, MKL, and MA was not significant (r = 0.067, P = 0.178, 0.076, P = 0.132, and 0.072, P = 0.153). The maternal weight had a slight positive connection with RKL, LKL, MKL, and MA (r = 0.207, P = 0.000). (Table 2) displays MKL values and standard deviations every week of gestation, together with BPD, HC, FL, and AC mean GAs. MKL grew linearly when GA defined by other factors increased.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

Table 2:
Mean combined kidney length vs. menstruation and gestational ages from fetal biometrics

Menstrual age (weeks)	Number of participants (n)	MKL+SD (mm)	Mean GA by BPD+SD (weeks)	Mean GA by HC+SD (weeks)	Mean GA by FL+SD (weeks)	Mean GA by AC+SD (weeks)
20	6	20.87±0.75	20.73±0.88	20.79±0.81	20.57±0.81	21.23±0.83
21	4	20.96±0.41	21.43±0.62	21.30±0.53	21.67±0.53	21.73±0.49
22	7	22.27±0.44	22.56±0.35	22.49±0.82	22.63±0.49	22.76±0.68
23	7	23.79±0.94	23.50±1.16	23.20±0.93	23.33±1.15	23.26±1.01
24	5	25.33±1.32	25.46±1.15	25.48±1.00	24.83±1.37	25.09±1.12
25	7	25.97±1.31	25.02±1.10	25.48±0.98	25.11±0.78	25.29±0.85
26	4	27.47±0.68	26.71±1.18	27.31±1.50	27.23±0.57	27.29±0.98
27	3	27.54±1.17	26.75±0.52	26.89±0.50	26.95±0.84	26.24±0.43
28	5	29.46±0.63	28.38±0.98	28.96±1.27	28.39±1.10	29.23±1.19
29	5	30.34±1.02	29.54±0.85	29.29±1.21	29.68±1.06	29.74±0.83
30	7	31.83±0.74	31.22±0.94	31.43±0.84	30.73±1.61	30.75±1.00
31	9	31.87±1.00	31.53±1.11	32.02±1.06	31.54±0.92	31.61±1.53
32	7	33.60±0.88	32.54±1.22	33.44±0.66	33.22±1.27	32.00±1.64
33	10	34.31±1.26	33.57±1.25	34.14±0.81	33.92±1.39	33.75±1.54
34	7	35.06±0.86	34.02±1.72	35.07±0.77	34.79±1.08	35.10±1.02
35	11	35.86±1.19	35.17±0.90	35.47±1.10	35.93±1.47	35.55±1.58
36	16	36.86±0.99	35.64±1.76	36.02±1.56	36.45±1.35	36.22±1.45
37	13	38.18±1.14	36.15±1.65	37.17±1.43	37.66±1.64	37.15±1.08
38	9	38.77±1.05	37.10±1.60	37.79±1.50	38.43±1.50	37.66±1.06
39	4	39.40±0.99	38.16±1.23	38.31±1.16	38.77±0.35	37.91±0.83
40	2	40.32±0.54	37.62±2.10	40.00±0.34	39.57±0.22	38.29±0.56
41	2	41.41±0.07	38.38±1.64	39.05±1.38	39.76±1.04	39.14±0.68
Total	150	32.18±5.96	31.27±5.48	31.72±5.72	31.77±5.91	31.59±5.62

Table 3 shows comparison between this study and the previous study.

Table 3: A comparison between the mean combined fetal kidney length in the current research and the mean combined fetal kidney length in other studies conducted at different gestational ages

GA (weeks)	MKL (mm) in present study (2014)	MKL (mm) (Nirmala et al., 2013)	MKL (mm) (Indu et al., 2012)	MKL (mm) (Kansaria et al., 2009)	MKL (mm) (Konje et al., 2002)
24	25.3	24.1	25.7	23.9	24.2
28	29.5	28.2	31.5	27.0	29.0
32	33.6	32.8	36.5	30.8	33.2
36	36.9	36.5	40.6	34.3	38.2

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

As a single parameter for predicting GA, BPD had the lowest level of accuracy, with a standard error of 10.36 days. On the other hand, MKL was the most accurate single parameter, with a standard error of ± 7.17 days. The following equations illustrate the basic linear regression equations that were constructed from each FKL parameter (RKL, LKL, and MKL) expressed as a function of GA:

- MA (weeks) = 0.661 + 0.969 RKL (mm)
- MA (weeks) = 0.264 + 0.969 LKL (mm)
- MA (weeks) = 0.326 + 0.973 MKL (mm)

The model with the highest accuracy for predicting gestational age (GA), with a standard error of ± 6.30 days, includes means kidney length (MKL), femur length (FL), biparietal diameter (BPD), head circumference (HC), and abdominal circumference (AC). High-resolution real-time ultrasonography can better visualize fetal organs. The fetal kidney is an exception. All 150-research participants had their embryonic kidneys examined. The transducer and angle of insonation relative to the fetal kidney plane were altered to make this work regardless of fetal position, lie, or presentation.
We excluded the surrounding fetal AG from our FKL measurements since the ultrasound machine's resolution was sufficient enough to define its borders. Due to dietary and genetic peculiarities in this study population, the weak positive correlation between maternal weight and MA suggests that maternal body habitus in this environment may significantly affect GA determination using Naegele's rule-based LMP. The results of this study contrast those of other researchers, who showed a slight positive association between maternal height and FKL and no correlation between maternal weight and FKL. In contrast, a recent study showed maternal weights before pregnancy when FKL was measured. This study demonstrated that FKL rose linearly with GA in weeks, supporting the millimeter-based MKL values' accuracy compared to genuine GAs. The prior study tested only the proximal embryonic kidney, but the present one measured both.

DISCUSSION

This study demonstrated a statistically significant kidney length difference, with the left kidney longer. Also, adult left kidneys are 1.5 cm longer than right kidneys.

Genetic and socioeconomic factors may explain the discrepancies in right and left kidney lengths between this research and others. In 74 fetuses, researchers found that the average right kidney width was substantially longer than the average left kidney width (P = 0.004), although RKL and LKL were not statistically different (P = 0.843). Previous research has revealed that fetal kidney width is reduced in small-for-GA foetuses, rendering it unreliable for GA assessment in utero. However, fetal kidney length was identical in GA-appropriate and small-for-GA foetuses. BPD, HC, FL, and AC indicated a favorable relationship between millimeters of MKL and weeks of GA, which this investigation confirmed. FKL and LMP-predicted GA are strongly correlated (r = 0.997). With just third-trimester students, MKL and GA were strongly correlated (r = 0.860)[4,5,6].

This analysis identified MKL as the best GA predictor. As pregnancy develops approaching term, the fetal skull engages and molds, making it harder to establish the usual plane for BPD measurement. Most vertex-presenting intrauterine fetuses do this. The

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE5, 2024

growing inaccuracy of BPD in GA determination beyond early 2nd trimester supports this, according to O'Brien. This study found that predicting the mean CGA using multiple variables yields a lower SE than with a single variable. This supports other authors' findings and recommendations for sonographic GA estimation using composite measures of prenatal biometric variables[7-12].

CONCLUSION

The results of this study emphasize the usefulness of ultrasound measures in determining the length of the fetal kidney during the course of a normal pregnancy and the association between that length and the gestational age of the fetus. As the gestational age increases, our findings indicate that there is a constant pattern of kidney growth. This provides vital insights into the development of the fetus as well as possible indicators for the health of the mother during pregnancy.

After doing careful ultrasound measurements, we found that there was a substantial positive link between the length of the fetal kidney and the gestational age of the fetus. Because of this association, the dynamic character of the development of fetal organs throughout pregnancy is brought to light, and the significance of maintaining frequent monitoring in order to identify any deviations from the norm is emphasized. More than that, the results of our research demonstrate that ultrasonography is a diagnostic tool that is both reliable and non-invasive when it comes to evaluating the health of the fetus.

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