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Ultrasound Evaluation of Kidney Length in Normal and Intrauterine Growth Restricted Fetuses

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Author`s Contribution

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ABSTRACT

Background: The failure of a fetus to attain its estimated development potential is referred to as intrauterine growth restriction (IUGR). This illness can be caused by a number of circumstances, the most often is malnutrition of mothers and inadequate oxygen delivery to the fetus.

Objectives: To compare length of kidney in normal and intrauterine growth restricted fetuses for estimation of gestational age

Methodology: A cross-sectional, case control study was conducted at Sheikh Abdullah Memorial Hospital, Radiology Department, and Muzaffarabad Azad Kashmir for a duration of 9 months. A total of 48 participants were enrolled in this study. Patients were scanned using ultrasound machine Hitachi EUB 7500, curvilinear transducer with frequency of 3.5-5.0-MHz. SPSS 25 was used to analyze data

Results: The participants' mean + SD age was 28.5 + 4.5 years. One fetus out of 48 had IUGR at 26 weeks, another at 28 weeks, and another at 29 weeks of gestation. IUGR was found in 5 out of 7 of the fetuses at 30 weeks. Similarly, at 31 weeks, 1 out of 3 fetuses had IUGR, whereas at 32 weeks, 4 out of 5 fetuses had IUGR. At 33 weeks, one out of every four fetuses had IUGR. As the gestational period increased, IUGR was detected in 5 of 8 pregnancies at 34 weeks and 2 of 4 pregnancies at 35 weeks. In addition, single incidences of IUGR were discovered at 37, 38, and 40 weeks of gestation.

Conclusion: The study findings suggested that fetal renal length is a more accurate strategy for estimating fetal age in IUGR fetuses than other biometric data.

Key words: Intra-uterine growth restriction Femur Length, fetal kidney length, Head abdominal circumference, Circumference.

Introduction

The restriction of intrauterine growth (IUGR) is the inability of a fetus to reach its expected growth potential. This syndrome is impacted by a number of variables, including low maternal nutrition and a lack of oxygen supplied to the fetus.[1] The definition emphasizes the importance of not only absolute size but also consistency of growth pattern. For example, a fetus with an AC in the 90th percentile at 28 weeks but in the 50th percentile at 36 weeks is more inclined to be growth-restricted than one consistently in the 50th percentile.[2] Furthermore, indicators such as lower volume of amniotic fluid and estimated fetal weight help to characterize intrauterine growth restriction.[2] IUGR is caused by a variety of factors. Fetal variables such as chromosomal aneuploidies, anatomical malformations, and infections such as TORCH infections are examples of these.[3] Multiple pregnancies are a risk factor for IUGR, accounting for around 3% of instances.[4] Age, nutritional state, and chronic disorders all play an impact in maternal health.

Gestational age can be estimated by fetal kidney length especially in the final weeks of the second and third trimesters of pregnancy. During this time, both kidneys are plainly visible and precisely quantifiable. Fetal renal length can be used as a standalone investigational metric or in combination with other data to estimate gestational age. While numerous criteria are routinely used by sonologists in the first and second trimesters, their precision decreases as the pregnancy proceeds. In contrast, the length of fetal kidneys in millimeters has a strong association with the age of gestation in weeks.[5]Intrauterine growth restriction (IUGR) is linked with reduced kidney volume compared to fetuses with appropriate weight for gestational age, according to research on fetal kidney size with known gestational age. The overall length of the kidneys remains similar to appropriately grown fetuses, while anteroposterior and oblique dimensions experience significant decreases.[6]

Presently, there is limited research on fetal kidney length and distinguishing IUGR from normal fetal growth in the third trimester of pregnancy in patients with a lack or absence of previous records (previous scans, LMP etc.). Hence the purpose of this research was to measure fetal kidney length in IUGR and normal pregnancy. Moreover, it can accurately predict gestational age in IUGR and normal pregnancies.

Methodology

A cross-sectional case-control research was conducted over a 9-month period with consent from both the university and the internal review board of Sheikh Abdullah Memorial Hospital in Muzaffarabad, Azad Kashmir. The study was conducted at the Radiology Department and included 48 subjects. Participants had to have a singleton pregnancy with a viable fetus beyond 24 weeks of gestation, as well as a verified last menstrual period (LMP). Patients with no documented prenatal kidney abnormalities, oligohydramniosis, or polyhydramniosis were eliminated. Patients were scanned with an ultrasound machine equipped with a curvilinear transducer working at a frequency of 3.5-5.0 MHz, the Hitachi EUB 7500. SPSS version 25 was used to analyze the collected data. Transabdominal scans were performed on each patient while they were laying supine. The transverse plane was used to see the embryonic kidney until it was evident in the lower belly. The ultrasound probe was then turned 90 degrees to outline the kidney's longitudinal axis. The length of the fetal kidney was measured from the outside edge of the higher pole to the outer edge of the lower pole. All acquired data were input and analyzed using SPSS version 25, with a p-value of 0.05 selected as the significance threshold.

Results

The mean ± SD of age of participants was 28.5 + 4.5 years with minimum and maximum age of 20 and 39 respectively. Out of 48 cases, one fetus exhibited IUGR at 26 weeks, another at 28 weeks, and one more at 29 weeks of gestation. Among the fetuses at 30 weeks, IUGR was identified in 5 out of 7. Similarly, at 31 weeks, 1 out of 3 fetuses had IUGR, while at 32 weeks; IUGR was noted in 4 out of 5 fetuses. At 33 weeks, 1 out of 4 fetuses displayed IUGR. As the gestational age advanced, IUGR was evident in 5 out of 8 fetuses at 34 weeks and in 2 out of 4 fetuses at 35 weeks. Furthermore, single cases of IUGR were detected at 37, 38, and 40 weeks of gestation.

Out of 5 women aged 25 IUGR was present in 1. 2 out of 4 women at age 26 had IUGR. 1 woman aged 27 and 3 women aged 28 showed presence of IUGR. In women aged 29, a significant increase in IUGR was observed, with 3 out of 4 showing this condition. Among a group of 7 women aged 30, 4 had IUGR. Similarly, among 6 women aged 31, 3 were affected by fetal growth restriction. Both women aged 32 experienced IUGR, as did 1 woman aged 33. All 3 women aged 35 had fetal growth restriction, while 1 out of the group aged 37 also displayed IUGR. Notably, 1 woman aged 39 did not exhibit any signs of IUGR. These findings consistently indicate a correlation between advanced maternal age and an increased likelihood of IUGR occurrence.

The mean ± SD of right and left kidney (Figure1) length in growth restricted fetuses was 34.9 ± 3.2 mm and 34.9 ± 3.0 mm respectively. The mean ± SD right kidney length in normal fetuses was 36.8 ± 2.5 mm and left fetal kidney length was 37.7 ± 2.3 mm (Table I). Independent sample T-test showed a statistical significance between bilateral kidney lengths in both growth restricted and normal fetuses. (Table II)

Table I: Group statistics Fetal kidney length in IUGR and Normal cases. (n=24)

	IUGR	Mean	SD
FK length - Right	No	34.9000	3.28528
	Yes	36.8750	2.59686
FK length - left	No	34.9750	3.04706
	Yes	37.7667	2.39541

Table II: Independent Samples Test.

		Levene's Test for Equality of Variances		t-test for Equality of Means					
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
								Lower	Upper
FK length – Right	Equal variances assumed	2.201	.145	-2.310	46	.025	-1.97500	-3.69564	-.25436
	Equal variances not assumed			-2.310	43.672	.026	-1.97500	-3.69812	-.25188
FK length – left	Equal variances assumed	2.265	.139	-3.529	46	.001	-2.79167	-4.38420	-1.19914
	Equal variances not assumed			-3.529	43.571	.001	-2.79167	-4.38659	-1.19674

Table III: Group statistics Biometric measurements

	IUGR	N	Mean	Std. Deviation	Std. Error Mean
FL(mm)	No	24	68.3708	6.09144	1.24341
	Yes	24	57.7750	15.10696	3.08370
HC (mm)	No	24	322.0000	20.94500	4.27538
	Yes	24	302.1292	30.45413	6.21642
AC(mm)	No	24	296.7833	36.07465	7.36371
	Yes	24	266.1750	27.12915	5.53771
BPD(mm)	No	24	86.5542	6.47638	1.32198
	Yes	24	80.2333	8.12632	1.65878

Table IV: Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
FL(mm)	Equal variances assumed	2.872	.097	3.187	46	.003	10.59583	3.32494	3.90307	17.28860
	Equal variances not assumed			3.187	30.286	.003	10.59583	3.32494	3.80809	17.38358
HC (mm)	Equal variances assumed	2.171	.147	2.634	46	.011	19.87083	7.54472	4.68410	35.05757
	Equal variances not assumed			2.634	40.780	.012	19.87083	7.54472	4.63147	35.11020
AC(mm)	Equal variances assumed	1.714	.197	3.322	46	.002	30.60833	9.21360	12.06231	49.15435
	Equal variances not assumed			3.322	42.711	.002	30.60833	9.21360	12.02369	49.19297
BPD(mm)	Equal variances assumed	.540	.466	2.980	46	.005	6.32083	2.12113	2.05122	10.59045
	Equal variances not assumed			2.980	43.818	.005	6.32083	2.12113	2.04548	10.59619

Figure 1: Ultrasound image of fetal kidney.

The mean + SD femur length in growth restricted fetuses was 57.7 + 15 mm and in normal fetuses mean + SD femur length was 68.3 + 6.09 mm. The mean + SD head circumference in growth restricted fetuses was 302.1 + 30.4 mm and in normal fetuses mean + SD head circumference was 322.0 + 20.9 mm. In growth restricted fetuses the mean + SD abdominal circumference was 266.1 + 27.1 mm and in normal fetuses mean + SD abdominal circumference was 296.7 + 36.0 mm. The mean + SD bi-parietal diameter in growth restricted fetuses was 80.2 + 8.1 mm and in normal fetuses mean + SD BPD was 86.5 + 6.4 mm (Table III). Independent samples test was applied to compare the means of two samples; Femur length, Head circumference, Abdominal Circumference and Biparietal diameter in IUGR and normal fetuses showed a significant difference ($P < 0.05$). (Table IV)

Discussion

Intrauterine Growth Restriction (IUGR) is a pregnancy disorder in which a growing baby fails to meet its estimated growth potential. This disease can have serious consequences for embryonic organs such as the kidneys. According to research, IUGR can cause changes in kidney growth and structure, resulting in a reduction in kidney size. The smaller kidney size may suggest poor renal function and significant long-term health consequences for the affected person. Early identification and treatment are critical in dealing with IUGR and its possible effects on kidney growth and function.

We investigated how ultrasonography measures of kidney length change among healthy fetuses and those with IUGR (intrauterine growth restriction) in this study. Our purpose was to determine if IUGR influences kidney development as measured by changes in renal length. We wanted to understand more about how IUGR can affect renal function and long-term health by comparing kidney length to other biometric parameters including FL, BPD, AC, and HC.

Interestingly, our study found statistically significant variations in various biometric characteristics between two study groups, including biparietal diameter, stomach circumference, head size, and femoral length. However, there were no significant variations in the amniotic fluid index (AFI). It's worth noting that the average age of our research participants was 28.5 years, with a standard deviation of 4.5 years. Notably, our data revealed that older mothers had a greater frequency of intrauterine growth retardation (IUGR). In addition, the majority of intrauterine growth retard cases were discovered between 30 and 35 weeks of pregnancy.

Toosi et al. (2013) conducted a research that supports our findings, emphasizing the reliability of fetal femur length (FKL) as a metric in late-stage pregnancy.[7] Similarly, Konje and Abrams (2002) investigated the predictive value of FKL in pregnant women aged 24 to 38 weeks and discovered that it outperformed other fetal biometric parameters such as biparietal diameter (BPD), length of femur (FL), the circumference of the head (HC), and abdomen circumference (AC)[8].

Similarly, a study reported that using fetal kidney length (FKL) enhanced the precision of gestational dates in India.[9] Notably, according to Witzani et al. (2006), fetal kidney growth follows a constant pattern, increasing by 1.7 mm every two weeks during pregnancy and remaining unaffected by growth problems.[10] This feature makes it a dependable parameter, especially in complicated pregnancies. Furthermore, Kaul et al. (2012) identified fetal renal length as the most reliable measure for determining gestational age.[11]These studies highlight the reliability and relevance of fetal renal length in improving gestational age estimation.[8]

Konje et al. conducted research to evaluate the efficacy of kidney length measurement for predicting gestational age between the 24th and 38th weeks. Their goal also includes comparing the precision of kidney length observations to other fetal biometric markers. The goal of this study was to compare kidney lengths in normal and intrauterine growth retarded (IUGR) fetuses, as well as to look for statistical significance across a variety of biometric measures. While Konje et al.'s work focused on using kidney length to determine gestational age and comprehensively assessing its reliability against other fetal biometric indicators, our research shed light on the possible influence of IUGR on kidney length. Notably, Konje et al.'s findings highlight the viability of using kidney length to estimate gestational age precisely.[8]

The study by Shivalingaiah et al. found a strong relationship between fetal renal length and gestational age, notably in the latter trimesters, even in intrauterine development restricted fetuses. According to the findings, kidney length was strongly connected to gestational age and had equivalent accuracy to all ultrasound biometric measures.[12]

Murugan et al. study, on the other hand, investigated the association and coefficient of regression of fetal renal length with gestational age, contrasting it with different other fetal biometric indicators. Their findings indicated an extraordinarily high Pearson's correlation value of 0.99 and a regression coefficient of 1.0, demonstrating a continuously linear development rate in gestational age and fetal kidney length throughout pregnancy. The study found that fetal kidney length has a favorable relationship with gestational age, regardless of underlying medical problems such intrauterine growth retardation.[13]

In this study, we compared fetal biometric indicators in growth-restricted fetuses to normal fetuses. The mean SD femur length in growth-restricted fetuses was found to be substantially shorter (57.7 $\pm$ 15 mm) than in normal fetuses (68.3 $\pm$ 6.09 mm). Similarly, growth-restricted pregnancies had a significantly smaller head circumference (302.1 $\pm$ 30.4 mm) than normal fetuses (322.0 $\pm$ 20.9 mm). Furthermore, growth-restricted babies had considerably smaller circumferences of the abdomen and biparietal diameter (266.1 $\pm$ 27.1 mm and 80.2 $\pm$ 8.1 mm, respectively) than normal fetuses (296.7 $\pm$ 36.0 mm and 86.5 $\pm$ 6.4 mm, respectively). The differences between growth-retarded and normal pregnancies in length of femur bone, head measurement, abdomen circumference, and biparietal diameter were determined to be statistically significant (P 0.05). Previous research has shown that biometric indicators such as bi-parietal diameter (BPD), length of the femur (FL), and the circumference of the head (HC) may be utilized in calculating gestational age (GA) throughout the pregnancy. Fetal biometry data acquired by ultrasound, such as crown-rump length (CRL), biparietal diameters (BPD), and the length of the femur (FL), are regarded trustworthy, especially in the first and second trimesters. However, their accuracy decreases as the fetus becomes older, making exact dating difficult in the latter stages of the second or third trimester due to physiological size changes.[14] These findings highlight the need of using physiological markers in the identification and tracking of restricted intrauterine growth, as well as the challenges associated with correct fetal age estimation as pregnancy progresses.

When we compare these studies with our study, which highlighted the mean kidney lengths in growth-restricted and normal fetuses, along with the significant differences in various biometric parameters, we can observe an alignment in the overall findings. The fetal kidney length in these studies has shown us that it's an important factor in understanding pregnancy.

Conclusion

The findings indicate that fetal kidney length is a more reliable approach for estimation of gestational age as compared to other biometric measurements in IUGR fetuses.

References

1. Radi Mohammad M, Mohammad Zakaria AA-M, Abd El-Fatah Mahmoud Abo-Rashed A, Abd Al-Hamid Sedek AA-M. ULTRA-SOUND ASSESSMENT OF FETAL KIDNEY VOLUME AND RENAL BLOOD FLOW VELOCIMETRY IN INTRAUTERINE GROWTH RESTRICTION. Al-Azhar Medical Journal, (2020); 49(3): 1093-1100. https://doi.org/10.21608/amj.2020.91631
2. Baschat AA, Gembruch U, Harman CR. The sequence of changes in Doppler and biophysical parameters as severe fetal growth restriction worsens. Ultrasound Obstet Gynecol, (2001); 18(6): 571-577. https://doi.org/10.1046/j.0960-7692.2001.00591.x
3. Andzane D, Gapatins I, Miskova A. Intrauterine growth restriction: distribution, risk factors, management of labour and outcome. International Journal of Reproduction, Contraception, Obstetrics and Gynecology, (2015); 1117-1121. https://doi.org/10.18203/2320-1770.ijrcog20150438
4. Miller J, Chauhan SP, Abuhamad AZ. Discordant twins: diagnosis, evaluation and management. Am J Obstet Gynecol, (2012); 206(1): 10-20. https://doi.org/10.1016/j.ajog.2011.06.075
5. Shaheen W, Gilani SA, Hasan Z-u, Fatima M, Bacha R, et al. Ultrasonographic evaluation of fetal kidney length as a reliable parameter for estimation of gestation age in 2nd & 3rd trimester. International Journal of Applied Sciences and Biotechnology, (2019); 7(1): 108-113. https://doi.org/10.3126/ijasbt.v7i1.23319
6. Brennan SF, Cresswell AG, Farris DJ, Lichtwark GA. In vivo fascicle length measurements via B-mode ultrasound imaging with single vs dual transducer arrangements. Journal of Biomechanics, (2017); 64240-244. https://doi.org/10.1016/j.jbiomech.2017.09.019
7. Seilanian Toosi F, Rezaie-Delui H. Evaluation of the normal fetal kidney length and its correlation with gestational age. Acta Med Iran, (2013); 51(5): 303-306.
8. Konje JC, Abrams KR, Bell SC, Taylor DJ. Determination of gestational age after the 24th week of gestation from fetal kidney length measurements. Ultrasound in Obstetrics & Gynecology, (2002); 19(6): 592-597. https://doi.org/10.1046/j.1469-0705.2002.00704.x
9. M MS, Maria Francis Y, Karunakaran B, G SN. Ultrasonographic Estimation of the Gestational Age Using the Fetal Kidney Length in the Second and Third Trimesters of Pregnancy Among South Indian Antenatal Women: A Cross-Sectional Study. Cureus, (2023); 15(6): e41172.
10. Witzani L, Brugger PC, Hörmann M, Kasprian G, Csapone-Balassy C, et al. Normal renal development investigated with fetal MRI. Eur J Radiol, (2006); 57(2): 294-302. https://doi.org/10.1016/j.ejrad.2005.11.027
11. Kaul I, Menia V, Anand AK, Gupta R. Role of fetal kidney length in estimation of gestational age. JK Science, (2011); 1465-69.
12. Shivalingaiah N, Sowmya K, Ananya R, Kanmani T, Marimuthu P. Fetal kidney length as a parameter for determination of gestational age in pregnancy. Int J Reprod Contracep Obstet Gynecol, (2014); 3424-427. https://doi.org/10.5455/2320-1770.ijrcog20140628
13. Murugan VA, Murphy BO, Dupuis C, Goldstein A, Kim YH. Role of ultrasound in the evaluation of first-trimester pregnancies in the acute setting. Ultrasonography, (2020); 39(2): 178-189. https://doi.org/10.14366/usg.19043
14. Lobo ML, Favorito LA, Abidu-Figueiredo M, Sampaio FJ. Renal pelvic diameters in human fetuses: anatomical reference for diagnosis of fetal hydronephrosis. Urology, (2011); 77(2): 452-457. https://doi.org/10.1016/j.urology.2010.06.049