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Evaluating the Relationship Between Fetal Kidney Length and Gender in Late Pregnancy: A Sonographic Approach

Nabaa Aswad Shakir[1], Ghasaq Maan Bakr[2*], Saja Ali Ahmed[3], Jehan Al-Musawi[4]

1. *Department of Surgery, Al-Kindy Collage of Medicine, University of Baghdad, Baghdad, Iraq*
2. *Department of Surgery, College of Medicine, Diyala University, Diyala, Iraq*
3. *Department of Surgery, Al-Kindy Collage of Medicine, University of Baghdad, Baghdad, Iraq*
4. *Department of Surgery, Faculty of Medicine, University of Kufa, Al-Najaf, Iraq*

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Corresponding Information:
Ghasaq Maan Bakr,
Department of surgery, College of Medicine, Diyala University, Diyala, Iraq

Email: ghasaq@uodiyala.edu.iq

ABSTRACT

Background & Objective: Ultrasound monitoring of fetal kidney length is of central importance for our assessment of intrauterine growth. It correlates strongly with gestational age and with weight and gender. Measurement according to gender is more accurate and aids early diagnosis of anomalies. The aim is to determine the relationship between fetal kidney length and gender during the second and third trimesters using ultrasonography.

Materials & Methods: Kidney length measurements were obtained by ultrasound of 500 pregnant women in Baghdad in a cross-sectional study, associating kidney length with demographic and fetal growth parameters. The Amniotic Fluid Index (AFI) was also checked. Too low or too high levels (<5 cm or >24 cm) indicate possible problems that further testing is needed.

Results: A study of 500 pregnant women established highly positive relationships between fetal kidney length and BPD, FL, AC, and fetal weight, which means that kidney growth is proportionate to the fetus. Female kidneys were relatively longer than male kidneys; the difference was statistically significant. The upper-normal AFI added to the length of the kidneys, which were the longest. This proves the fact that amniotic fluid is important to the development of the fetus.

Conclusion: In the study, gender-based differences in fetal kidney lengths were statistically significant. However, significant differences were seen across the AFI groups, with the largest kidney lengths belonging to the upper normal AFI category. Kidney length also increased significantly with gestational age, being strongly correlated with BPD, FL, and AC.

Keywords: Relationship, Fetal, Kidney, Length, Gender, Late, Pregnancy, A sonographic, Approach

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1. Introduction

Viewing fetal parts during pregnancy is a major component of prenatal care, vital in the detection of problems at an early stage, with important diagnostic accuracy in the assessment of fetal growth. In standard obstetrical ultrasounds performed throughout the pregnancy, it has now become an established fact that the length of fetal kidneys helps in understanding normal fetal growth and its relationship with fetal gender **(1)**. Ultrasound accurately measures fetal kidney length, providing a safe, repeatable measurement that is associated with important information about fetal health and well-being. Early in gestation, the fetus's kidneys start their development; thereafter, they exhibit significant maturation and growth in the second and third trimesters. The overall fetal development and function can be marked by the duration and trajectory of growth, therefore reflecting the genetic-environmental nexus **(3, 4)**. Because it is safe, readily available, and capable of providing real-time anatomical and functional data, ultrasound is an often utilized imaging modality in obstetrics. Fetal kidneys are easily seen during the second trimester and their length may be measured very precisely. Research on kidney dimensions such as length, breadth, and volume has found that gestational age, fetal weight, and general fetal growth are rather significantly correlated **(5)**. An interesting point about measuring the kidneys of fetuses is the association it might have with fetal sex.

Some earlier studies have suggested that small differences in how males and females grow could be associated with organ lengths, including kidneys **(6)**. Hormones mostly androgens may play a role in these variations, impacting how organs form while in the womb. Thus, examining how fetal kidney length and gender are correlated can aid in understanding more about fetal growth and the biological reasons for such disparities **(7)**. Appreciating this relationship is explicitly not only being it of academic value, but it also holds a possible adjustment in clinical importance. Detecting sexual dimorphism in kidney dimensions may upgrade the evaluation of fetal growth and raise the chances for premature diagnoses of deviations **(8)**. As an illustration, deviations from the expected value of kidney dimensions of a gestational age and sex would express potential developmental irregularities and thus require further treatment. More importantly, sex-based growth templates could alter judgment activities in perinatal care, thereby focusing on the importance of researching such links **(9)**. The second and third trimesters are the most critical periods in the life of a developing fetus. It is during this time that there is a rapid increase in both the length and weight of the fetus. This study is based on the hypothesis that ultra-sonographically measured kidney length at these two periods of gestation can give an adequate assessment of fetal growth and development. The objective of this study is to determine the relationship between ultrasonographically measured kidney length and gender during the second and third trimesters.

2. Materials and Methods

A cross-sectional analytical study was conducted on 500 pregnant women admitted to a general hospital with specialized departments for gynecology and obstetrics care in Baghdad. Participants were selected for the present study using purposive sampling. Only pregnant women whose ages varied, and gestational ages were confirmed by ultrasonography were considered eligible. Prior to their inclusion in the study, written informed consents were obtained from all participants. Recorded the name, age, gestational age (as confirmed by ultrasound), Biparietal Diameter (BPD), Femur Length (FL), and Abdominal Circumference (AC) of each participant. The fetal gender was also noted during the ultrasound scan. Following the collection of these details, participants underwent an ultrasonography evaluation to measure fetal kidney length. An experienced radiologist used the Samsung H60 ultrasound scanner with a CV 1-8 AD 4D convex array transducer to perform the ultrasound examinations. We visualized both kidneys and measured their lengths in millimeters to ensure consistent and accurate results. Recorded the kidney's longest dimension by taking measurements in the longitudinal plane. Paid special attention to minimizing inter-observer variability by having a single radiologist perform all measurements.

The Amniotic Fluid Index (AFI) is a measure used to assess the volume of amniotic fluid in the uterus during pregnancy. The normal range is 8-18 cm.

- >24 cm: Indicates polyhydramnios (excessive amniotic fluid).
- < 5 cm: Indicates oligohydramnios (low amniotic fluid).
- 5-8 cm: Considered lower normal range.
- 18-24 cm: Considered upper normal range.

Abnormal AFI levels may require further evaluation to ensure fetal well-being **(10)**.

All fetal kidney lengths are measured in the true sagittal plane; the longest axis is best visualized with the assurance that the kidney is fully elongated and not obliquely cut. The true sagittal plane gives a clearer anatomical landmark; the renal cortex, medulla, and sinuses can be better visualized with reduced variability and less foreshortening compared to other images. Statistical analysis was done by SPSS 22, frequency and percentage used for categorical data, mean, median, and SD for continuous data. Chi-square is used for assessing association between categorical variables. The ANOVA test is used for evaluating differences between the mean and median of continuous variables with normal distribution, while the Mann-Whitney U is used for data that is not normally distributed. A p-value less than or equal to 0.05 is considered significant.

3. Results

Distribution of Patients According to Study Variables: Gender: The sample consists of 54.6% males (273 patients) and 45.4% females (227 patients). Presentation: Most patients had a cephalic presentation (81.0%), while 19.0% were presented in breech. Placenta Location: Most common placenta location was posterior (49.8%), followed by anterior (46.2%), and the least common was fundal (4.0%). Amniotic Fluid Index (AFI):

- Normal AFI was the most frequent category (87.2%).
- Oligohydramnios (5.4%) was more common than polyhydramnios (3.2%).
- Upper normal (3.8%) and lower normal (0.4%) values were less frequently observed. As in Table 1.

Differences in Kidney Length According to Gender:

Right Kidney Length (RT K.)

Femaleshad a significantly longer right kidney compared to males. P-value=0.04, indicating a statistically significant difference.

Left Kidney Length (LFT K.)

Females had a significantly longer left kidney compared to males. P-value=0.014, also showing a statistically significant difference. As in Table 2.

Table 3 shows the differences in means of study variables according to Amniotic Fluid Index (AFI), Right kidney length differed significantly across AFI groups (P-value: 0.006). The largest mean right kidney length was in the upper normal AFI group (40.15 mm), while the normal group had the average mean length (34.72 mm). Left kidney length also showed significant differences (P-value: 0.01). The upper normal AFI group had the highest mean left kidney length (39.71 mm), while the average was in the normal group (34.91 mm).

Table 4 shows the correlation between right kidney length and fetal gestational parameters: Correlation with Biparietal Diameter (BPD): The right kidney length showed a strong positive correlation with BPD (r=0.907), and the correlation was statistically significant (P-value=0.0001). This indicates that as the BPD increases, the right kidney length also increases proportionally. Correlation with Femur Length (FL): A similarly strong positive correlation was observed between right kidney length and FL (r=0.906), with the correlation being statistically significant (P-value=0.0001). This suggests that fetal kidney growth is closely aligned with femur length growth. Correlation with Abdominal Circumference (AC): The correlation between right kidney length and AC was also strong and positive (r=0.871), with a significant p-value (P-value=0.0001). This highlights the association between fetal kidney development and abdominal growth. Correlation with Fetal Weight: The right kidney length demonstrated a strong positive correlation with fetal weight (r=0.897), with the correlation being statistically significant (P-value=0.0001). This indicates that larger fetuses tend to have longer right kidneys.

As shown in Table 5, there is a difference in the mean of right kidney length according to gestational age parameters. Right kidney length means a significantly increase according to increase in BPD, FL and AC.

Table 6 shows the correlation between left kidney length and fetal gestational parameters: Correlation with Biparietal Diameter (BPD): The left kidney length showed a strong positive correlation with BPD (r=0.894), and the correlation was statistically significant (P-value=0.0001). This indicates that an increase in BPD is strongly associated with an increase in left kidney length. Correlation with Femur Length (FL): A strong positive correlation was observed between left kidney length and FL (r=0.891), with the correlation being statistically significant (P-value=0.0001). This suggests that left kidney growth closely parallels femur length growth. Correlation with Abdominal Circumference (AC): The correlation between left kidney length and AC was also strong and positive (r=0.856), with a significant P-value (P-value=0.0001). This demonstrates that fetal abdominal growth is strongly related to the length of the left kidney. Correlation with Fetal Weight: The left kidney length demonstrated a strong positive correlation with fetal weight (r=0.881), and this correlation was statistically significant (P-value=0.0001). This indicates that heavier fetuses tend to have longer left kidneys.

As shown in Table 7, there is a difference in the mean of left kidney length according to gestational age parameters. Left kidney length mean significantly increase according to increase in BPD, FL and AC. Also as shown in Figure 1.

Table 1. Distribution of patients according to study variables

variables		frequency	percentage
Gender	Female	227	45.4
	Male	273	54.6
Presentation	Breech	95	19.0
	Cephalic	405	81.0
Placenta location	Anterior	231	46.2
	fundal	20	4.0
	Posterior	249	49.8
AFI	upper normal	19	3.8
	lower normal	2	.4
	normal	436	87.2
	oligohydramnios	27	5.4
	polyhydramnios	16	3.2

Table 2. Differences in mean of (length of RT kidney and length of left kidney) according to gender

	Gender	N	Mean of Right Kidney Length	SD	P-value
RT K.	Females	227	36.00	6.6	0.04
	Males	273	34.68	7.6	
	Gender	**N**	**Mean of left kidney length**	SD	**P-value**
LFT K.	Females	227	36.00	6.5	0.014
	Males	273	34.7	7.2	

Table 3. Differences in mean of (length of RT kidney and length of left kidney) according to Amniotic Fluid Index (AFI)

	AFI	N	Mean of Rt Kidney Length	SD	P-value
Right Kidney	upper normal	19	40.15	4.0	
	lower normal	2	38.45	2.3	0.006
	normal	436	34.72	6.9	
	oligohydramnios	27	37.55	2.2	
	polyhydramnios	16	37.30	3.1	
	AFI	**N**	**Mean of left kidney length**	**SD**	**P-value**
Left Kidney	upper normal	19	39.71	4.4	
	lower normal	2	39.30	3.3	0.01
	normal	436	34.91	6.8	
	oligohydramnios	27	38.32	3.5	
	polyhydramnios	16	36.32	2.2	

Table 4. Correlation between RT kidney length and fetal gestation (BPD, FL, AC) and fetal weight

		BPD	FL	AC	Wight
RT kidney length	R	0.907	0.906	0.871	0.897
	P	0.0001	0.0001	0.0001	0.0001

R: correlation, P: P-value

Table 5. Difference in mean of right kidney length according to gestational age parameters

		N	Mean of Right Kidney Length	SD	P-value
BPD	20-22	44	22.27	2.09	
	23-25	57	25.82	2.81	0.0001
	26-28	36	27.75	3.99	
	29-31	33	34.91	2.64	
	32-34	70	36.58	2.66	
	35-37	188	38.96	2.74	
	38-40	72	41.37	3.97	
		N	**Mean of Rt Kidney Length**	**SD**	**P-value**
FL	20-22	48	22.31	1.98	
	23-25	53	25.96	2.73	0.0001
	26-28	36	27.85	4.00	
	29-31	43	34.53	2.50	
	32-34	56	37.19	1.98	
	35-37	231	39.27	3.07	
	38-40	33	42.75	4.06	
		N	**Mean of Rt Kidney Length**	**SD**	**P-value**
AC	20-22	47	22.58	2.44	
	23-25	50	26.10	2.85	0.0001
	26-28	37	27.75	3.75	
	29-31	33	34.18	2.54	
	32-34	76	35.83	4.75	
	35-37	221	39.56	3.19	
	38-40	36	41.78	4.78	

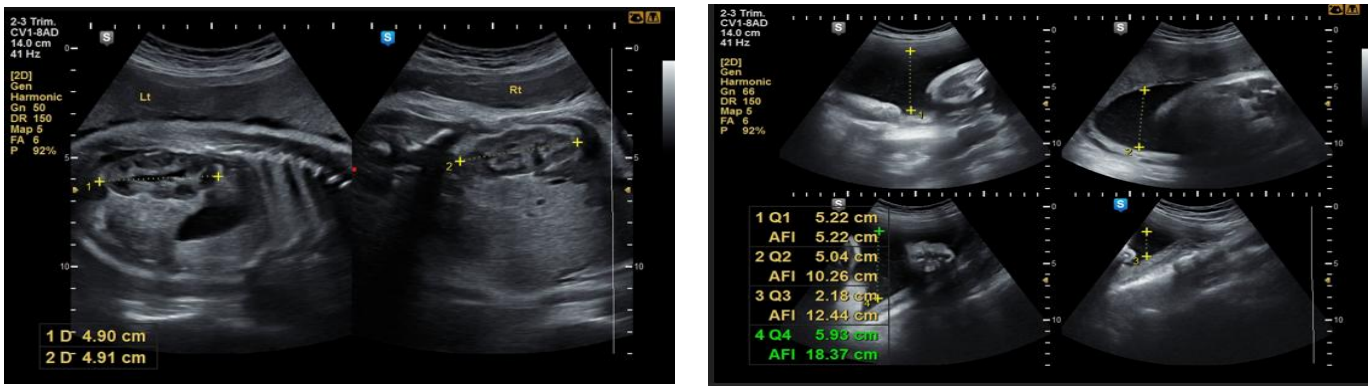
Table 6. Correlation between left kidney length and fetal gestation (BPD, FL, AC) and fetal weight

		BPD	FL	AC	Wight
Left kidney length	R	0.894	0.891	0.856	0.881
	P	0.0001	0.0001	0.0001	0.0001

R: correlation, P: P-value

Table 7. Difference in mean of left Kidney length according to gestational age parameters

		N	Mean of left Kidney length	SD	P-value
BPD	20-22	44	22.83	2.90	
	23-25	57	26.14	2.98	0.0001
	26-28	36	28.77	3.30	
	29-31	33	34.93	2.80	
	32-34	70	36.60	2.69	
	35-37	188	38.91	2.98	
	38-40	72	41.49	4.05	
		N	**Mean of left Kidney length**	**SD**	**P-value**
FL	20-22	48	22.97	2.77	
	23-25	53	26.20	2.98	0.0001
	26-28	36	28.86	3.30	
	29-31	43	34.77	2.50	
	32-34	56	36.86	2.31	
	35-37	231	39.28	3.30	
	38-40	33	42.83	4.03	
		N	**Mean of left Kidney length**	**SD**	**P-value**
AC	20-22	47	23.23	3.28	
	23-25	50	26.50	2.76	0.0001
	26-28	37	28.59	3.37	
	29-31	33	34.26	2.62	
	32-34	76	36.07	5.01	
	35-37	221	39.47	3.39	
	38-40	36	42.00	4.66	



A B

Figure 1. Ultrasound scan of 3rd trimester obstetric examination indicated by fetal measurement and annotation. Showing a male fetus at 38 weeks of gestation , the scan focuses on fetal measurements, particularly the kidneys, which are labeled as "Rt" (right) and "Lt" (left). The measurements of the fetal kidneys are around 49 mm in a true sagittal plane. The last image shows a quadrant measurement of amniotic fluid index

4. Discussion

In prenatal care, the assessment of gestational age is of great relevance since it helps doctors evaluate fetal development and growth, guide their decisions on pregnancy management, and project the expected date of delivery. Although other ultrasonic parameters such as crown-rump length, biparietal diameter, and femur length have long been used to estimate gestational age, recent research has suggested fetal kidney length as another metric with possible benefits **(11)**. The study revealed significant differences in fetal kidney lengths across AFI groups, with the upper normal AFI group exhibiting the largest kidney lengths. This aligns with studies such as those by M. V, T. C, et al., (2021) and Lord M. et al., (2023), which reported a positive correlation between optimal amniotic fluid levels and fetal growth parameters, including kidney length **(12,13)**. Conversely, the polyhydramnios group had the lowest mean kidney measurements, consistent with findings by Simmons PM et al., (2020), suggesting that abnormal AFI levels may impact organ development. The elevated values in the oligohydramnios group might be reflections of compensatory systems resulting from limited fluid. These findings help to emphasize the relevance of AFI monitoring in evaluating organ growth and fetal development **(14)**. In this study, there was a statistically significant difference in the length of both kidneys among the male and female genders. The female kidneys were significantly longer than the male kidneys, on the right as well as on the left (P=0.04). The right kidney was significantly greater (P=0.04). The left kidney was also significantly greater in females (P=0.014). This result agrees with similar previous studies that indicate an anatomical difference between male and female kidneys. This difference could be attributed to hormonal effects and to differences in body composition and can thus be used as a reference for advancing findings **(15)**. Meanwhile, the variations imaged in the lengths of the kidneys have potential clinical application in diagnostic imaging and nephrological assessments **(16)**. The results of this study indicate that, as gestational age increases, the biparietal diameter, right and left sides, femur length, right and left sides, and abdominal circumference, right and left sides, tend to increase. Findings of this study are in agreement with previous work, which stressed that fetal kidney growth closely depends on general fetal growth and maturity at a given pregnancy period. This also happened for the right kidney length, which steadily and considerably rose as BPD, FL, and AC were increased. This fact is in line with the study conducted by Walad R. et al., (2023), which found strong correlations between fetal kidney dimensions and gestational age markers. It seems that renal development reflects general development **(17)**. Likewise, left kidney length showed a notable positive correlation with these criteria, agreeing with results by Choudhary A. et al., (2024), who observed that fetal kidney length raised proportionately with other biometric measures, so showing good organ development **(18)**. Kidney length seems strongly correlated with pregnancy markers, perhaps because organogenesis of the kidneys occurs mainly during those trimesters. Fetal growth probably triggers increased kidney lengths due to more marked renal cortical and medullary differentiation. Results like these ones highlight how important it is to implement kidney measurements into regular fetal assessments since those are non-invasive and very good indicators for the well-being of the fetus and how pregnancy is progressing. Furthermore, the substantial connections draw attention to the use of fetal kidney length as a supplementary indicator of gestational age, especially in situations when conventional criteria like BPD and FL might be erratic. This is particularly helpful in spotting disorders such as intrauterine growth restriction (IUGR) or anomalies in development. As advised by Osho et al., (2019), future studies should investigate the creation of defined reference ranges for foetal kidney lengths across various groups to raise prenatal care diagnosis accuracy **(19)**. limitations facing the measurement of fetal renal length through ultrasonography are: fetal movement obscuring the optimal imaging of the kidneys; obesity, particularly that of the mother, reduces ultrasound penetration and quality of the image; amniotic fluid volume within low levels, therefore, limits the acoustic window and kidney visualization; the second-trimester gestation of smaller kidneys is also harder to differentiate, while in the third trimester, it is easier to actually measure them; and image resolution, acoustic shadowing, and also the need for multiple imaging attempts or different transducer positions.

5. Conclusion

This study establishes the mean differences in kidney lengths by considering gender and the amniotic fluid index. The results show that the mean value of the fetal left and right kidney for females is relatively high compared to that of males,but the differences are statistically significant. Statistically significant differences were noted in the lengths of the kidneys across different groups of AFI. Upper Normal AFI had the highest mean kidney length. Both Biparietal Diameter (BPD), Femur Length (FL), and Abdominal Circumference (AC) all indicated that the length of the kidneys on both sides increases with gestational age.

6. Declarations

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Ethical Considerations

This research has received ethical approval from Al-kindy College of medicine/university of Baghdad with the number 345 in 25-1-2025.

Authors' Contributions

The study was conceived, the experiments were planned, the data were collected and analyzed, and the first draft of the manuscript was written by the first author. The second author completed the data analysis, reviewed the manuscript, and assisted with the study's planning. The manuscript was reviewed and revised by the third and fourth author.

Conflict of Interest

The authors declared no conflict of interest.

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