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ORIGINAL ARTICLE

Accuracy of Fetal Kidney Length and Transcerebellar Diameter in Assessment of Gestational Age in Normal and Growth Restricted Fetuses

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Abstract

Background and Aim: Accurate monitoring of fetal gestational age is one of the most critical components of prenatal care. This study aims to assess the accuracy of gestational age estimation using mean fetal kidney length (FKL) and transcerebellar diameter (TCD). We compare their efficacy with other biometric measurements in both normal and growth-restricted fetuses.

Subjects and Methods: Our prospective study was conducted on 251 pregnant women seeking routine ultrasound examinations during the second half of pregnancy at Al-Hussein and Al-Zahraa University Hospitals. The study period extended from November 2021 to November 2022. During each ultrasound examination, we obtained fetal biometric parameters transabdominally: transcerebellar diameter (TCD), fetal kidney length (FKL), biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL).

Results: In normal pregnancies, FKL and TCD had comparable gestational age estimation sensitivity to standard parameters (p>0.05). In IUGR, FKL and TCD demonstrated superior sensitivity compared to traditional parameters (83.3%, 75.8% vs 3.0-30.3%; p<0.001). Only FKL and TCD showed no significant sensitivity difference between groups. In IUGR fetuses, FKL showed the highest correlation with the actual gestational age (R=0.952) followed by TCD (R=0.903, p<0.001).

Conclusion: Fetal kidney length and TCD are accurate parameters for assessment of gestational age in 2nd half of normal pregnancy. In addition, fetal kidney length and TCD are highly accurate for detection of gestation age in IUGR suspected pregnancies.

Keywords: Gestational age, Fetal kidney length, Transcerebellar diamete

INTRODUCTION

Accurate monitoring of fetal gestational age is a critical component of prenatal care. The ability to determine fetal gestational age and recognize abnormal growth patterns is essential for making decisions regarding early intervention in high-risk pregnancies [1].

The traditional method of estimating gestational age, based on the last menstrual period, may be influenced by the regularity of menstrual cycles, especially in the three months immediately pre-conception, and by prior exposure to hormonal contraception. In developing countries, late antenatal booking, the absence of accurate menstruation records, and menstrual cycle irregularities present additional challenges [2].

Sonographic estimation of gestational age, particularly the measurement of crown-rump length (CRL) in the first trimester, is considered the gold standard in antenatal care [3].

In routine ultrasonography, parameters including BPD, HC, AC, and FL are used to estimate gestational age and the estimated date of delivery. However, these parameters become increasingly unreliable as pregnancy advances [4]. Previous studies have demonstrated that fetal kidney length (FKL) and transcerebellar diameter are more accurate methods for estimating gestational age than BPD, HC, AC, and FL after 20 weeks of gestation [5].

Fetal kidney length exhibits variability in its width and anterior-posterior measurements, which can be affected by conditions like intrauterine growth impediments. However, its length remains relatively stable throughout pregnancy, unaffected by fundamental growth anomalies [6].

The transcerebellar diameter (TCD), a measure of the widest anteroposterior diameter of the cerebellum, is relatively unaffected even in cases of severe intrauterine growth retardation. It maintains its shape and is not significantly altered by extrinsic pressure. Therefore, it can be used for dating pregnancy more reliably than other ultrasound parameters. Its value in millimeters corresponds roughly to the gestational period between 14-40 weeks [7,8].

SUBJECTS AND METHODS

Subjects:

This prospective study involved 251 pregnant women who sought routine ultrasound examinations during the second half of pregnancy at Al-Hussein and Al-Zaharaa University Hospitals from November 2021 to November 2022.

Inclusion criteria:

Eligible participants were pregnant women between 21 and 40 weeks of gestation with a viable, singleton pregnancy, and a known date (either through a regular 28-day menstrual cycle or confirmed through their Last Menstrual Period, or those who had a first-trimester obstetric scan in the current pregnancy that was dated using Crown-Rump Length (CRL). Excluded were those with medical disorders or congenital malformations.

And subsequently divided into 2 groups:

- **Control group:** Comprising women with normal pregnancies.
- **Case group:** Comprising women with IUGR fetuses (fetal weight below the 10th percentile for gestational age, determined through ultrasound).

The study protocol and objectives were explained in detail to all participants and written informed consent was obtained by the authors prior to enrollment. A thorough

medical and surgical history was taken from each patient including age, parity, last menstrual period, gestational age, and any relevant conditions.

Transabdominal ultrasonography was performed using a high-resolution convex transducer with a frequency range of 3.0-5.0 MHz. All ultrasound examinations were conducted by a single experienced sonographer who was an obstetrician with over 5 years of experience in fetal medicine and held a postgraduate Diploma in fetal medicine. Strict adherence to protocol was followed during image acquisition and biometric measurements.

The following fetal biometric parameters were measured transabdominally during each ultrasound examination including the transcerebellar diameter (TCD), fetal kidney length (FKL), biparietal diameter (BPD), head circumferences (HC), abdominal circumferences (AC) and femur length (FL).

Fetal transcerebellar diameter was measured in millimeters by assessing the widest diameter of the cerebellum. Fetal kidneys were identified in the sagittal plane, and the maximum length of each fetal kidney was measured from the upper pole to the lower pole, as shown in Fig. (1). Care was taken to exclude the adrenal glands (AGs) from these measurements.

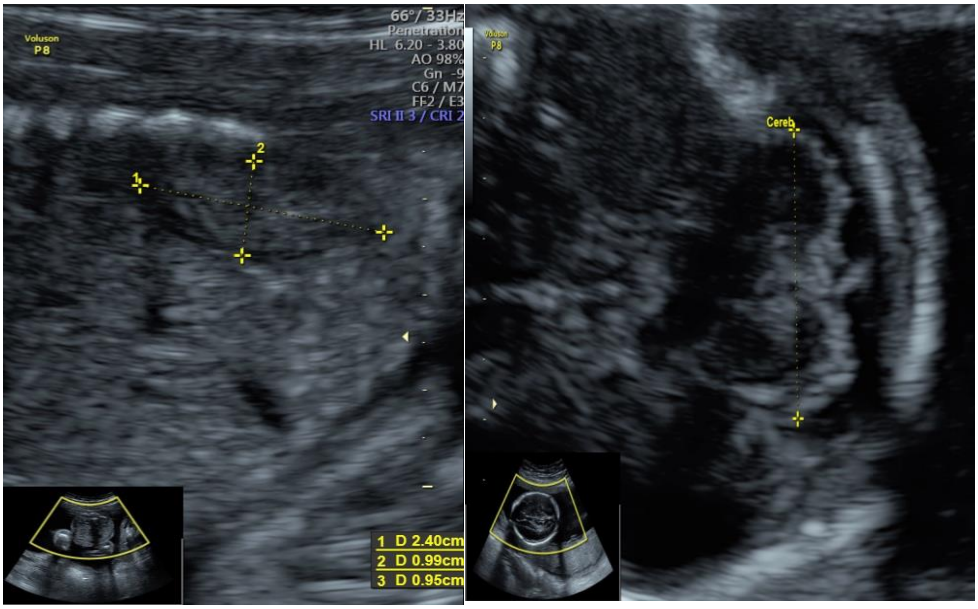

Fig (1): Fetal kidney length and trancerebellar diameter measurement Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 20.0 (IBM Corp, Armonk, NY). All data collected was first tabulated in Microsoft Excel spreadsheets then imported into SPSS for analysis. Appropriate statistical tests were selected based on the type and distribution of variables. Continuous numerical data was presented as mean and standard deviation after checking for normality of distribution using the Shapiro-Wilk test. Normally distributed continuous variables were compared between groups using the Student's t-test. A *p*-value less than 0.05 was considered statistically significant.

The sample size was determined using the

power analysis feature in SPSS version 20.0, setting alpha error at 5% and power at 95%. Based on results from a previous related study [10] that showed a strong positive correlation between TCD, FKL and gestational age (r=0.9), the minimum required sample size was calculated to be 100 cases assuming a more conservative correlation coefficient of 0.5. A larger final sample was recruited to improve study validity and generalizability.

RESULTS

The total of 251 pregnant women consented to participate in this study were collected from the inpatient wards & outpatient clinics in which 36 women were excluded (29 with medical disorders as hypertension or diabetes and 7 with congenital anomalies). All women were in the 2nd half of pregnancy by reliable LMP or crown rump length. 149 normal and 66 IUGR.

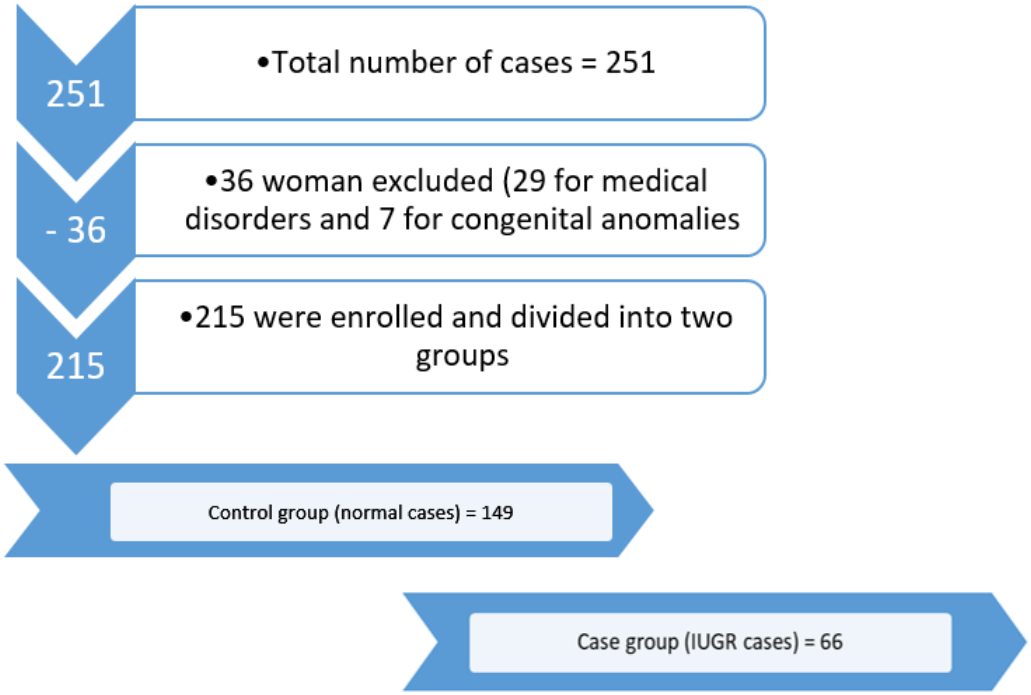

Table (1): *p* value Comparing between the percentage of accurate assessment of gestational age (sensitivity) within 1 and 2 weeks between normal patients and IUGR using BPD

		Normal		IUGR		*p* value
		Count	%	Count	%	
Within 2 weeks	Accurate	137	91.95%	8	12.12%	**<0.001**
	Not accurate	12	8.05 %	58	87.88%	
Within 1 week	Accurate	117	78.52 %	2	3.03 %	**<0.001**
	Not accurate	32	21.48 %	64	96.97%	

The sensitivity of the BPD showed significant statistical difference between normal and IUGR cases within 1 and 2 weeks with *p* value <0.001 in both. Therefore, sensitivity within 1 week had been 78.52 % in normal compared with 3.03 % in IUGR. Meanwhile, sensitivity at 2 weeks was 91.95 % in normal compared with 12.12% in IUGR.

Table (2): *p* value comparing the percentage of accurate assessment of gestational age (sensitivity) within 1 and 2 weeks between normal patients and IUGR using HC

		Normal		IUGR		*p* value
		Count	%	Count	%	
Within 2 weeks	Accurate	139	93.29%	5	7.58 %	<0.001
	Not accurate	10	6.71%	61	92.42%	
Within 1 week	Accurate	114	76.51%	2	3.03%	<0.001
	Not accurate	35	23.49%	64	96.97%	

Regarding HC, there was a significant statistical difference in its sensitivity between normal and IUGR cases within 1 and 2 weeks with *p* value <0.001 in both. As sensitivity within 1 week was 76.51% in normal compared with 76.51% in IUGR. In addition, sensitivity at 2 weeks was 93.29% in normal compared with 7.58% in IUGR

Table (3): *p* value comparing the percentage of accurate assessment of gestational age (sensitivity) within 1 and 2 weeks between normal patients and IUGR using FL

		Normal		IUGR		*p* value
		Count	%	Count	%	
Within 2 weeks	Accurate	144	96.64%	20	30.30%	<0.001
	Not accurate	5	3.36 %	46	69.70%	
Within 1 week	Accurate	127	85.23%	6	9.09%	<0.001
	Not accurate	22	14.77%	60	90.91%	

Moreover, when sensitivity of the FL was assessed, there was a significant statistical difference between normal and IUGR cases within 1 and 2 weeks with *p*<0.001 in both. Sensitivity within 1 week was 85.23% in normal compared with *9.09*% in IUGR. Furthermore, sensitivity at 2 weeks was *96.64*% in normal compared with 30.30% in IUGR.

Table (4): P value Comparing between the percentage of accurate assessment of gestational age (sensitivity) within 1 and 2 weeks between normal patients and IUGR using AC

		Normal		IUGR		*p* value
		Count	%	Count	%	
Within 2 weeks	Accurate	138	92.62%	1	1.56%	<0.001
	Not accurate	11	7.38%	65	98.48%	
Within 1 week	Accurate	112	75.17%	0	0%	<0.001
	Not accurate	37	24.83%	66	100%	

Similarly, sensitivity of the AC denoted a significant statistical difference between normal and IUGR cases within 1 and 2 weeks with $p<0.001$ in both. Hence, sensitivity within 1 week had been 75.17% in normal compared with 0% in IUGR. Moreover, sensitivity at 2 weeks was 92.62% in normal compared with 1.56% in IUGR.

Table (5): *p* value comparing the percentage of accurate assessment of gestational age (sensitivity) within 1 and 2 weeks between normal patients and IUGR using TCD

		Normal		IUGR		*p* value
		Count	%	Count	%	
Within 2 weeks	Accurate	135	90.60%	55	83.33%	0.125
	Not accurate	14	9.40%	11	16.67%	
Within 1 week	Accurate	120	80.54%	50	75.76%	0.427
	Not accurate	29	19.46%	16	24.24%	

On the other hand, the sensitivity of the TCD denoted a non-significant statistical difference between normal and IUGR cases within 1 and 2 weeks with $p>0.001$ in both. Hence, sensitivity within 1 week had been 80.54% in normal compared with 75.76% in IUGR. Moreover, sensitivity at 2 weeks was 90.6% in normal compared with 83.33% in IUGR.

Table (6): *p* value comparing the percentage of accurate assessment of gestational age (sensitivity) within 1 and 2 weeks between normal patients and IUGR using mean FKL.

		Normal		IUGR		*p* value
		Count	%	Count	%	
Within 2 weeks	Accurate	140	93.96%	60	90.91%	0.418
	Not accurate	9	6.04%	6	9.09%	
Within 1 week	Accurate	131	87.92%	55	83.33%	0.364
	Not accurate	18	12.08%	11	16.67%	

In addition, the sensitivity of the FKL denoted a non-significant statistical difference between normal and IUGR cases within 1 and 2 weeks with p >0.001 in both. Hence, sensitivity within 1 week had been 87.92% in normal compared with 83.33% in IUGR. Moreover, sensitivity at 2 weeks was 93.96% in normal compared with 90.91% in IUGR.

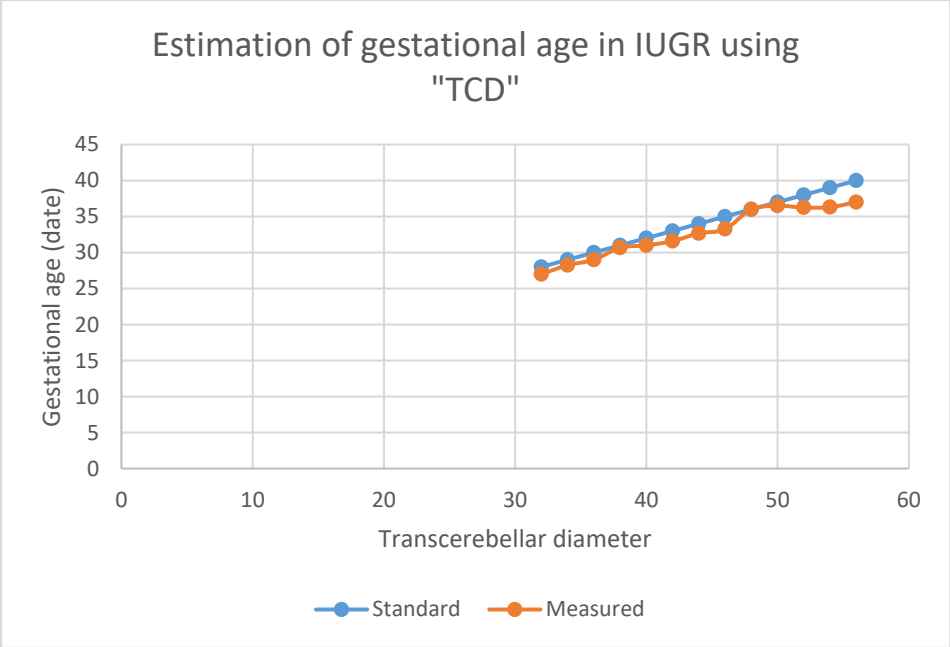

Figure (2): Scatter diagram showing the near perfect linear relation between the gestational age estimated using the 'Transcerebellar diameter" (explanatory variable) and the gestational age by date (dependent variable) in IUGR.

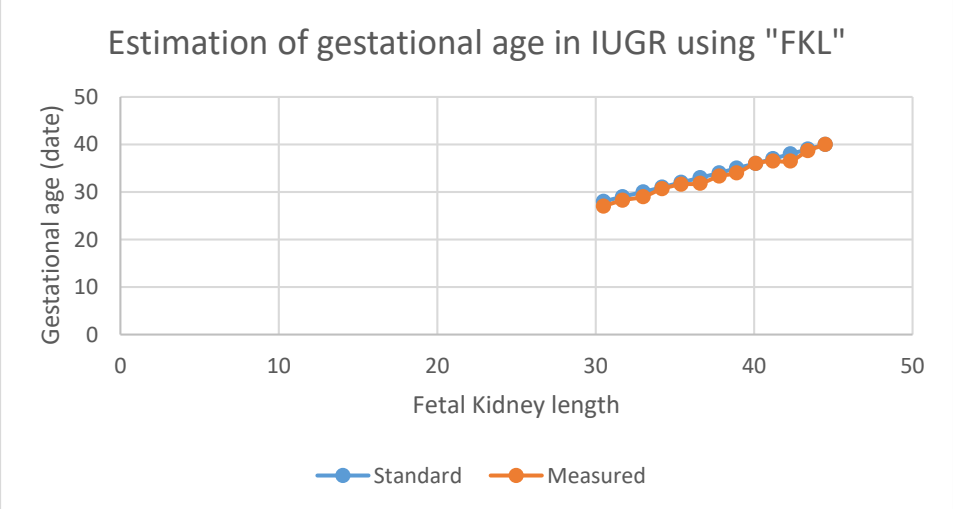

Figure (3): Scatter diagram showing the perfect linear relation between the gestational age estimated using the 'Fetal kidney length" (explanatory variable) and the gestational age by date (dependent variable) in IUGR.

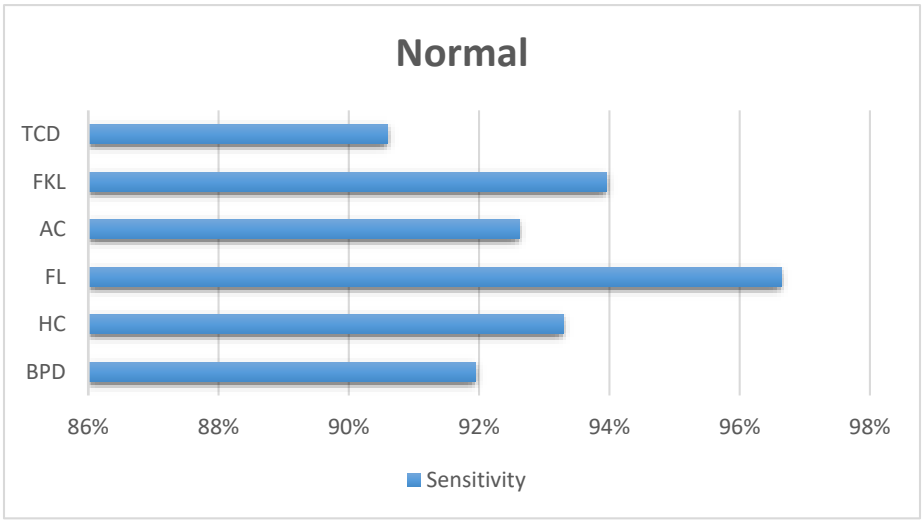

Figure (4): sensitivity of different parameters in normal pregnancy cases

Regarding normal cases, sensitivity was highest with FL (96.64%) followed by FKL (93.96%). However, sensitivity of each of TCD, BPD, HC and AC was 90.6%, 91.5%, 93.29% and 92.62% respectively.

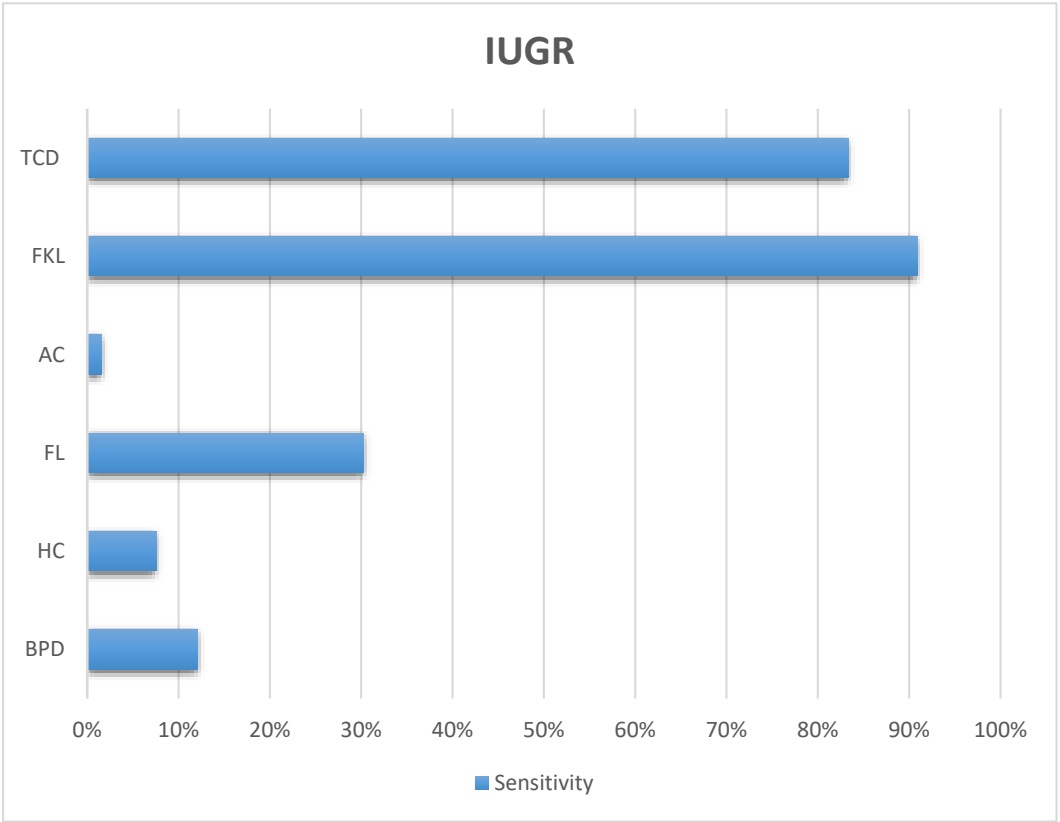

Figure (5): The sensitivities of different US parameters in IUGR patients

Regarding IUGR cases, sensitivity was highest with TCD (94.29%). However, the sensitivity of each of BPD, HC, FL and AC was 30%, 4.29%, 17.14% and 2.86% respectively.

DISCUSSION

Accurate estimation of gestational age is crucial for the management of all pregnancies, particularly those considered high-risk. Many pregnant women, especially those from remote areas, delay their first antenatal care visit until the third trimester. Additionally, some lactating mothers become pregnant again, making the determination of their Last Menstrual Period (LMP) uncertain. Without early ultrasound or a reliable LMP, calculating their due dates becomes challenging. Uncertain gestational age is associated with adverse pregnancy outcomes, including low birth weight, preterm delivery, perinatal mortality, and post-term pregnancy [9].

Numerous studies have reported a strong correlation between fetal kidney length and TCD with gestational age in the second and third trimesters [5,10]. Furthermore, these parameters have shown their utility as growth assessment tools, particularly in cases of Intrauterine Growth Restriction (IUGR) [5].

Key findings from our study include:

- In normal pregnancies, sensitivity of TCD and fetal kidney length for accurately estimating gestational age within 1 week and 2 weeks closely matched sensitivity of other parameters, such as BPD, HC, FL, and AC.
- Conversely, in cases of IUGR, sensitivity of TCD and fetal kidney length for accurate gestational age assessment within 1 week and 2 weeks was significantly higher compared to other parameters (p<0.001).
- Furthermore, when comparing sensitivity of each ultrasound parameter in normal and IUGR cases, only fetal kidney length and TCD exhibited no significant difference, as they demonstrated high sensitivity in both normal and IUGR cases. In contrast, other parameters showed a significant difference, with higher sensitivities in normal pregnancies compared to IUGR cases.
- Additionally, when comparing the mean actual gestational age with the mean gestational age estimated using different parameters in IUGR fetuses, fetal kidney length exhibited the strongest positive correlation with the patients' actual gestational age. TCD was the second most correlated parameter on scatter diagrams, unlike other parameters, which showed much lower correlations.

The findings of the present study find validation in previous research [11], where researchers compared transcerebellar diameter between normal and IUGR fetuses and reported no significant difference in gestational age estimation between these groups. Similarly, our results are in accordance with the work of others [12] who demonstrated a robust positive linear relationship between transcerebellar diameter (TCD) and gestational age (GA). Their study revealed that GA estimated through sonographically measured TCD was notably close to the actual GA during the second and third trimesters, surpassing the accuracy of estimates derived from other fetal parameters.

Furthermore, the accuracy of TCD for gestational age detection was evaluated by other researchers [13] in a study involving 100 pregnant women. Their investigation highlighted TCD's resilience in the face of intrauterine growth restriction, exhibiting a superior correlation with gestational age when compared to other parameters falling below the 10th percentile. These findings

from prior research are consistent with the results of the present study.

Moreover, our study's outcomes are in alignment with the work of researchers [14] who emphasized the robustness of TCD measurements, particularly in cases of IUGR. Even in instances of severe growth restriction, TCD demonstrated only mild alterations. Their study concluded that fetal TCD experiences a more than twofold increase in the second half of pregnancy.

In our current study, we also established a linear relationship between TCD and gestational age during the latter half of pregnancy, aligning closely with clinical dating. Both fetal kidney length (FKL) and TCD exhibited a strong correlation with gestational age. Notably, kidney size may be influenced by growth variations, mainly affecting anterior-posterior and transverse diameters, but the longitudinal kidney length remains relatively unaffected in fetuses categorized as small for their gestational age.

Similarly, in prior research [15], investigators aimed to establish the correlation and regression coefficient of fetal kidney length with gestational age and conducted a comparative evaluation against various other fetal biometric indices. Their study concluded that fetal kidney length exhibits a positive correlation with gestational age, displaying a consistent linear growth pattern throughout pregnancy, irrespective of underlying growth restrictions.

In contrast to the study conducted by other authors [16], which encountered challenges in imaging the kidney under certain fetal positions, our study encountered no such issues in visualizing and measuring kidney length. This successful imaging can likely be attributed to the utilization of high-quality ultrasound equipment, resulting in more precise measurements and enhanced imaging clarity.

Furthermore, as highlighted by other experts [17], technical errors or maternal obesity can sometimes lead to poor-quality scans, particularly in the early stages of gestation when fetal kidneys and adrenal glands closely resemble each other. These factors may contribute to variations in findings between studies.

The FKL and TCD in the present study correlated well with the assigned GA. This provides an obvious advantage where there is difficulty in measuring BPD, HC due to engaged head or small AC due to IUGR. In such circumstances, FKL and TCD can be used on its own to estimate GA accurately. The present study hence validates the recommendation that FKL and TCD can be used as an important sonographic parameter for accurate prediction of fetal gestation age especially in IUGR fetuses. The relationship of fetal kidney growth and TCD with GA is statistically significant.

CONCLUSION

In summary, fetal kidney length and TCD are accurate parameters for assessing gestational age in the second half of normal pregnancies and for detecting gestational age in IUGR cases. We recommend their routine use for gestational age assessment in IUGR fetuses, with further research on a larger sample size for additional validation.

Declarations

Ethics Approval and Informed Consent: This study obtained ethical approval from the ethics committee of the university's Faculty of Medicine. All participants included in the study provided written informed consent to partake in the research.

Consent for Publication: Written consent was secured from all participants, granting permission for the utilization of their data in this publication.

Availability of Data and Materials: The datasets employed and/or analyzed during the course of this study are available upon reasonable request from the corresponding author.

Conflict of Interest: The authors affirm that they have no conflicts of interest to disclose.

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Authors' Contributions: Each author of this manuscript contributed equally and significantly to the study. They collectively reviewed and approved the final version of the manuscript.

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دقة طول كلى الجنين وقطر المخيخ في تقييم عمر الحمل في الأجنة الطبيعية والأجنة متأخرة النمو

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الملخص

المنهجية والأهداف: يعتبر التقييم الدقيق لعمر الجنين أحد أهم مكونات رعاية الحوامل أهمية حيث يعتبر حجر الأساس في تحديد الموعد الأمثل للولادة وتجنب الولادة المبكرة عن طريق الخطأ. ويهدف هذا البحث إلى تقييم دقة تقدير عمر الجنين باستخدام متوسط طول الكلية وقطر المخيخ حيث نقارن فعالية ذلك مع قياسات حيوية أخرى في الأجنة الطبيعية والذين يعانون من تأخر النمو.

منهجية الدراسة: أُجريت دراستنا التوقعية على 251 امرأة حامل تطلب إجراء الفحص بالموجات فوق الصوتية الروتينية خلال النصف الثاني من الحمل في مستشفيات الحسين والزهراء الجامعيتين، وتمتد فترة الدراسة من نوفمبر 2021 إلى نوفمبر 2022. خلال كل فحص بالأمواج فوق الصوتية ، قمنا بقياس المعلمات الحيوية الجنينية التالية عبر البطن: قطر المخيخ ، طول كلية الجنين، قطر الحدبة الثنائية، محيط الرأس، محيط البطن وطول عظمة الفخذ.

النتائج: في الحمل الطبيعي ، كان قياس طول كلية الجنين وقطر المخيخ مساويا في الدقة في تقدير عمر الجنين للقياسات المعتادة. أما في حالة تأخر نمو الجنين فقد أبقى قياس طول كلية الجنين وقطر المخيخ على حساسية عالية على عكس المعايير الأخرى، أيضا أظهر قياس طول كلية الجنين وقطر المخيخ فرقا طفيفا غير مؤثر إحصائيا بين مجموعتي الدراسة. في حالة الأجنة متأخري النمو، أظهر قياس طول كلية الجنين أقصى ترابط مع العمر الجنيني الفعلي يليه قياس قطر المخيخ.

الاستنتاجات: يعد قياس طول كلية الجنين وقطر المخيخ معايير دقيقة لتقييم عمر الجنين في النصف الثاني من الحمل الطبيعي. بالإضافة إلى ذلك ، يُعتبر قياس طول كلية الجنين وقطر المخيخ إجراءا دقيقًا للغاية في اكتشاف عمر الحمل في الحالات المشتبه فيها بتأخر النمو

الكلمات الدالة: عمر الجنين، طول كلية الجنين، قطر المخيخ.