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THE ACCURACY OF ULTRASOUND ESTIMATION OF FETAL WEIGHT IN COMPARISON TO BIRTH WEIGHT

Original Research

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ABSTRACT

Background: Accurate estimation of fetal weight is a crucial component of obstetric care, influencing decisions related to delivery planning, mode of birth, and management of potential complications. Errors in estimation may result in inappropriate clinical interventions, posing risks to both maternal and neonatal health. Ultrasonography is widely used due to its non-invasive nature and accessibility; however, its precision varies based on multiple clinical and technical factors, necessitating evaluation in diverse healthcare settings.

Objective: To assess the accuracy of fetal weight estimation using ultrasonography in comparison to actual birth weight.

Methods: This observational study was conducted at the Armed Forces Institute of Radiology, Rawalpindi, Pakistan, from September 2023 to February 2024. A total of 139 postpartum women were included through convenience sampling. All participants had complete data on both ultrasound-estimated fetal weight (EFW) and actual birth weight (ABW). Women with multiple gestations, major fetal anomalies, or deliveries outside the facility were excluded. Fetal biometry was performed using standardized equipment and protocols, applying the Hadlock 4 formula based on BPD, HC, AC, and FL. Birth weights were recorded within 10 minutes post-delivery. Data analysis was performed using SPSS version 26.0.

Results: The mean EFW was 2752.68 ± 282.95 grams, while the mean ABW was 2819.30 ± 397.31 grams. A statistically significant difference was observed between the two values ($p = 0.000$). The mean absolute error in estimation was 193.95 ± 248.08 grams. Underestimation occurred in 44.6% of cases, overestimation in 28.8%, and accurate estimation within ±10% was observed in only 26.6% of the sample.

Conclusion: Ultrasonographic estimation of fetal weight tends to underestimate actual birth weight and should be interpreted alongside clinical findings to guide appropriate obstetric decision-making.

Keywords: Birth Weight, Estimation Techniques, Fetal Weight, Pregnancy, Ultrasonography, Weight Prediction Error, Women's Health.

INTRODUCTION

Accurate estimation of fetal weight (EFW) is a cornerstone in obstetric practice, playing a pivotal role in clinical decision-making related to prenatal management, delivery planning, and the prevention of perinatal complications (1). Recognizing abnormal fetal weight—whether it is intrauterine growth restriction (IUGR), defined as fetal weight below the 10th percentile for gestational age, or macrosomia, where the fetal weight exceeds the 90th percentile—is essential for anticipating and mitigating risks associated with adverse neonatal and maternal outcomes (2-4). These conditions are closely linked with increased rates of preterm birth, cesarean delivery, birth trauma, and perinatal morbidity and mortality, thus underscoring the clinical imperative of precise fetal weight evaluation. Historically, a range of clinical methods has been used to estimate fetal weight, including abdominal palpation and established formula-based assessments such as Johnson's and Insler's (Dare's) methods (5,6). These techniques rely on symphysiofundal height measurements and are valued for their practicality, low cost, and ease of application in low-resource settings. Their simplicity allows healthcare providers, including midwives, to conduct assessments without requiring sophisticated equipment, making them especially useful in routine antenatal care (7,8). Despite their convenience, these methods often present limitations in accuracy, particularly in cases of maternal obesity, multiple gestations, or polyhydramnios.

With advancements in imaging technology, ultrasonography has increasingly become the preferred tool for fetal weight estimation. Ultrasound-based methods incorporate biometric parameters—such as biparietal diameter, femur length, and abdominal circumference—to generate more precise estimates (9). Recent studies suggest that ultrasound can predict birth weight with a margin of error within 10% of actual neonatal weight, and it shows significant reliability in detecting both IUGR and macrosomia (10,11). Nevertheless, literature presents conflicting perspectives on whether ultrasound consistently outperforms clinical estimation methods, particularly in varied demographic and healthcare contexts (12). These discrepancies highlight the need for further investigation into the comparative accuracy of these tools. In light of the clinical importance of accurate fetal weight assessment and the ongoing debate surrounding the most reliable method, this study aims to evaluate the reliability and precision of ultrasound in estimating fetal weight. By critically examining its accuracy and comparing it to traditional clinical techniques, the objective is to inform evidence-based improvements in obstetric care and optimize maternal and neonatal outcomes.

METHODS

A prospective observational study was conducted at the Armed Forces Institute of Radiology and Imaging (AFIRI), Rawalpindi, Pakistan, over a four-month period from December 2023 to March 2024. The study population comprised women who had delivered live-born infants at the respective hospital during the study period. Participant recruitment was based on convenience sampling, utilizing patient admission records irrespective of maternal age or gestational age at delivery. All eligible postpartum women meeting the inclusion criteria were enrolled consecutively. The inclusion criteria encompassed women who had recently delivered live births within the hospital and had complete documentation of both ultrasound-estimated fetal weight (EFW) and actual birth weight. Women were excluded if they had delivered outside the study setting, had incomplete or missing medical records, or were diagnosed with major fetal anomalies that could influence birth weight. Furthermore, cases of multiple gestations (e.g., twins or triplets) were excluded to avoid the potential confounding impact of shared intrauterine environments on fetal growth. Women with pre-existing medical conditions known to significantly affect neonatal birth weight—such as diabetes mellitus, chronic hypertension, and HIV/AIDS—were also excluded from participation to minimize bias. Sample size estimation was based on the formula for calculating a single mean: $\mathbf{N = (Z\alpha/2 \times \sigma / d)^2}$, where $Z\alpha/2 = 1.96$ (for a 95% confidence interval), $\sigma = 0.15$ (estimated standard deviation of prediction error), and $d = 0.05$ (acceptable margin of error). This yielded a minimum required sample of 123 participants. Accounting for a 10% non-response rate, the final adjusted sample size was set at 139 to ensure adequate power for statistical analysis.

All fetal biometry assessments were carried out by experienced obstetricians, gynecologists, or qualified ultrasound technologists trained in obstetric imaging. The assessments adhered to standardized protocols and involved measurements of biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). The Hadlock 4 formula was applied to calculate the EFW based on these biometric parameters (13). Each assessment was documented with static images, real-time video clips, and a detailed written report. Birth weight was measured immediately after delivery by either a midwife or a pediatrician in the labor ward using calibrated neonatal weighing scales to ensure accuracy (14). Data were retrospectively extracted from the hospital's medical records and ultrasound logs. Variables collected included maternal age, gestational age at delivery, mode of delivery, EFW, and actual birth weight. Additional ultrasound-specific details were recorded, such as the equipment used, gestational age at the time of the scan, and formula applied for fetal weight estimation. Neonatal outcome measures and any delivery-related complications were also documented to assess the clinical relevance of fetal weight estimation. The research protocol was reviewed and approved by the Ethical Review Committee of the Armed Forces Institute of Radiology and Imaging (Reference: AFIRI-RWP-ERC-APPV:2). Informed consent was obtained from all participants prior to their inclusion in the study, ensuring adherence to ethical principles outlined in the Declaration of Helsinki. Descriptive statistics including means, standard deviations, ranges, and frequency distributions were calculated to summarize demographic and clinical variables. A paired-sample t-test was applied to compare the ultrasound-estimated fetal weight with actual birth weight. The prediction error was computed as the difference between the EFW and actual birth weight. Both overestimations and underestimations were noted. To quantify the degree of estimation error, the absolute error was calculated and expressed as a percentage of the actual birth weight. The threshold for significant prediction error was defined as a deviation greater than 10%. Mean absolute error and mean percentage error were also reported. A significance level of $p < 0.05$ was considered statistically meaningful.

RESULTS

A total of 139 women who delivered live-born infants at the hospital were included in the study. The mean maternal age was 27.25 years (SD = 5.66), with most participants falling within the young to middle-aged reproductive group. The mean gestational age at the time of ultrasound was 36.86 weeks (SD = 2.96), while the mean gestational age at delivery was 38.30 weeks (SD = 2.52), indicating that most deliveries occurred at or near term. Among the neonates, 81 were male (58.3%) and 58 were female (41.7%). In terms of parity, 25 participants (18.0%) were primiparous, and 114 (82.0%) were multiparous. Vaginal delivery was the predominant mode of delivery, observed in 84 cases (60.4%), while 55 cases (39.6%) were cesarean sections. The mean estimated fetal weight by ultrasonography was 2752.68 grams (SD = 282.95), with a range between 2050 and 3450 grams. The mean actual birth weight recorded within 10 minutes of delivery was 2819.30 grams (SD = 397.31), ranging from 2100 to 3900 grams. These findings revealed a mean underestimation of birth weight by approximately 66.62 grams when using ultrasonography. Statistical comparison between ultrasound-estimated fetal weight and actual birth weight demonstrated a significant difference. The estimated fetal weight had a mean of 2752.68 grams (95% CI: 2705.23–2800.14, $p < 0.001$), while the actual birth weight had a higher mean of 2840.09 grams (95% CI: 2787.10–2893.09, $p < 0.001$), indicating a consistent trend of underestimation by ultrasonography. The analysis of prediction error showed that the mean absolute error in fetal weight estimation was 193.95 grams (SD = 248.08), with a 95% confidence interval of 155.26 to 240.36 grams.

Mean underestimation was -140.53 grams (SD = 238.31), while overestimation showed a smaller mean of 57.29 grams (SD = 154.26). Among all observations, 26.6% (n = 37) were accurately predicted, 44.6% (n = 62) were underestimated, and 28.8% (n = 40) were overestimated. Furthermore, 36 cases (25.9%) had an error margin greater than 10% of the actual birth weight, which is clinically significant. To further understand the variation in estimation error, stratified analysis was conducted based on neonatal gender, maternal parity, and mode of delivery. Among male neonates (n = 81), the mean error in ultrasound-estimated fetal weight was -160.2 grams (SD = 240.5; 95% CI: -212.58 to -107.82), indicating a tendency toward underestimation. For female neonates (n = 58), the mean error was lower at -110.4 grams (SD = 210.3; 95% CI: -164.52 to -56.28), suggesting a relatively smaller discrepancy. When stratified by parity, primiparous mothers (n = 25) showed the highest mean underestimation of -195.6 grams (SD = 270.1; 95% CI: -301.48 to -89.72), while multiparous mothers (n = 114) had a mean underestimation of -135.9 grams (SD = 235.7; 95% CI: -179.17 to -92.63). These findings imply that prediction errors were more pronounced in first-time mothers. Regarding mode of delivery, the mean error for vaginal deliveries (n = 84) was -128.3 grams (SD = 220.8; 95% CI: -175.52 to -81.08), whereas cesarean section deliveries (n = 55) showed a slightly greater underestimation of -155.7 grams (SD = 260.6; 95% CI: -224.57 to -86.83). These subgroup differences suggest that maternal and neonatal characteristics may influence the accuracy of ultrasound-based fetal weight estimation. Incorporating these variables into predictive models could improve clinical decision-making in obstetric care.

Table 1: Maternal and neonatal demographic characteristics (n=139)

Variables	**Mean± SD (n %)**
Maternal Age	27.2518+5.66338
Gestational age at ultrasound	36.86+2.959
Gestational age at delivery	2.51850
Child Gender	
Male	81 (58.3%)
Female	58 (41.7%)
Parity	
Primiparous	25 (18%)
Multiparous	114 (82%)
Mode of delivery	
Vaginal Delivery	84 (60.4%)
C section	**55 (39.6%)**

Table 2: Mean Estimated birth weight by ultrasonography and actual birth weight (n=139)

Procedure	**Mean± SD**	**Range**
Ultrasonography (gr)	2752.68±282.95	2050-3450
Actual birth weight after 10 minutes of birth (gr)	**2819.30±397.31**	**2100-3900**

Table 3: Comparison of actual birth weight and estimation of fetal weight by ultrasonography (n=139)

	T	**Df**	**Sig. (2-tailed)**	**Mean Difference**	**95% Confidence Interval of the Difference**	
					Lower	Upper
Estimated fetal weight (gr)	114.694	138	.000	2752.68345	2705.2275	2800.1394
Birth weight (gr)	**105.961**	**138**	**.000**	**2840.09353**	**2787.0952**	**2893.0918**

Table 4: Mean Error in Birth Weight Prediction and 95% Confidence Intervals (N=139)

	Mean	**SD**	**95% Confidence Interval (gr)**	
			Lower limit	Upper limit
Absolute (gr)	193.95	248.08	155.26	240.36
Underestimation (gr)	-140.53	238.31	-180.49	-100.56
Overestimation (gr)	**57.29**	**154.26**	**31.42**	**83.16**

Table 5: Subgroup Analysis of Birth Weight Prediction Error

Subgroup	N	Mean Error (g)	SD	95% CI Lower (g)	95% CI Upper (g)
Male	81	-160.2	240.5	-212.58	-107.82
Female	58	-110.4	210.3	-164.52	-56.28
Primiparous	25	-195.6	270.1	-301.48	-89.72
Multiparous	114	-135.9	235.7	-179.17	-92.63
Vaginal Delivery	84	-128.3	220.8	-175.52	-81.08
C-Section	55	-155.7	260.6	-224.57	-86.83

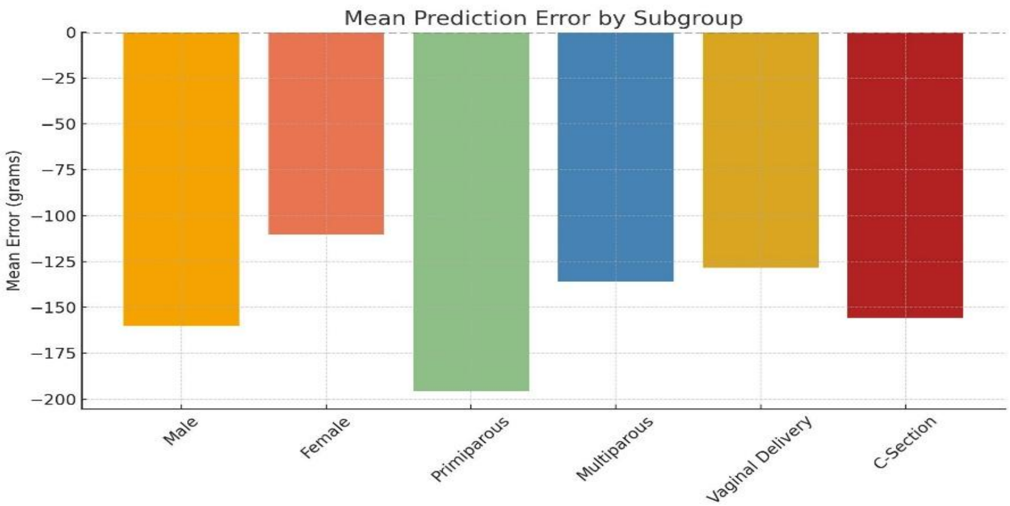

Figure 1 Mean Prediction Error by Subgroup

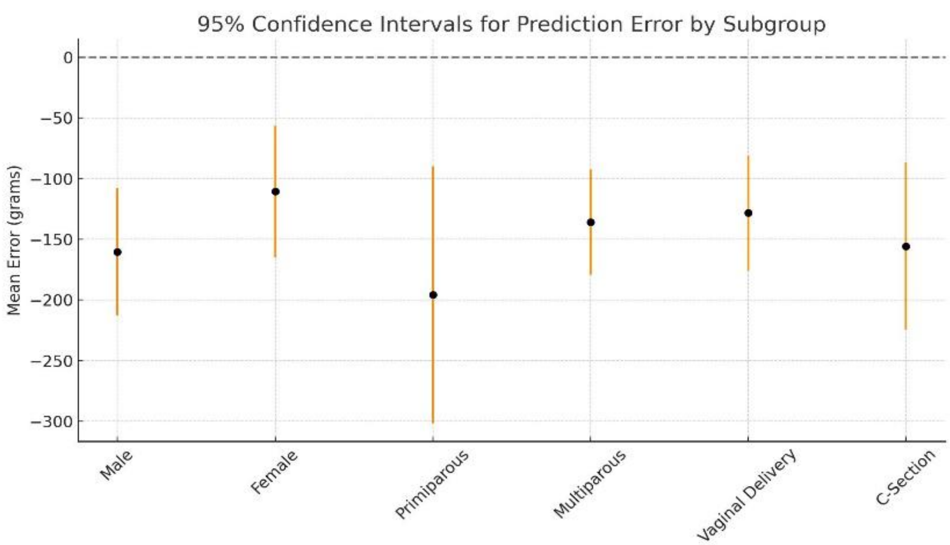

Figure 2 95% Confidence Intervals for Prediction Error by Subgroup

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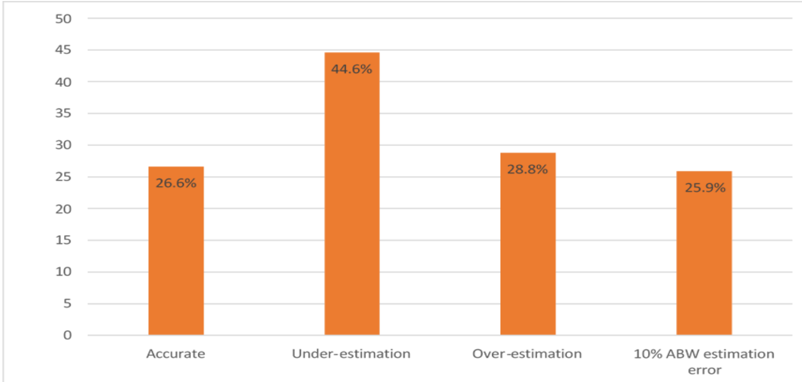

DISCUSSION

Precise estimation of fetal weight is fundamental to obstetric management, particularly in planning for safe delivery and minimizing perinatal risks. In the present study involving 139 women who gave live birth at a tertiary care hospital, ultrasound-based fetal weight estimation demonstrated a modest but statistically significant discrepancy when compared with actual birth weight. The mean estimated fetal weight was 2752.68 grams, whereas the mean actual birth weight measured post-delivery was 2819.30 grams. The mean absolute prediction error was 193.95 grams, and a noteworthy proportion of estimates (25.9%) deviated by more than 10% from the actual weight. These findings align with prior studies that acknowledge ultrasound's utility in estimating fetal weight, while also highlighting its limitations in precision (15-17). Although some earlier reports have shown high accuracy of ultrasound estimations—reporting up to 72% of values falling within ±10% of actual birth weight—other studies have identified considerable estimation errors, particularly in the context of fetal macrosomia or intrauterine growth restriction (18,19). The current study's error rates are consistent with findings from literature that have documented underestimation trends in similar settings (20,21). Variation in the accuracy of fetal weight predictions across studies may be attributed to differences in operator skill, equipment calibration, gestational age at the time of assessment, fetal presentation, amniotic fluid volume, and maternal body habitus. Additionally, factors such as parity, fetal sex, and mode of delivery were observed to have some influence on estimation accuracy, as reflected in the subgroup analysis conducted in this study.

The clinical implications of inaccurate fetal weight estimation are profound. Underestimation may result in unanticipated complications during labor, such as shoulder dystocia in macrosomic infants, while overestimation can contribute to unnecessary cesarean deliveries. Therefore, although ultrasound remains a cornerstone of prenatal assessment due to its non-invasiveness and affordability, clinicians should interpret its estimations with caution and complement them with physical examinations, especially in borderline or high-risk cases (22,23). A major strength of this study lies in its prospective observational design and the exclusive use of standardized ultrasonographic protocols, including the Hadlock formula, which remains one of the most widely validated tools for fetal weight estimation. The use of a diverse clinical population and inclusion of both primiparous and multiparous women adds to the generalizability of the findings. However, limitations must be acknowledged. The study employed convenience sampling, which could introduce selection bias. The relatively small sample size and single-center setting may limit the external validity of the results. Additionally, the study did not perform stratified accuracy analyses across different gestational age groups or fetal weight percentiles, which could have provided further insights into the contexts in which ultrasound may be more or less reliable.

Another limitation pertains to the operator dependency of ultrasound. Variability in technique and inter-observer differences may influence the biometric measurements that underpin fetal weight estimation. Despite efforts to ensure consistency by involving experienced sonographers and obstetricians, this factor remains an inherent limitation in all sonographic research. Future studies should consider multicenter designs with larger sample sizes to enhance the robustness and applicability of findings. Integration of machine learning models and three-dimensional ultrasonography may offer opportunities to refine fetal weight estimation further. Comparative assessments involving clinical palpation methods and sonographic estimations could also help delineate best practices, particularly in low-resource settings where access to high-end ultrasound may be limited. In conclusion, while ultrasonography continues to be an

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indispensable tool in estimating fetal weight, its precision is subject to a range of influencing factors. A critical and balanced interpretation of sonographic findings, supported by clinical judgment, remains essential for optimizing maternal and neonatal outcomes.

CONCLUSION

The findings of this study underscore that while ultrasonography remains a valuable and widely utilized method for estimating fetal weight, it does not consistently provide precise measurements when used in isolation. Discrepancies between estimated and actual birth weights highlight the need for integrating clinical judgment with sonographic findings to guide obstetric decision-making. Relying solely on ultrasound may contribute to unnecessary interventions or missed complications. Therefore, a combined assessment approach enhances the reliability of fetal weight estimation, ultimately supporting safer, more informed management strategies and improving outcomes for both mothers and newborns.

AUTHOR CONTRIBUTION

Author	Contribution
Saba Kanwal*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Khawaja Muhammad Baqir Hussain	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ayesha Niaz	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Koukab Javed	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Aliya Halim	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Sara Khan	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
Farah Afzal	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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