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DIAGNOSTIC ACCURACY OF ULTRASOUND IN MEASURING ESTIMATED FETAL WEIGHT WITHIN 48 HOURS BEFORE DELIVERY KEEPING THE BABY WEIGHT AT BIRTH AS A GOLD STANDARD

Original Research

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ABSTRACT

Background: Accurate estimation of fetal weight in the third trimester is vital for optimal perinatal care, particularly in identifying low birth weight (LBW) neonates and preventing related complications. Ultrasonography remains a cornerstone in antenatal assessment due to its safety and accessibility, yet the precision of its estimations compared to actual birth weight remains a subject of continued research interest.

Objective: To determine the diagnostic accuracy of ultrasound in estimating fetal weight before delivery, using birth weight at delivery as the gold standard.

Methods: This cross-sectional validation study was conducted over six months at the Department of Diagnostic Radiology, Khyber Teaching Hospital, Peshawar. A total of 265 pregnant women between 29 and 40 weeks of gestation were enrolled using consecutive non-probability sampling. Fetal weight was estimated using ultrasound based on standard biometric parameters. Actual birth weight was recorded within two hours of delivery. Diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using a 2x2 contingency table. Data were analyzed using SPSS v21.

Results: Of the 265 participants, 92 (34.7%) had low fetal weight on ultrasound, and 96 (36.2%) neonates were confirmed to have low birth weight. The ultrasound showed a sensitivity of 80.21%, specificity of 91.12%, PPV of 83.70%, NPV of 89.02%, and an overall diagnostic accuracy of 87.17%, demonstrating strong agreement between ultrasound estimates and actual birth weight.

Conclusion: Ultrasound proved to be a reliable tool for fetal weight estimation in late pregnancy, showing high diagnostic accuracy for detecting low birth weight. Its integration into routine obstetric care can enhance prenatal decision-making and neonatal outcomes.

Keywords: Birth Weight, Diagnostic Accuracy, Fetal Biometry, Fetal Weight Estimation, Pregnancy Trimester Third, Sensitivity and Specificity, Ultrasonography, Weight Gain.

INTRODUCTION

The accurate assessment of fetal weight is a cornerstone of modern obstetric care, particularly in the third trimester when rapid fetal development demands careful monitoring. Estimating fetal weight not only aids in evaluating fetal growth but also plays a crucial role in guiding clinical decisions such as the timing and mode of delivery, especially in high-risk pregnancies (1). Among the available methods, ultrasound has emerged as a preferred tool due to its noninvasiveness, accessibility, and safety. By utilizing fetal biometric parameters—namely biparietal diameter, abdominal circumference, and femur length—clinicians derive the estimated fetal weight (EFW) using standardized formulas. These estimates are instrumental in identifying growth abnormalities, anticipating complications, and improving maternal and neonatal outcomes (2-4). Despite its widespread use, the diagnostic accuracy of ultrasound-based fetal weight estimation remains a topic of continued research and clinical debate. Variations in fetal growth patterns during the third trimester, combined with physiological and technical factors, can lead to discrepancies between the estimated and actual birth weights. The gold standard for evaluating fetal weight remains the weight recorded at birth, which reflects the complex interplay of genetic, nutritional, placental, and environmental influences throughout gestation (5,6). Therefore, comparing ultrasound-derived EFW with the actual birth weight provides a meaningful metric to assess the reliability of this commonly used diagnostic modality.

Several studies have highlighted both the strengths and limitations of ultrasound in this context. A recent study reported a sensitivity of 80.04% and specificity of 90.04% for ultrasound in detecting low birth weight, with the frequency of low-birth-weight neonates observed at 36.33% (7-9). These findings underscore the need for a comprehensive analysis of the accuracy of ultrasound, particularly in differentiating between low and normal birth weight neonates. False positive or negative estimations may lead to unnecessary interventions or missed opportunities for timely management, potentially compromising neonatal outcomes (10). In clinical terms, diagnostic accuracy encompasses sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), all of which reflect the performance of ultrasound in predicting actual birth weight. Understanding these parameters is critical for obstetricians and sonographers to refine diagnostic thresholds and interpret findings with greater precision (11). Factors such as fetal positioning, maternal habitus, amniotic fluid volume, and operator experience also contribute to variability in ultrasound accuracy, further emphasizing the need for standardized assessment frameworks. Given the technological advancements in ultrasonography and evolving standards in perinatal care, it is imperative to revisit and rigorously evaluate the diagnostic accuracy of ultrasound for fetal weight estimation. This study seeks to address the existing knowledge gap by systematically comparing ultrasound-derived estimated fetal weight with actual birth weight, using the latter as the gold standard. Through this approach, the study aims to enhance the clinical utility of ultrasound in late pregnancy and contribute to improved perinatal care practices. Therefore, the objective of this study is to determine the diagnostic accuracy of ultrasound in detecting estimated fetal weight before delivery in pregnant women, keeping birth weight at birth as the gold standard.

METHODS

This study was designed as a cross-sectional validation study conducted at the Department of Diagnostic Radiology, Khyber Teaching Hospital, Peshawar. The research was planned over a minimum duration of six months following the approval of the synopsis. Ethical clearance was sought and obtained from the Ethical Review Committee of the hospital and the Research Department of the College of Physicians and Surgeons Pakistan (CPSP), Karachi. Written informed consent was obtained from all participants after providing a clear explanation of the study's purpose, potential benefits, and any associated risks, ensuring voluntary participation in compliance with ethical standards. The sample size was determined using the WHO sample size calculator, based on a 36.33% frequency of low birth weight (8), an expected ultrasound sensitivity of 80.04%, and specificity of 90.04% in detecting low birth weight (9), with an absolute precision of 8% and a 95% confidence level. The calculated sample size was 265 participants. Consecutive non-probability sampling was used to enroll eligible women who met the inclusion criteria: singleton pregnancies, aged between 18 and 35 years, with gestational age ranging from 29 to 40 weeks, and suspected of having low fetal weight based on predefined ultrasound criteria. Women diagnosed with diabetes mellitus, hypertension, or experiencing stillbirths were excluded to avoid potential confounding effects on fetal growth and to minimize bias in the study findings (12).

After enrollment, each participant underwent a detailed history and physical examination. Demographic details including maternal age, body mass index (BMI), area of residence, socioeconomic status, occupational status, and education level were documented on a structured proforma. Eligible women were then subjected to ultrasound evaluation to estimate fetal weight using standard fetal biometric parameters—biparietal diameter, abdominal circumference, and femur length. These measurements were assessed by a radiologist with at least five years of post-fellowship experience, and low fetal weight was diagnosed if all the following thresholds were met: biparietal diameter <7 cm, abdominal circumference <21 cm, and femur length <5 cm. Following delivery, each neonate was weighed within two hours using a calibrated baby weighing scale to determine the actual birth weight. A weight of less than 2500 grams was defined as low birth weight, which served as the gold standard for comparison with the ultrasound findings (13-15). Data analysis was carried out using SPSS version 21. Continuous variables such as maternal age, gestational age, and BMI were expressed as mean ± standard deviation, while categorical variables including demographic factors, ultrasound findings, and birth weight outcomes were reported as frequencies and percentages. The diagnostic performance of ultrasound was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy using a 2x2 contingency table. These parameters were computed as follows: Sensitivity = (True Positives / True Positives + False Negatives) x 100; Specificity = (True Negatives / False Positives + True Negatives) x 100; PPV = (True Positives / True Positives + False Positives) x 100; NPV = (True Negatives / False Negatives + True Negatives) x 100; and Accuracy = (True Positives + True Negatives) / Total Sample Size x 100. To identify potential effect modifiers, diagnostic accuracy was stratified based on variables such as maternal age, gestational age, BMI, area of residence, socioeconomic status, occupation, and education level. Post-stratification, chi-square tests were applied to assess statistical significance at a 5% level.

RESULTS

A total of 265 pregnant women were included in the study based on predefined eligibility criteria. The mean age of participants was 27.6 ± 4.3 years, with a mean gestational age of 35.2 ± 2.4 weeks and a mean BMI of 26.1 ± 3.2 kg/m². In terms of socioeconomic distribution, 41.5% of the participants belonged to the lower socioeconomic class, 46.4% to the middle class, and 12.1% to the upper class. Employment status revealed that 51.3% of the women were employed, while 48.7% were unemployed. The urban population accounted for 55.8% of the study group, and the remaining 44.2% resided in rural areas. Regarding education, 56.2% of the women were literate, and 43.8% were illiterate. On ultrasound assessment before delivery, 92 women (34.7%) were diagnosed with low fetal weight, whereas 173 (65.3%) had a normal estimated fetal weight. Upon birth, 96 neonates (36.2%) were confirmed to have a low birth weight (defined as <2500 grams), while 169 (63.8%) had a normal birth weight. The contingency analysis between ultrasound estimation and actual birth weight demonstrated 77 true positives, 154 true negatives, 15 false positives, and 19 false negatives. Based on these observations, the sensitivity of ultrasound in detecting low birth weight was 80.21%, while specificity was 91.12%. The positive predictive value (PPV) of ultrasound findings was calculated to be 83.70%, and the negative predictive value (NPV) was 89.02%. The overall diagnostic accuracy of ultrasound in estimating fetal weight was 87.17%, affirming its reliability as a non-invasive tool in identifying low birth weight neonates. These results are visually summarized in the accompanying charts that depict the distribution of low fetal weight as diagnosed by ultrasound and the actual incidence of low birth weight at delivery. Both graphical and tabular data clearly show that ultrasound has a strong diagnostic performance and aligns well with postnatal birth weight assessments.

Table 1: Demographic Characteristics of Study Participants (n = 265)

Variable	Mean ± SD / n (%)
Age (years)	27.6 ± 4.3
Gestational Age (weeks)	35.2 ± 2.4
BMI (kg/m²)	26.1 ± 3.2
Socioeconomic Status	
Lower	110 (41.5%)
Middle	123 (46.4%)
Upper	32 (12.1%)
Occupation Status	
Employed	136 (51.3%)
Unemployed	129 (48.7%)
Residence	
Rural	117 (44.2%)
Urban	148 (55.8%)

Variable	Mean ± SD / n (%)
Education Status	
Literate	149 (56.2%)
Illiterate	116 (43.8%)

Table 2: Frequency of Low Fetal Weight on Ultrasound and Low Birth Weight

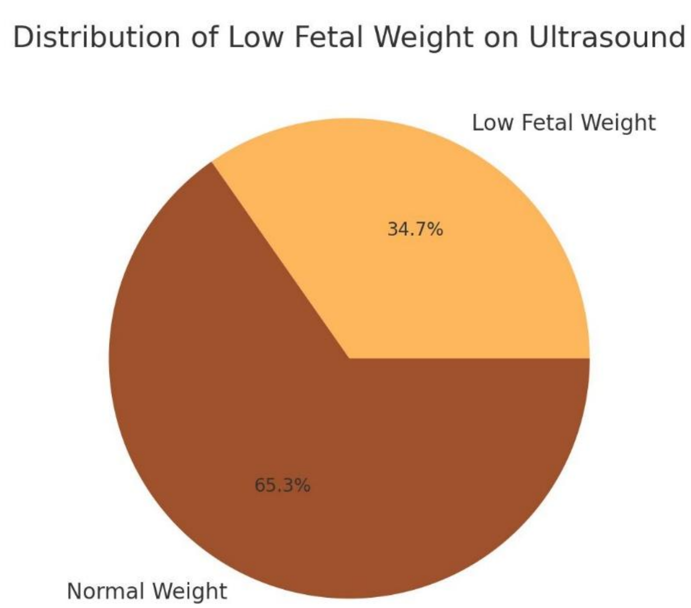
Variable	Yes [n (%)]	No [n (%)]
Low Fetal Weight on Ultrasound	92 (34.7%)	173 (65.3%)
Low Birth Weight	96 (36.2%)	169 (63.8%)

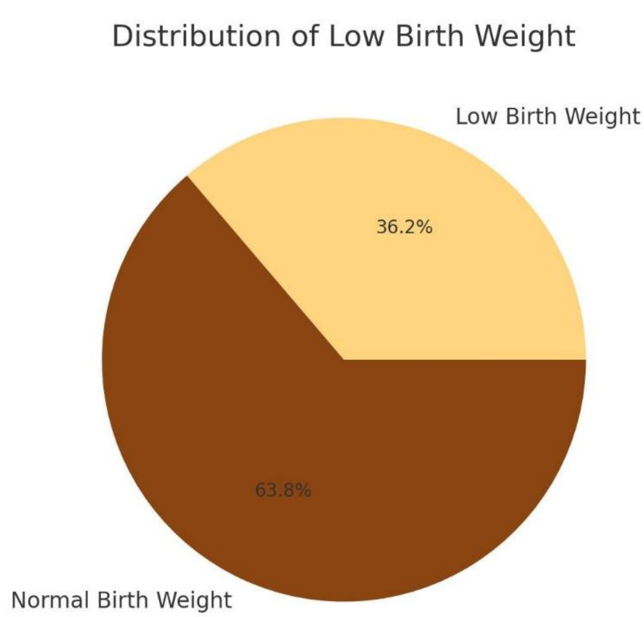
Table 3: Diagnostic 2x2 Contingency Table Comparing Ultrasound and Birth Weight

	Low Birth Weight: Yes	Low Birth Weight: No
Low Fetal Weight on U/S: Yes	77 (True Positive)	15 (False Positive)
Low Fetal Weight on U/S: No	19 (False Negative)	154 (True Negative)

Table 4: Diagnostic Accuracy of Ultrasound in Estimating Low Birth Weight

Metric	Value (%)
Sensitivity	80.21
Specificity	91.12
Positive Predictive Value (PPV)	83.70
Negative Predictive Value (NPV)	89.02
Diagnostic Accuracy	87.17





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Discussion

The findings of this study reinforce the diagnostic utility of ultrasound in estimating fetal weight in the third trimester, demonstrating high sensitivity (80.21%), specificity (91.12%), and diagnostic accuracy (87.17%). These results support the reliability of ultrasound as a non-invasive tool in prenatal care, particularly for identifying low birth weight neonates prior to delivery. Notably, the calculated sensitivity and specificity align well with recent literature emphasizing the value of ultrasonography in guiding delivery planning and risk stratification. Comparison with other regional and international studies reveals consistent trends. For instance, a prospective study conducted at Pak Emirates Military Hospital reported ultrasound-based fetal weight estimation as more accurate than clinical methods, showing statistically significant lower error margins in all categories evaluated (15). Similarly, another study from Nepal showed that the Hadlock formula used in ultrasonography produced a fetal weight estimation error within 10% of actual birth weight in over 91% of cases, validating its predictive value (16). Multiple studies have endorsed the superiority of ultrasound over clinical palpation, especially in estimating weights closer to term. A study found that while both ultrasound and clinical methods had moderate reliability, ultrasound performed slightly better in identifying low birth weight, which parallels the present study's findings (17,18). Moreover, Hadlock-based formulae, especially Hadlock IV, have repeatedly been demonstrated to be the most accurate across diverse populations, as evidenced in a study where it closely correlated with actual birth weight (19). However, the study also acknowledges intrinsic limitations of ultrasonography. Several sources of variability such as fetal position, operator experience, maternal BMI, amniotic fluid volume, and gestational age at the time of scan may impact the accuracy of fetal weight estimation. This was echoed in a study, where maternal BMI >30 kg/m² and the time interval between scan and delivery significantly influenced estimation precision (20). Moreover, in low-birth-weight neonates, ultrasound accuracy was slightly lower, particularly in cases of small-for-gestational-age (SGA) fetuses, as reported by a study, suggesting possible overestimation or underestimation in such subgroups (21,22).

The strengths of this study lie in its well-defined inclusion criteria, standardized ultrasound assessments by an experienced radiologist, and the use of actual birth weight within two hours of delivery as a gold standard. These methodological aspects enhance the internal validity and practical relevance of the findings. Additionally, stratification of diagnostic metrics across socio-demographic variables provides a comprehensive understanding of potential effect modifiers. Nonetheless, some limitations merit attention. The single-center setting and use of non-probability consecutive sampling may restrict the generalizability of the results. The study also did not assess inter-operator variability or the impact of factors such as placental location or amniotic fluid index, which are known to affect ultrasound visibility and measurement accuracy. Furthermore, while the time interval between the ultrasound and actual delivery was minimized, it was not standardized across all participants, which may introduce bias, especially in cases nearing term. Future research should consider multicenter designs with larger sample sizes and incorporate stratification based on fetal growth categories (SGA, AGA, LGA) (23,24). Evaluating different formulae and ultrasound techniques, including 3D/4D ultrasound and AI-assisted estimation models, may enhance diagnostic precision. Additionally, establishing standard training protocols for sonographers may help reduce variability due to operator experience, as highlighted in recent Ethiopian research on training-level impact on EFW accuracy (24). In conclusion, the current study substantiates the high diagnostic accuracy of ultrasound in estimating fetal weight prior to delivery, supporting its use as a reliable tool in obstetric care. While ultrasonography demonstrates substantial agreement with actual birth weights, ongoing technological advancements and standardized training may further enhance its clinical utility, especially in identifying and managing low birth weight neonates effectively.

Conclusion

This study demonstrated that ultrasound is a highly accurate and reliable tool for estimating fetal weight in the third trimester, with strong diagnostic performance in detecting low birth weight neonates. Its non-invasive nature, combined with high sensitivity and specificity, reinforces its practical value in routine obstetric care. Incorporating ultrasound-based fetal weight assessments can significantly improve clinical decision-making and neonatal outcomes.

AUTHOR CONTRIBUTIONS

Author	Contribution
Sara Daud	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hina Gul*	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 Begum	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

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