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DIAGNOSTIC ACCURACY OF ULTRASOUND FOR SCREENING OF MACROSOMIA

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Abstract

Introduction: *Macrosomia poses significant maternal and neonatal risks, including prolonged labor, cesarean delivery, and birth trauma. In Pakistan, where limited healthcare resources and rising rates of obesity and gestational diabetes exacerbate the burden, timely detection is crucial. Ultrasound, as a non-invasive and cost-effective tool, offers potential for macrosomia screening in resource-constrained settings.*

Objective: *To determine the accuracy of ultrasound findings for predicting the macrosomia among pregnant women who will be clinically suspected for macrosomia and referred to the radiology department for the ultrasound diagnosis of macrosomia presenting to the tertiary care setting for delivery, taking neonatal birth weight as gold standard.*

Methodology: *This cross-sectional validation study was conducted at a tertiary care hospital of Islamabad from 6th July 2024 to 5th January 2025. A total of 155 female with age between 18-40 weeks having gestational age >36 weeks having singleton pregnancy and suspected for macrosomia on clinical examination and presented at term for delivery were selected for this study. Clinically Suspected Macrosomia was defined as the fundal height greater than 3 cm of the patient's gestational age. Macrosomia on ultrasound was diagnosed by the Hadlock method. Macrosomia was confirmed through the fetal weight at the time of birth and neonate labelled macrosomic if weighs ≥4000 grams.*

Results: *Ultrasound identified 43.9% (n=68) of cases as positive for macrosomia, while 32.9% were positive for macrosomia at birth. Among the cases identified as positive by USG, 29.0% (45/155) were true positive; while, those cases who were identified as negative by USG 52.3% (81/155) were true negatives. Sensitivity, specificity, PPV, NPV and overall accuracy of ultrasound for macrosomia screening was found as 88.2%, 77.9%, 66.2%, 93.1% and 81.3% respectively.*

Conclusion: *The study demonstrates that ultrasound is a valuable screening tool for macrosomia, with high sensitivity and NPV. However, its moderate specificity and PPV highlight the need for cautious interpretation and integration with clinical assessment.*

INTRODUCTION

Macrosomia is an obstetric disorder linked to many potentially life-threatening problems for both the mother and the fetus. It is characterized by a birth weight over 4000 to 4500 g, as well as being classified as LGA, where the birth weight surpasses the 90th percentile for population and sex-specific development curves.[i] Macrosomia impacts 3–15% of pregnancies globally. In low- and middle-income nations, the prevalence of macrosomia ranged significantly from 0.5% in low-income countries to 14.9%.[ii] Pregnancies involving macrosomic fetuses are often classified as high-risk due to the associated maternal and neonatal morbidities. In a properly timed pregnancy, macrosomia is typically associated with constitutional factors, maternal diabetes (either gestational or pregestational), and/or maternal obesity or excessive gestational weight gain.[iii] Macrocosmic infants are more predisposed to both short-term and long-term health complications in later life. Short-term health effects encompass birth hypoxia, stillbirth, shoulder dystocia, hypoglycemia, bone fractures, meconium aspiration, infant death, and diminished Apgar scores.[iv,v] Maternal complications such as postpartum hemorrhage, prolonged labor, perineal laceration, cesarean delivery, failed instrumental delivery, maternal death, uterine rupture, and wound infection are associated with fetal macrosomia. [4,vi]

Estimating fetal weight is a standard aspect of prenatal care that allows healthcare practitioners to determine suitable delivery methods and assess risk. This can be conducted either clinically or by utilizing the estimated fetal weight obtained from an ultrasound. Leopold's maneuvers, a time-honored practice in obstetrics and midwifery, involve placing both hands on the woman's abdomen to ascertain the fetus's position and the uterine fundus's level, thereby identifying any disproportion between the fetus and the female pelvis. Multiple studies indicate that fundal height (FH) possesses a limited positive predictive value for detecting fetuses with aberrant growth; the rising prevalence of maternal obesity complicates this clinical assessment. The optimal approach for determining the delivery of a presumed big pregnancy is to utilize ultrasonography assessments of fetal weight.[vii] Two-dimensional ultrasound imaging is employed to capture fetal biometric features for the purpose of estimating fetal weight using a formula. Over 30 equations have been published; however, the Hadlock formula, which considers abdominal circumference (AC), head circumference (HC), femur length (FL), and biparietal diameter (BPD), is employed by the majority of obstetricians.[viii,ix] The most effective predictor of FGR among all these measures is AC.[x] AC is regarded as the first and most sensitive indicator in assessing fetal macrosomia, signifying irregularities in liver growth. However, all these factors can be connected provided the gestational age is precisely determined.[xi,xii]

Presently, obstetricians in low-resource settings predominantly depend on clinical estimation of macrosomia and eschew ultrasonographic diagnosis due to different economic and social impediments, frequently resulting in adverse feto-maternal outcomes. Conversely, ultrasound is a modality that is significantly dependent on the operator, and comprehending its accuracy in predicting macrosomia is essential for enhancing diagnostic protocols and optimizing patient treatment.

MATERIAL AND METHODS

This cross-sectional validation study was conducted at Department of Radiology in collaboration with Gynecology Department of Dr. Akber Niazi Teaching Hospital, Islamabad from 6th July 2024 to 5th January 2025. Sample size was calculated using sensitivity & specificity sample size calculator taking sensitivity of the test as 86.7% and specificity of the test as 67.1% as described by Abdelazem O et al (2021). Expected prevalence considered as 45% as per findings of Rodrigues de Souza MV et al (2021).

Confidence level kept as 95% while required precision as 10% and sample size comes out to be 155 patients. Female with age between 18-40 weeks having gestational age >36 weeks having singleton pregnancy and suspected for macrosomia on clinical examination and presented at term for delivery were shortlisted for this study. Female with established fetal abnormalities, polyhydramnios, intrauterine fetal death or breech presentation and women with gestational diabetes were excluded from the study.

Clinically Suspected Macrosomia was defined as the fundal height greater than 3 cm of the patient's gestational age. Macrosomia on ultrasound was diagnosed by taking Bi Parietal Diameter, (BPD), Head Circumference (HC), Abdominal Circumference (AC), and Femur Length (FL) before calculating fetal weight using the Hadlock method. Macrosomia labelled as positive if EFW is >4000g using Hadlock Method.

Macrosomia was confirmed through the fetal weight at the time of birth and neonate labelled macrosomic if weighs ≥4000 grams.

Initially, permission for performing the research was obtained by the hospital research committee. The trainee researcher meticulously gathered clinical histories and reviewed healthcare records for all selected patients. The ultrasound diagnostic was conducted by a trainee researcher utilizing a 3.5 MHz ultrasound machine, under the supervision of an experienced consultant radiologist with a minimum of three years of teaching experience. Patient demographic information, along with clinical and ultrasonographic results, was meticulously recorded on the specially constructed data collection form. The diagnostic accuracy of ultrasonographic findings in predicting macrosomia was assessed by sensitivity, specificity, positive predictive value, and negative predictive value. Data was entered and analyzed using IBM-SPSS software version 17.0. Mean ± SD were computed for quantitative factors in the study, such as maternal age, BMI, birth weight, and gestational age, whereas frequency and percentages were determined for all qualitative variables, including parity, true positives, false positives, true negatives, and false negatives. The overall diagnostic accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were assessed for clinical and ultrasound abnormalities related to macrosomia. A 2×2 table was created for this purpose. Confounders such as maternal age, gestational age, body mass index, and parity were controlled through stratification. The diagnostic accuracy of post stratification was assessed for all effect modifiers.

RESULTS

The participants' ages ranged from 18 to 40 years, with a mean age of 29.01±5.77 years. The mean BMI was 26.88±4.85 kg/m² with a range of 17.00 to 39.50 kg/m², while mean gestational age at delivery was 40.54±2.14weeks, with a range of 37 to 44 weeks. Most importantly, mean birthweight was 3,811.24 grams (±572.49), with a range of 2,086 to 5,532 grams. The majority of participants were multiparous. Furthermore, patients were categorized in different groups on the basis of age, BMI and gestational age which is presented in table 1.

Ultrasound identified 43.9% (n=68) of cases as positive for macrosomia, while 32.9% were positive for macrosomia at birth (table 2). Among the cases identified as positive by USG, 29.0% (45/155) were true positive; while, those cases who were identified as negative by USG 52.3% (81/155) were true negatives. Sensitivity and specificity of ultrasound was determined as 88.2% and 77.9% respectively (Table 3). Stratification analysis was performed for effect modifiers such as mother age, gestational age, parity and BMI and diagnostic accuracies are illuminated in Table-4.

Table 1: Baseline demographic and clinical details of the study subjects (n=155)

Variable		Frequency	Percentage
Gestational Age	≤40 Weeks	78	50.3%
	>40 Weeks	77	49.7%
Age Groups	<30 Years	88	56.8%
	30-40 Years	67	43.2%
Parity	Nulliparous	66	42.6%
	Multiparous	89	57.4%
BMI Groups	<25 kg/m²	58	37.4%
	≥25 kg/m²	97	62.6%

Table 2: Overall results of ultrasonographic screening of macrosomia and macrosomia at birth

Macrosomia	Ultrasound Findings	Macrosomia at Birth
Positive	68 (43.9%)	51 (32.9%)
Negative	87 (56.1%)	104 (67.1%)
Total	155 (100%)	155 (100%)

Table 3: Diagnostic accuracy of ultrasound screening for macrosomia keeping macrosomia at birth as gold standard

Macrosomia on Ultrasound	Macrosomia at Birth		
	POSITIVE	NEGATIVE	TOTAL
Positive	45 (29.0%) (True Positives)	23 (14.8%) (False Positives)	68 (43.9%)
Negative	06 (3.9%) (False Negatives)	81 (52.3%) (True Negatives)	87 (56.1%)
Total	51 (32.9%)	104 (67.1%)	155 (100%)

Sensitivity	Specificity	Accuracy	PPV	NPV
88.2 %	77.9 %	81.3 %	66.2 %	93.1 %

PPV: Positive Predictive Value, NPV: Negative Predictive Value

Table 4: Diagnostic accuracy of ultrasound screening for macrosomia keeping macrosomia at birth as gold standard (stratification analysis for various study confounders)

Effect Modifiers	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Gestational Age					
≤40 Weeks	89.3%	74.0%	65.8%	92.5%	79.5%
>40 Weeks	87.0%	81.5%	66.7%	93.6%	83.1%
Age Groups					
<30 Years	90.0%	77.6%	67.5%	93.8%	81.8%
30-40 Years	85.7%	78.3%	64.3%	92.3%	80.6%
Parity					
Nulliparous	89.5%	78.7%	63.0%	94.9%	81.8%
Multiparous	87.5%	77.2%	68.3%	91.7%	80.9%

Effect Modifiers	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Gestational Age					
≤40 Weeks	89.3%	74.0%	65.8%	92.5%	79.5%
>40 Weeks	87.0%	81.5%	66.7%	93.6%	83.1%
BMI					
<25 kg/m²	90.0%	71.1%	62.1%	93.1%	77.6%
≥25 kg/m²	87.1%	81.8%	69.2%	93.1%	83.5%

PPV: Positive Predictive Value, NPV: Negative Predictive Value

DISCUSSION

In low- and middle-income countries like Pakistan, where healthcare resources are often limited and maternal and neonatal mortality rates remain high, the timely detection and management of macrosomia are critical to improving outcomes. Pakistan faces a dual burden of malnutrition and rising rates of obesity and gestational diabetes, both of which are key risk factors for macrosomia. This makes the condition particularly relevant in the Pakistani context, where early and accurate diagnosis can help mitigate adverse outcomes.[xiii] Ultrasound, as a non-invasive, cost-effective, and widely available diagnostic tool, holds immense potential for screening macrosomia in resource-constrained settings like Pakistan.[xiv] However, proper assessment of its diagnostic performance is essential in order to smoothly incorporate into routine prenatal screening. Such a study was performed to evaluate the efficacy of ultrasound screening for macrosomia which judgments its strength and weakness in a place where advanced diagnostic laboratory or imaging equipment cannot be reached. The results are significant for enhancing maternal and neonatal health outcomes in Pakistan and similar settings.

The study showed that ultrasound has a high sensitivity of 88.2%, which meant that it correctly identified most cases of true macrosomia. This is a major strength because a sensitive test has a low risk for false negative results meaning that most cases of macrosomia are identified. As those conditions become critical, early detection is essential, allowing for timely intervention and minimizing the risk of complications, including shoulder dystocia, birth trauma, and postpartum hemorrhage. But high sensitivity is often achieved at the expense of specificity. The specificity of 77.9% suggests that ultrasound could over diagnose macrosomia in some instances, resulting in false positives. False positives can result in unnecessary interventions, such as cesarean sections or inductions, which carry their own risks and costs. This trade-off between sensitivity and specificity is a common challenge in diagnostic testing and underscores the need for careful interpretation of ultrasound results. The overall diagnostic accuracy of ultrasound was 81.3%, which is acceptable for a screening tool. However, the moderate specificity and PPV highlight the limitations of ultrasound as a standalone diagnostic method. These findings align with previous studies, which have reported varying sensitivity and specificity for ultrasound in diagnosing macrosomia. A local study by Hina GE et al, reported high prevalence of macrosomia in Pakistan as 45%.[xv] In another study, Abdelazem O and Mohammed AH assessed the accuracy of clinical evaluation and ultrasound examination in prediction of fetal macrosomia and they reported that sensitivity and specificity of ultrasound for determining macrosomia was 86.7% and 67.1% with a cutoff value of 4125g and both sensitivity and specificity were far better than clinical estimations.[xvi] Naz F in another local study reported that sensitivity and specificity of ultrasound were found to be 94.20%, 84.00%, and overall diagnostic accuracy was observed 90.27% in the detection of macrosomic infants, taking birth weight as the gold standard.[xvii] In a meta-analysis, contrary to our findings, the pooled sensitivity and specificity of ultrasound was 54% (95% CI: 0.40–0.68) and 94% (95% CI: 0.90–0.96) respectively.[xviii] The consistency of these results across different populations and settings reinforces the reliability of ultrasound as a screening tool while emphasizing the need for complementary diagnostic approaches.

Ultrasound performed consistently well across different age groups, with slightly higher sensitivity in participants under 30 years (90.0%) compared to those aged 30 years or older (85.7%). This means that age does not have a significant effect on diagnostic accuracy of ultrasound for macrosomia. But older mothers may also have risk factors that can affect fetal growth and complicate ultrasound interpretation, such as gestational diabetes or obesity.[xix]

Ultrasound showed better sensitivity in a subgroup with BMI <25 kg/m² (90·0% vs 87.1% for BMI ≥25 kg/m²) This corresponds with earlier literature which identifies that maternal obesity affects the precision of ultrasound measurements because of technical difficulties with imaging, such as increased abdominal wall thickness or decreased visibility of fetal structures. The results underscore the necessity for specialized imaging techniques or modified protocols for patients with obesity.[xx] The ultrasound sensitivity was marginally higher in nulliparous women (89.5%) than multiparous women (87.5%). This may be due to differences in abdominal wall thickness, fetal positioning, or uterine tone between nulliparous and multiparous women. Multiparity may also be associated with past macrosomic deliveries, which may affect our clinical decision more than what the ultrasound says.[xxi]

The study was has optimum sample size (n=155), which adds robustness to the results. Subgroup analyses were conducted to evaluate the impact of age, gestational age, BMI, and parity on diagnostic accuracy, providing a comprehensive understanding of the factors influencing ultrasound performance. The study was conducted at a single center, which may limit the generalizability of the findings. The gold standard for macrosomia (birthweight >4,000 grams) was used, but this does not account for variations in fetal body composition or maternal factors that may influence birthweight. The study did not evaluate the impact of operator experience or ultrasound machine quality on diagnostic accuracy.

On the basis of our findings, we suggest that ultrasound should be used as a first-line screening tool for macrosomia, particularly in high-risk populations (e.g., women with diabetes, obesity, or a history of macrosomia). Ultrasound results should be interpreted in conjunction with clinical risk factors, such as maternal weight, fundal height, and gestational diabetes status, to improve diagnostic accuracy. In cases where macrosomia is suspected, serial ultrasound measurements can help track fetal growth and improve the reliability of the diagnosis. Clinicians should counsel patients about the limitations of ultrasound and involve them in shared decision-making regarding delivery planning. This includes discussing the risks and benefits of interventions such as cesarean sections or inductions.

CONCLUSION

Our findings reflected that ultrasound is an excellent primary screening modality for macrosomia, with high sensitivity (88.2%) and negative predictive value (93.1%), making it reliable for ruling out the condition. However, its moderate specificity (77.9%) and positive predictive value (66.2%) underscore the necessity of interpretation in conjunction with clinical assessment to prevent overdiagnosis and intervention. Overall, ultrasound serves as an effective first-line screening tool, particularly in resource-limited settings like Pakistan, where early detection can significantly improve maternal and neonatal outcomes. The use of ultrasound must be integrated to a holistic prenatal care and used in context of maternal and fetal indications. Ultrasonography can reduce the risks of macrosomia and improve the maternal and neonatal outcome by providing precise diagnostic accuracy and robust delivery planning.

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