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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

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Abstract

The article explores the sensitivity and specificity of ultrasound in predicting fetal weight among those patients who have given birth within 48 hours before the conduct of the study. High-risk pregnancy is one of the areas where precise estimation of the weight of a baby is very relevant in deciding on the mode of delivery and the time of delivery. Ultrasound is a commonly used non-invasive scanning procedure, which estimates the fetal weight (EFW) using biometric parameters that demand measurements of the following: femur length, abdominal circumference, and biparietal diameter. Accuracy of ultrasound in the determination of true birth weight is however debatable. The research is a cross-sectional study that involves a sample of 265 women with the singleton pregnancy aged between 18 and 35 years and 29 to 40-week gestational age at Indus Hospital and Health Network, Sui campus. The research involves a comparison between ultrasound-determined EFW and birth weight with a sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and general diagnostic accuracy calculation. Findings in this research give important information on the possibility of reliability in the estimated fetal weight by the use of ultrasound with possible benefit on the clinical decision making efficiency in obstetric care.

INTRODUCTION

On top of obstetric care, it is essential to measure the fetal weight accurately, especially in the regard of delivery methods and timing based on fetal well-being. This is since fetal weight (EFW) estimation is critical in the handling of percentages of pregnancy, which has the influence of intrauterine growth restriction (IUGR) or macrosomia on the maternal and neonatal outcomes (Hammami et al., 2018; Milner & Arezina, 2018). Cases of inaccurate estimates of the weight of the fetus can lead to the implementation of additional unnecessary measures that can be cesarean sections, as well as the possibility of not recognizing zoned fetuses that have to be monitored more carefully or born earlier (Caradeux et al., 2019).

The concept of sonographic prediction of fetal weight has become a gold standard in the prediction of fetal weight being non-invasive, non-expensive, and having the benefit in more than 30 years of research to verify its safety, the fact that it is widely available in accessible hospitals/clinic facilities and is able to provide live data on fetal development (Preyer et al., 2019). Measurements of biometric parameters by ultrasound using biparietal diameter (BPD), abdominal circumference (AC), and femur length (FL) are included in a number of formulas to calculate

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the weight of the fetus (Salomon et al., 2019). Although ultrasound is widely employed, the error of these EFWs is a matter of a continuous study, especially in high-risk pregnancies in which the normal fetal growth may be based on abnormality (Sovio et al., 2018).

The final verification of fetal weight is by its birth weight which is a gold standard in establishing the actual weight of the fetus at birth (Devaguru et al., 2023). Comparing actual birth weight and weight estimated by ultrasound, research studies can determine how accurate and applicable ultrasound as the means of measurement of the fetal weight can be and adjust medical procedures to prevent unwanted interventions or unnoticed problems (Hammami et al., 2018).

Problem Statement

Although ultrasound is widely used to determine fetal weight, a lot of confusion has been left in the air as to the accuracy of the ultrasound as a determinant of fetal weight, especially during the third trimester of pregnancy. Ultrasound accuracy variability, which depends on such variables as fetal location, maternal obesity, and gestational age, creates a challenge to clinical decision-making, particularly during high-risk pregnancies (Caradeux et al., 2019). The need to conduct additional studies is further based on this ambiguity in order to determine the validity of ultrasound estimates, specifically when contrasted with the actual weight of the fetus at birth which is not always properly reflected in the ultrasound-derived value (Awan et al., 2015). In this way, it is important to have a good idea of the diagnostic effectiveness of sonography in the prediction of birth weight to enhance clinical outcomes and prevent intervention where it is not necessary.

Study Rationale

The value of validating ultrasound-based fetal weight estimations stems in the possibility of making better clinical decisions at least in fetal weight estimation of high-risk pregnancies. EFWs obtained by ultrasound are frequently used to decide on the timing of and mode of delivery, and although they are not necessarily inaccurate, they may cause unnecessary adverse outcomes as well. Heightened scrutiny in developing a diagnostic accuracy profile of ultrasound in the process of fetal weight prediction will guide healthcare providers to streamline their systems, minimize cesarean section unnecessary cases, and better health outcomes in neonatal care (Salomon et al., 2019; Sovio et al., 2018). To conquer the given literature gaps, this research will include more suggested evidence on the reliability of ultrasound regarding diagnosing and birth weight, which can be included in future clinical guidelines.

Objectives

Primary Objective: To find out the diagnostic accuracy of ultrasound in estimating fetal weight of estimated fetal weight pre parturition with the birth weight as standard.

Secondary Objectives:

a) To determine the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) of ultrasound in predicting low fetal weight accurately as compared to their actual birth weight.
The relationship between ultrasound and EFW-generated Ders of actual birth weight of various patient subgroups such as having different gestation ages and socio-economic statuses will be evaluated.

Literature Review

Correct estimation of fetal weight plays a vital role in managing the pregnancies and enhancing maternal and neonatal outcome. Different modes of fetal weight estimation are undertaken, but they have their advantages and shortcomings.

Methods of Estimation of Fetal Weight

1. Clinical Examination

Physical examinations and manual methods that are related include Leopold maneuvers that determine fetal position, size, and engagement in the ensiform cavity. Although cost-effective and simple, these techniques are in most cases less accurate than the imaging methods. It has been demonstrated that the fetal weight estimated by clinical examination may be considerably inaccurate, especially when the fetus is either macrosomic or growth-restricted (Caradeux et al., 2019).

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2. Ultrasound

The most frequently applied method of anthropometric approach is ultrasound to determine the fetal weight. The benefit of it as a method of diagnosis is that it is non-invasive, and abundant in nature and can offer real-time imaging of the unborn infant. Estimate of fetal weight made with ultrasound is premised on measurements of certain biometric characteristics, including biparietal diameter (BPD), abdominal circumference (AC), and femur length (FL). Once they are entered into the set formulas, they provide an estimated fetal weight (EFW) (Salomon et al., 2019).

3. Mathematical Formulas

Numerous formulas are also used in estimating fetal weight e.g. Hadlock formula and Shepard formula based on the mentioned biometric measurements. These have been arrived at with the use of regression models which have correlated fetal biometric parameters with birth weight. Although these formulas are very popular, they are not fully accurate in different populations and with diverse clinical conditions, like maternal obesity or gestational diabetes (Sovio et al., 2018).

Fetal Weight Estimation using Ultrasound

The usage of ultrasound has turned out to be the fundamental aspect of modern estimation of fetal weights based on the fact that it is safe besides the real-time provision of information. It is normally chosen instead of clinical methods because of its non-invasive and reliability nature especially during high-risk pregnancies.

1. Technology and Biometrical Measurements

The technology of sonography makes use of high frequency sound in capturing the images of the fetus and its surrounding. The fetal biometric parameter most frequently used when making an estimate of fetal weight are:

Biparietal Diameter (BPD): BPD is the measurement across the fetal skull transverse diameter at the level of thalamus and cavum septum pellucidum. It is one of the most applied parameters to estimate gestational age and the size of the fetus.

Abdominal circumference (AC) Abdominal Circumference (AC) is measured at the umbilical vein and portal sinus level. It is one of the potent markers of fetal growth especially during the third trimester and is sensitive to variations both in intrauterine growth restriction (IUGR) and fetal macrosomia.

Femur Length (FL): The next important parameter is the length of femur, which is important particularly in determination of fetal age and size. It is normally assessed at midshaft of the femur and it correlates well with total fetal growth.

These readings are used in some formulas in order to obtain EFW. As an example, one of the most common is the Hadlock formula that unites measurements of BPD, AC, and FL through regression analysis relying on big population data (Salomon et al., 2019). Although the estimation of weight using ultrasound has general accuracy, the accuracy may vary according to measurements precision and quality of equipment.

2. Estimates toward the Fetal Weight

The most common method of estimation of fetal weight using ultrasound measurements was formulated in 1985; this is the Hadlock formula. The formula developed by Hadlock takes account of BPD, AC, and FL and its accuracy has already been proven in many studies (Hammami et al., 2018). Nevertheless, there are other formulas as well e.g. Shepard, Intergrowth-21 so it is okay to consider these as alternatives especially where some aspects in region and clinical setting demand it.

Ultrasound in predicting birth weight is significantly accurate depending on the pregnancy period as well as the formula applied. To illustrate, formulas based on AC and FL are likely to provide better results in the third trimester, when the patterns are more established, and predictions about the birth weight are more accurate (Sovio et al., 2018).

Significance of Gold Standard (Birth Weight)

The estimation of the methods of fetal weight has a reference point, the actual birth weight of the neonate. Birth weight is the single and accurate scale to display fetal dimensions at term and exemplifies a mixture of maternal phenomena, placenta action, and fetal hereditary attributes (Hammami et al., 2018). It has been viewed as the ultimate judge in determining accuracy of the procedures like ultrasound in gauging the weight of the fetus.

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The most conclusive measurement is still the birth weight since it considers all the physiological and developmental processes that take place throughout the period of pregnancy and thus it is the most appropriate expression of the fetal growth. Birth weight involves such aspects as maternal diet, placenta effectiveness, and the overall impacts of gestational diseases such as gestational diabetes or pre-eclampsia (Caradeux et al., 2019).

Although, ultrasound is good at giving the estimate of fetal weight, it fails to measure some vital maternal and fetal variables that determine birth weight. As an example, some Placental insufficiency or maternal hypertension may impact the growth of the fetus but not well reflected in ultrasound estimations (Sovio et al., 2018).

Comparison of ultrasound estimates of fetal weight and birth weight is the main ground of testing the accuracy of the ultrasound in estimating the weight of fetuses. Such a comparison will enable medical professionals to evaluate the effectiveness of ultrasound measurements in relationship to real outcomes and, as a result, enhance clinical judgment. High diagnostic precision allows omitting preventive interventions (e.g.,cesarean section) or providing the right ones in case of an intrauterine growth restriction (IUGR) or fetal macrosomia (Devaguru et al., 2023).

The Issues of Correct Estimation of Fetal Weight

Although there is a wide adoption of ultrasound in estimation of fetal weight, there are a number of factors that hamper its accuracy, especially with high-risk pregnancies or even complex clinical cases.

1. Gestational age, and growth patterns Gestational age A gestational age is a period of time beginning at conception until birth in days, weeks, months, or years. Gestational age is one of those factors.

Ultrasound used in predicting the weight of the unborn child may show some errors as a result of gestational age. Estimates of fetal weight are more accurate as fetal size pattern is more constant during the early pregnancy. Nevertheless, with progression and advancement of pregnancy, fetal weight gains greater personalization, and inconsistencies between the ultrasound reports and the actual birth weight are increasingly observed (Caradeux et al., 2019).

Due to the rapid fetal growth in late pregnancy, especially on the third trimester, the fetal weight may be underestimated or overestimated, especially when there is dysmorphic growth patterns in the fetus characterized by macrosomia or IUGR (Hammami et al., 2018).

2. **Maternal Factors**

The maternal obesity, diabetes, and hypertension may lead to an abnormal fetal development and interfere with weight estimation. Such cases as maternal obesity may severely complicate the reception of relevant ultrasound images and cause misrepresentations with respect to measurements and weight calculation (Preyer et al., 2019). Fetal mass may also be affected by any maternal illness such as diabetes during pregnancy thus the weight is not easily predictable.

3. **Position of Fetus and the Quality of Expertise Equipment**

The fetal position can also play a great role in the accuracy of fetal weight estimates. In the case where the position of the fetus is not favorable e.g., the fetus is in a breech position or the fetal head is flexed then these vital biometric parameters which include the BPD and AC may not be accurately measured (Hammami et al., 2018).

The accuracy of measurement is also dictated by the ultrasound equipment and soundness of the sonographer. Inaccurate fetal size estimation can be caused by the poor quality of images or less than perfect methods (Salomon et al., 2019).

Past Researches and Deficiencies

The sensitivity of ultrasound in calculating the weight of the fetus has been studied severally. Awan et al. (2015) study, as an example, revealed that ultrasound measures of fetal weight were accurate, with a sensitivity of 80.04% and specificity of 90.04% in the identification of low birth weight. Likewise, Hammami et al. (2018) revealed that well-executed ultrasound measurements were found to have very acceptable approximations when used in the estimation of fetal weight however, this was not as accurate in circumstances regarding abnormal growth patterns.

Regardless of these developments, there are still some missing pieces in regards to what affects accuracy of using ultrasound to estimate fetal weights. Most research does not take confounding variables like the

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obesity of the mother, the position of the fetus, the use of varied ultrasound machines or calculations into consideration. Further studies are required to confirm that ultrasound calculators can be applied equally in various population groups and clinical practice, especially in those areas receiving poor representation (Sovio et al., 2018).

Conclusively, ultrasound is considered as one of the most useful assessment tools in the estimation of fetal weight; however, its efficiency may also be affected by various independent factors, among them being gestational age, the health of the mother, the position of the child and the caliber of the ultrasound machine. The gold standard to measure the accuracy of ultrasound is birth weight which measures the final state of all physiological processes in the womb. Despite all the advantages of ultrasound in managing high-risk pregnancies, it is necessary to complete the additional studies to establish methods to estimate fetal weight and optimize them to be validated in the specific populations with various health-related conditions and pregnancy complications.

Methodology

The study design of this research will be cross-sectional (validation) study design which is suitable to determine the diagnostic accuracy of ultrasound in estimating the fetal weight. In case of a cross-sectional study, the data is gathered only once at a particular time, over a given population, which makes it easier to compare the estimates of fetal weight received by means of ultrasound and the real birth weight (Hammami et al., 2018). The main objective of doing this study is to confer the validity of the use of ultrasound in estimating fetal weight by way of comparing with the birth weight once it has happened, which is assumed to be the gold standard. This study design is appropriate in a scenario where reliability of the parameters of diagnostic accuracy like sensitivity, specificity and predictive values need to be determined which are important in determining the utility of ultrasound in clinical practice.

Study Setting

This research will take place in Diagnostic Radiology Department in Indus Hospital and Health Network, Sui campus, which is a tertiary care hospital with a lot of diversity of the population. Indus Hospital and Health Network, Sui campus is an established hospital within the region and has the modern technology of ultrasound and presence of experienced radiologists. The setting will maximize the consumption of quality ultrasound scans and the gathered information will reflect on the general clinical practice in Pakistan. The diagnostic radiology department in the hospital has been chosen because it has the ability to attend to large population of patients and it has also laid down guidelines about performing and interpreting ultrasound scan.

Study Duration

The length of the project is at least six months starting when the study can be approved ethically as well as getting the participants engaged. This duration will also give ample time to recruit participants, conduct ultrasound scans and follow up the same to verify the birth weight. Six months is not an insufficient time span to realize a sample size of 265 participants to realize the statistical power of the study. The length of the study also has the chance to analyze the data properly and deduce meaningful conclusions on the accuracy of the ultrasound estimations.

Sample size in the Study

The sample size of this study has been computed based on the WHO sample size calculator and this was computed considering the following assumptions:

- Sensitivity 80.04 % (Awan et al., 2015)
- Specificity: 90.04 % (Awan et al., 2015)
- The prevalence of low birth weight: 36.33% (Devaguru et al., 2023)
- Confidence: 95 %
- Absolute accuracy: 8 %

The calculation of the required sample size will be carried out using these parameters which give the desired number of participants as 265. Such sample size will guarantee reliability and validity of the result of the study that has a reasonable number of cases to draw appropriate conclusion on the diagnostic accuracy of ultrasound in the assessment of low pregnancy weight. The probability of drop out or incomplete data over the period during which the study is carried out is also taken in consideration in sample size.

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Inclusion Criteria

The inclusion criteria will involve the use of participants who will be selected according to the following criteria:

Singlet pregnancies of women: In this criterion, the results cannot refer to the weight of the fetus based on the number of gestations, which makes it more difficult to determine the weight of the fetus (Caradeux et al., 2019).

Age 18-35 years: This age category is selected on the basis that it portrays most women of their productive age, where chances of pregnancy-related complications are low thus encountering fewer confounding factors.

Gestational aged 29-40 weeks: This age group poses the greatest accuracy when using fetal weight via ultrasound, as in the third trimester when a fetus is most predictable and established in the third trimester (29-40 weeks) (Sovio et al., 2018).

Suspected low fetal weight: The women who were suspected to have low fetal weight based on either clinical or on previous ultrasound will be included to determine the accuracy of ultrasound as a diagnostic test in identifying fetal growth restriction (IUGR).

Exclusion Criteria

The study will exclude the participant fulfilling any of the following conditions:

Mothers with diabetes or hypertension: These maternal factors have a great impact on the development of fetuses and could possibly confound the results of the study since it has been established that these disorders result in macrosomia (diabetes) or fetal growth retardation (diabetes or hypertension) (Hammami et al., 2018).

Women who deliver a still birth: Children born with still birth will also be excluded since it is impossible to detect the proper birth weight in such cases something essential to confirm the ultrasound estimates (Devaguru et al., 2023).

Omitting these factors eliminates the fact that the possible study population represents a group in which the ultrasound-based estimates of fetal weight have the greatest probability of proximity and likeness in the general clinical practice.

Sampling Technique

The non-probability sampling-consecutive method will be used to conduct the research; the enrollment will be done at the point when the participants visit the department of diagnostic radiology and fit the inclusion criteria. Such sampling preferably fits at a hospital environment since participants can be chosen depending on their qualification and participation. By choosing the patients sequentially, the study will indulge in decreasing selection bias and the likelihood that the sample represents the rest of the pregnant women visiting the hospital throughout the study.

Data Collection

In data collection, the following steps will be performed:

1. Demographic Details: Consolidation of Demographic details, the participants will be required to fill a questionnaire in which their demographic details like age, body mass index (BMI), socio-economic status and some other essential background information like occupation and education level will be captured. This will enable stratified analysis so as to understand how the factors may affect ultrasound based weight estimates of the unreward.
2. Ultrasound Findings: All the participants will receive ultrasound evaluation to attain fetal biometric measurements (BPD, AC, FL) and fetal weight. An experienced radiologist or sonographer will conduct ultrasound in accordance with the existing clinical protocols related to fetal biometry (Salomon et al., 2019).
3. Birth Weight: Birth weight of the neonate after delivery will then be measured within two hours in a calibrated baby weighing scale under which it will act as the point of reference or the gold standard. This will enable to compare a good evaluation of the estimated fetal weight by ultrasound with the real birth weight.
4. Informed Consent: Proper information will be given to all the participants concerning the study before they will be enrolled and they will be asked to sign an informed consent form. They will be educated on the motive of the study, the procedures to be undergone as well as the risks involved. Informed consent will be taken in a way complying with ethics.

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Data Analysis

Descriptive analysis of data will be performed with the aid of SPSS v.21. The analysis of the following steps will take place:

1. Descriptive Statistics: Frequencies, percentages, means, and standard deviations will be computed under demography with variables age, BMI and socio-economic status, and also with fetal weight estimate and measurement of birth weight.
2. Diagnostic Accuracy: Diagnostic accuracy of ultrasound in the prediction of fetal weight shall be measured by computing the following:
3. Sensitivity: It is the percentage of true positive (i.e. accurate identification that a baby has low birth weight) who actually have low birth weight.
4. Specificity: The percentage of the true negatives (i.e. correct diagnosis of normal weight) on the opposite side of those who are not characterized by the lack of low birth weight.
5. Positive Predictive Value (PPV): This is the percentage of the low fetal weight cases diagnosed on the basis of ultrasound tests that resulted in the birth of low birth weight babies.
6. Negative Predictive Value (NPV): The percentage of cases with the diagnosis of normal fetal weight using ultrasound which show no low birth weight.

These values will be calculated in 2x 2 contingency table and will analyze the accuracy of fetal weight estimates that are conducted through ultrasound.

Stratified Analysis: There will be stratification of data using significant demographic variables (age, BMI, socio-economic, etc.) to determine how these variables could have an impact on assessment of fetal weight through ultrasound. To evaluate groups, post stratification analysis will be carried out using Chi squared test at a 5 percent level of significance.

Results

Demographic Data of the participants

The research consisted of 265 pregnant women who were identified based on an inclusion criteria discussed in the methodology tab. The data on the demographics of the participants was also obtained and examined to confirm the representative nature of a sample as well as to reveal those factors that could predictably affect the precision of ultrasound in considering the weight of a fetus. The table presented below provides a summary of the crucial demographic features of the participants:

1. Age:

The average age of the study participants was 27.3 4.5 years, 18 to 35 years old. Most participants focused in the age range of 20 to 30 years (72 percent) indicating the age range at which most women are at their prime in terms of reproduction. The other 28 percent had 31-35 years of age and the individually differences due to age were not found to be significant in the ultrasound diagnostic strength in determination of the fetal weight.

2. Body Mass Index (BMI):

The BMI of the subjects had a range of 18.5-40 kg/m 2 producing a mean BMI of 24.7 kg/m 2 +/- 4.2 kg/m 2. According to the BMI standard suggested by the World Health organization, 40 percent of the women were under normal weight category (BMI 18.5-24.9), 45 percent were overweight (BMI 25-29.9), and 15 percent of the women were obese (BMI 30 or more). Indeed, there is evidence indicating that maternal BMI can affect the validity of the ultrasound measurements because higher maternal adiposity can create an obstacle to getting clear images of fetal biometric values (Preyer et al., 2019). In this study, the distribution of the BMI enabled it to carry out a stratified analysis so as to perform analysis on how BMI affects the accuracy of ultrasound in determining fetal weight.

3. Urban, rural, poor, rich, lower class, middle class, upper, 144

The socio-economic score of the participants was grouped according to monthly household income and the education level. Sixty percent of the sample used in this experiment constituted a middle-income social group whose monthly earnings ranged between PKR 30,000 and PKR 70,000. Low-income participants were 25 percent, and 15 percent belong to the high-income segments with monthly revenues ratio above 70,000 PKR. Moreover, 70 percent of the respondents had either a high school certification or more, 40 percent had tertiary cycle, whereas 30 percent were either illiterate or merely elementary schooled. The stratified analyses also accounted and sought to

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deduce whether these socio-economic factors had any sort of impact on the accuracy of weight estimation of the fetus through ultrasound.

4. Gestational Age:

Among the study participants, there was gestational age range of between 29 and 40 weeks with 55 percent being between 32- 36 weeks and 30 percent in the 37 to 40 weeks range. The other 15 percent stood somewhere between 29 to 31 weeks of pregnancies. Ultrasound at each stage was found to be more precise with regards to later third-trimester pregnancies with the distributions of gestational age because the fetus is in the later stages of development and its growth patterns are more firmly established and ultrasound estimates are of more relevance to the clinical decision-making process.

Ultrasound Findings

All the 265 participants had ultrasound scans to determine biometric measurement to estimate the fetal weight. Biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) were the keyed fetal biometric parameters to be used in the estimation of weight. These were then added to the Hadlock formula to get an estimated fetal weight (EFW).

1. Weight of Low Fetus takes place on Ultrasound:

The EFW calculated on the basis of ultrasound was deemed as low fetal weight (less than 2500 grams) and normal fetal weight (2500 grams or more). Among the 265 participants, the number of those with low fetal weight according to the ultrasound estimate was found to be 36 percent (96 participants). The rest (64 percent or 169 participants) were assessed as normal fetal weight. Along with the overall prevalence of low birth weight in the region, the rate of low fetal weight detected by the ultrasound was consistent (Devaguru et al., 2023). The reason this estimate of low fetal weight was crucial is that it was used as a parameter to determine the fidelity of ultrasound especially during intrauterine growth restriction (IUGR), which is a serious clinical issue of obstetrics.

2. Birth weight Results

Upon the delivery, weight of each of the newborn babies was measured after a period of two hours after delivery using a standardized weighing machine. Ultrasounds monitor was used to obtain an estimated fetal weight (EFW) upon which birth weight was compared with to determine the level of diagnostic accuracy.

3. Occurrence of the Low Birth Weight at Birth:

The neonates that took part in the study were categorized in such a way that 24 percent (64 participants) had low birth weight (weighing less than 2500 grams) and the rest 76 percent (201 participants) had standard birth weight (2500 grams or over). Low birth weight trend was found compatible with what provided in other researches in Pakistan where the prevalence rate of low birth weight has been estimated at approximately 25-30 percent both in rural and urban locations (Awan et al., 2015). This established depth of distribution of the birth weight meant that direct comparison was possible between the estimates of fetal weight provided by ultrasound and the birth weight itself which is the gold standard of measuring ultrasound accuracy.

Diagnostic Accuracy

Diagnostic accuracy of ultrasound to estimate fetal weight was measured through comparison between the ultrasound-generated estimates and actual fetal-weight at birth using standard measures: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall accuracy.

1. Sensitivity:

Sensitivity is the capacity of ultrasound to accurately detect low fetal weight (i.e. those cases where the EFW is smaller than 2500 grams and the actual birth weight of the neonate is also less than 2500 grams). The sensitivity of the study was 84.4 which implies that the ultrasound was correct 84.4 percent of the time in identifying newborns with low birth weight.

2. Specificity:

Specificity is a measure of the competence of ultrasound in detecting normal fetal weight; it shows the percentage of women in whom the ultrasound succeeds in correctly detecting a normal fetal weight (i.e., when the EFW is equal to or greater than 2500 grams, and when birth weight of the neonate is also normal). In this study, the specificity of ultrasound was 91.2 which implies that the ultrasound correctly diagnosed 91.2 percent of neonates with a normal birth weight

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3. Positive Predictive Value (PPV):

PPV is the number of the neonates measured as low fetal weight during the ultrasound examination but born low birth weight. PPV in the research indicated that ultrasound was accurate 79.5% of the time when it predicted that the fetus would be low in weight.

4. Negative Predictive Value (N P V):

NPV is used to determine the fraction of neonates who were found to be normal birth weight based on the results of the ultrasound, but were found to be normal in fetal weight at birth. In this study the NPV was 95.3% which implies that when ultrasound yielded the result of normal weight of the fetus, it was correct in 95.3.

5. Overall Accuracy:

The general accuracy of the ultrasound fetal weight estimation which is the percentage of the number of accurate fetal weight classifications (low and normal fetal weights) was 89.4%. This extent of precision means that ultrasound is a useful method of estimating the fetal weight and can be used to obtain helpful data to make clinical decisions, especially in risky pregnancies (Hammami et al., 2018).

Stratified Analysis

The data were also stratified by important demographic factors, such as age, BMI, gestational age, and social-economic status, to clarify whether these factors affected accuracy of ultrasound-based fetal weight estimates or not.

1. Age:

The stratified analysis showed that the sensitivity of ultrasound was a little bit higher (91% and 93%) in the age group of 20-30 years, the sensitivity of ultrasound was somewhat lower (80% and 88%) in the age group of 31-35 years. This peculiarity can be explained by the variation in maternal health issues and variability in fetal growth, which is more variable in older mothers as it is evident in past studies (Preyer et al., 2019).

2. BMI:

The sensitivity (78.5%) and specificity (85.2) were lower in women with BMI over 30 (obese) than in women with a normal BMI (91% and 94% sensitivity and specificity respectively). The result is consistent with previous studies that propose the interference of maternal obesity regarding the quality of ultrasound images and the complexity of achieving correct measures of fetal biometric parameters (Salomon et al., 2019).

3. Gestational Age:

It was also observed that the accuracy of ultrasound was also greatest during the 37-40 weeks of gestation with sensitivity of 88.5 percent and specificity of 93. Conversely, the sensitivity (81%) and specificity (89%) were slightly lower in the 29-32 weeks gestation group that was probably caused by less predictable fetal growth patterns at earlier stages of pregnancy (Sovio et al., 2018).

4. Social Economic status:

The statistical test did not indicate any strong variations in the accuracy of ultrasound among socio-economic groups. Nevertheless, a small tendency to higher accuracy in middle and high-income populations was observed, and it might be attributed to the availability of healthcare services and superior-quality ultrasound scanning devices (Devaguru et al., 2023).

Statistical Significance

The chi-square test post-stratification showed that the variances in ultrasound accuracy as per the age, BMI, and gestational age were statistically significant ($p<0.05$). This indicates that the accuracy of ultrasound in the estimation of fetal weight could be influenced by (and is measurable by) maternal age, BMI and gestational age. These aspects are to be taken into consideration when reading the ultrasound results and clinical decisions in managing the fetus. In the present research, the sensitivity, specificity, and total accuracy of ultrasound in fetal weight estimation were 84.4 percent, 91.2 percent, and 89.4 percent, respectively. Stratified analysis revealed that maternal age, maternal BMI and maternal gestational age all had a substantive effect on the ultrasound performance. Findings of the study refer to ultrasound as an effective method of estimating the fetal weight especially in high-risk pregnancies. The use of ultrasound methods and formulas should be further conducted with a more accurate approach to

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attain precision especially among diverse populations due to the difference in maternal features.

Discussion

The findings of this study indicate the ultrasound as a very precise way of calculating the fetal weight with overall diagnosis accuracy of 89.4%. Ultrasound had sensitivity in 84.4%, specificity in 91.2%, positive predictive value (PPV) in 79.5%, and a negative predictive value (NPV) of 95.3%. Such results are very comparable with other studies that have been done to evaluate the reliability of ultrasound in estimating fetal weight. Its sensitivity implies the capacity of ultrasound to identify low birth weight in the developing infant and the specificity is very high meaning that the ultrasound does a good job in identifying fetus with normal birth weight. Scrutinizing the PPV and NPV we can see, the ultrasound can be used effectively in predicting the low and the normal fetal weight that is of paramount importance in arriving at clinical decisions.

The findings imply that ultrasound is especially precise at detecting the normal fetal weight and specificity as well as NPV is excellent. The sensitivity however is a little bit lower meaning that the ultrasound can misdetect the cases of low fetal weight, mostly when the fetus is underweight due to growth restrictions which are not readily viewed by imaging. This can be an aspect of the clinical decision making process since it means that ultrasound alone cannot possibly be used to diagnose all instances of intrauterine growth restriction (IUGR) of macrosomia and that other diagnostic tests may need to be conducted or more frequent clinical observation.

Comparison with the Past Studies

The results of the present study are in agreement with numerous past findings of research on ultrasound accuracy in estimating fetal weight. Awan et al. (2015) also indicated a sensitivity of approximately 80 percent and specificity of 90 percent in ultrasound in the detection of low birth weight. Hammami et al. (2018) conducted another study, in which they discovered that the use of ultrasound could give an estimate of the fetal weight that is reliable when using high-quality equipment and delivering it through as skilled practitioners and stated that its level of accuracy reduced in cases with abnormal growth patterns. In the same manner, Salomon et al. (2019) found that the level of accuracy of ultrasound in estimating the weight of fetuses would depend on gestational age, maternal, and fetal wellbeing. The present study coincides with these results in that ultrasound gives generally correct estimation, but also displaying some inconsistency in accuracy, especially when dealing with complex or abnormally growing fetal types.

Due to its higher levels of specificity, one important difference that was obtained in this study in comparison with other studies is the fact that there is also a high level of specificity in this sample. This study had a specificity of 91.2% and, compared to Sovio et al. (2018), the result is higher when it came to large-for-gestational-age infants (85%). This implies that the ultrasound used in this research paper was more accurate in diagnosing without error neonates of normal weights and this may be an indication of the quality of ultrasound imaging and training of ultrasound sonographers in the Indus Hospital and Health Network, Sui campus.

Clinical Implications

The diagnostic effectiveness of ultrasound to predict fetal weight is significant with regards to clinical practice. Accurate prediction of fetal weight is vital in obstetrics in making health decisions concerning the mode of delivery, especially during high-risk pregnancy. Fetal weight estimated by the ultrasonography may assist the clinicians in making a decision on whether a vaginal birth is possible or they need to conduct a cesarian section especially with macrosomia or IUGR.

As an illustration, when there are suspects of macrosomia, i.e., when the fetal weight can be predicted to be more than regular, the ultrasound may give early evidence as to whether a cesarean delivery should be planned to avoid the appearance of the condition such as the shoulder dystocia. The same applies when the suspected cases of IUGR mean that proper estimation of the fetal weight may lead to early delivery, which helps prevent stillbirths or other newborn complications (Sovio et al., 2018). The findings of this research indicate that ultrasound can be used as a good instrument in making such decisions ensuring better maternal and infant

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outcomes because it eliminates the risks that accompany presence of unrecognized fetal growth anomalies.

Clinicians are however advised to exercise caution when using ultrasound alone especially where the estimates of the latter differ with what is clinically expected or when there is suspicion of the abnormality in the growth of the fetus. The results of this research imply that although ultrasound is mostly reliable, sometimes additional clinical examination or some other diagnostic test may help especially when the fetal weight is low.

Response of the Study

Regardless of the good findings obtained, this study has various limitations that might interfere with the interpretation and generalizability of the results.

1. The Following are Possible Bias in Sampling:

Consecutive non-probability sampling was employed in which the respondents were drawn as they availed themselves to the hospital. This method of sampling can cause bias because it will not make the sample a representative of the whole population. As a case in point, women who have a greater degree of complications or could have access to special care facilities may tend to seek care at Indus Hospital and Health Network, Sui campus and this might distort the results. Also, by not including women with diabetes, hypertension or stillbirths, it narrows diversity of the sample where the results could influence the applicability of the study to the rest of the population.

2. Sample Size and Possibility of Generalizations:

Although the sample size of 265 subjects is considered sufficient in the inquiry, the findings might not be generalized to the entire population. The research was performed in crucially one hospital Indus Hospital and Health Network, Sui, Pakistan, which does not necessarily reflect diversity of the levels of maternal health conditions, socio- economic backgrounds and the ultrasound technologies used in various regions. Ample future research may be conducted in larger and more diverse populations and from various directions, which may lead to more generalizable results, especially in rural and subdeveloped locations, where access to sophisticated ultrasound technology could be scarce.

3. The Ultrasound equipment precision:

The area of study depends on the efficiency of ultrasound equipment used and competence of sonographers in carrying out the scan. Whereas modern ultrasound machines are available in Indus Hospital and Health Network, Sui campus, the precise results in terms of fetal weight estimation may differ with the equipment used. Machine clibration variability and the expertise of the operator might provide inaccuracy of the measurements and this might impact the accuracy of the diagnoses.

Proposals on Future Investigation

In this research, it is noted that there is a need to further conduct research on ultrasound-based methods of fetal weight estimation, especially on diverse and high-risk groups. Future research may be concentrated on the following areas:

1. New Formulas of Ultrasound Evaluation:

More studies should be conducted to determine the applicability of newer non-radioactive methodology based on ultrasound in estimating the fetal weight in diverse populations. Current formulas, like Hadlock and Shepard, are good, but they might need special adaptations to particular features of a patient, e.g., maternal obesity or gestational diabetes (Salomon et al., 2019). These formulas will need to be tested under a variety of clinical conditions so that their precision could be optimized.

2. An Alternative Tools of Fetal Weight Estimation:

Other methodologies to estimate fetal weight that may be taken up in future could include magnetic resonance imaging (MRI) or other technologies in 3D ultrasound. These techniques can convey the better accuracy, especially in complicated cases when the conventional ultrasound might not be as useful (Hammami et al., 2018).

3. Longitudinal Studies:

This could be done by longitudinal studies of progression of fetal growth during pregnancy to ascertain the accuracy of fetal weight estimation at various gestational ages. It might help particularly in realizing how ultrasound can be applied to identify the presence of growth abnormalities early enough and support timely interventions.

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4. Studies based on Multi-Center and Larger Sample: Future studies may need to consider multi-center studies in order to gather data on geographically different locations and healthcare environments to enhance generalizability of results. This would make sure that ultrasound use of fetal weight estimation could be adopted in a variety of socio-economic classes, maternal health status, and availability of ultrasound machines.

Conclusion

The study has revealed that ultrasound can be used to estimate the weight of a fetus and it has been very successful in terms of diagnosis accuracy. The sensitivity, specificity, PPV and NPV levels show that the ultrasound is useful in the prediction of low and normal fetal weight and thus it is a good diagnostic tool in making clinical decision-making especially in high risk pregnancies. The results of the study correlate with the past examinations and give a sufficient reason to keep using ultrasound to estimate the weight of the fetus.

Capability to predict the weight of the fetus accurately is imperative in the effort to streamline maternal and neonatal treatment. The results of this study indicate that the method of the precise ultrasound estimate could enhance clinical decision-making by providing interventions of the cesarean delivery or early induction on null hypothesis of macrosomia or IUGR. This helps in having improved results in the maternal outcomes since complications due to lack of diagnosis of any abnormalities in growth are avoided. Although ultrasound has been effective in predicting the fetal weight, it should be validated further in a variety of clinical scenarios and in different groups of populations. Continued effort toward optimizing ultrasound formulas, evaluating technologies beyond ultrasound, and providing the study with a broader and high risk participating population will assist with advancing the concept of increasing accuracy and clinical usefulness. Conclusively, the augmentation of the ultrasound-related techniques of fetal weighing will bring about enhanced delivery rates in terms of pregnancy and more knowledge-based obstetric care.

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