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A prospective cross-sectional study for prediction of fetal macrosomia using sonographic measurement of placental thickness and umbilical cord cross-section area

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Abstract

Background: Macrosomia is an obstetric problem with maternal and neonatal adverse outcomes that are associated with a high rate of perinatal morbidity and mortality. The aim is to assess the accuracy of predicting fetal macrosomia by measuring the cross-sectional area of the umbilical cord and the central placental thickness at cord insertion by ultrasound.

Design: A prospective cross-sectional study was performed at Banha University Hospital among 60 patients coming into labor from January to June 2024.

Method: Trans-Abdominal Sonography was done to measure fetal biparietal diameter, femur length, abdominal circumference, the central placental thickness (PT) at cord insertion in mm, mean umbilical cord cross-sectional area (UCA), and ultrasonically estimated fetal weight. Mode of delivery, use of instrumentation, actual fetal weight, shoulder dystocia, Apgar scoring, and neonatal outcome were recorded.

Results: The incidence of macrosomic babies was 13.3%. There was a high statistical difference between (the macrocosmic group and the average group) regarding PT and UCA in favor of the macrosomic group (P<0.001). The ROC curves for PT for the prediction of macrosomia indicate that the best cutoff value for PT was 46 mm (at which Sensitivity was 87.5%, Specificity 88.5%, Positive predictive value (PPV) 53.8%, Negative predictive value (NPV) 97.9% and Accuracy 88.3%). The area under the curve was 0.91 [95%CI. (0.88-0.96)]. ROC curves for UCA for prediction of macrosomia indicate that the best cutoff value for UCA was 2.40 cm2 (at which Sensitivity was 87.5%, Specificity 78.8%, Positive predictive value (PPV) 38.9%, Negative predictive value (NPV) 97.6% and Accuracy 80%). The area under the curve was 0.89 [95%CI. (0.86-0.94)].

Conclusion: The sonographic measurement of placental thickness and umbilical cord cross-section area are good predictors for macrosomia.

Keywords: Placental thickness, umbilical cord, cross-section area, macrosomia

Introduction

Macrosomia, characterized by excessive fetal growth, is clinically defined as birth weight greater than the 90th percentile or exceeding two standard deviations for the gestational age, typically exceeding 4000 grams. This condition predisposes the fetus to a range of potential complications, including but not limited to premature birth, shoulder dystocia, obstructed labor, brachial plexus injury, skeletal injuries, neonatal hypoglycemia, meconium aspiration syndrome, and neonatal jaundice. Mothers carrying macrosomic fetuses are susceptible to various complications during childbirth, including the need for operative delivery, third and fourth-degree perineal lacerations, postpartum infection, and bleeding[1,2].

In the traditional approach, fetal weight estimation relies on biometric parameters, the most common being bi-parietal diameter (BPD), abdominal circumference (AC), and femur length (FL). Additionally, ultrasound-based methods have been utilized to predict birth weight, incorporating techniques such as assessing fat thickness at various locations. However, these ultrasound-based methods are less reliable than conventional biometric measurements[3].

The umbilical cord is a crucial link between the placenta and the developing fetus, providing valuable insights into the fetus's growth and development. Its thickness indicates the quantity of Wharton's jelly (WJ) within the cord. Wharton's jelly, a mucous connective tissue abundant in proteoglycans, safeguards and insulates the cord. Previous research has demonstrated a relationship between umbilical cord thickness and birth weight, highlighting its significance in prenatal health assessment[4-6].

Placental growth significantly determines birth weight, abdominal circumference, head circumference, femur length, and biparietal diameter between the 17-20 weeks gestational age range[7]. Numerous research studies have delved into various aspects of placental growth, including its volume, weight, and surface area. *Clamp et al's* study yielded noteworthy findings, showing a strong link between placental growth in the second trimester and birth weight[8].

The aim is to assess the accuracy of predicting fetal macrosomia by measuring the cross-sectional area of the umbilical cord and the central placental thickness at cord insertion using ultrasound.

Patients and methods

The study was conducted between January and June 2024 at Banha University Hospital. This cross-sectional study enrolled 60 pregnant women at term who were admitted to the delivery ward planned for delivery either vaginally or by C.S. The protocol of the study was approved by the Department of Obstetrics and Gynecology in January 2024 and then gained the approval of the faculty of medicine Research Ethical committee (REC) of Banha University RC952024.

Patient Population: All patients were selected from the group of women who fulfilled the following criteria: Any Parity, Gestational age 37-41 weeks (term pregnancies). Patients who met the inclusion criteria and were diabetic were not excluded from the study. Patients were excluded if they had multiple pregnancies, Polyhydramnios, a history of immune or non-immune hydrops, placental mass or anomaly, maternal diseases like liver disease or thromboembolism, hemolytic disorders, cardiopulmonary dis-

Table 1. Demographic data, ultrasonographic findings and neonatal outcome.

Variable	Mean ± SD	Range
Age (Years)	28.69±5.58	16 – 42
Gestational Age (Weeks)	39.75±1.29	37 – 42
Parity	1.64±1.51	0 – 7
BPD (mm)	94.26±3.36	79 – 102
AC (mm)	341.36±20.60	282 – 414
FL (mm)	77.12±3.40	66-91
Ultrasonic estimated fetal weight (g)	3539.79±226.70	2088 – 4327
Placental thickness (mm)	49.73±2.69	43 – 64
Umbilical cord cross-sectional area (cm^2)	3.16±0.38	2.3 – 4.0
Actual Neonatal Birth weight (g)	3425.93±442.75	2100 – 4700
APGAR(1-min)	7.27±0.70	6– 8
APGAR(5-min)	8.81±0.61	7– 9

eases, severe preeclampsia, IUGR, and hypertension.

Procedure

All participants gave informed consent before the beginning of the study and ultrasonographic examination. Gestational age was calculated from the first day of the last menstrual period (LMP) and confirmed by first-trimester ultrasound (US). The first-trimester ultrasound measurements were used in cases with discrepancies between LMP and US. Clinical assessment of fetal size: by abdominal examination, Leopold's grips are used to assess the fetal size, presentation, and lie.

All included women underwent trans-abdominal ultrasound to measure fetal biparietal diameter, femur length, abdominal circumference, central placental thickness at cord insertion in (mm), mean umbilical cord cross-sectional area, and ultrasonically estimated fetal weight. The Hadlock formula assessed fetal weight using BPD, FL, and AC.

All ultrasonography examinations were done by a single observer (to abolish the interobserver bias)

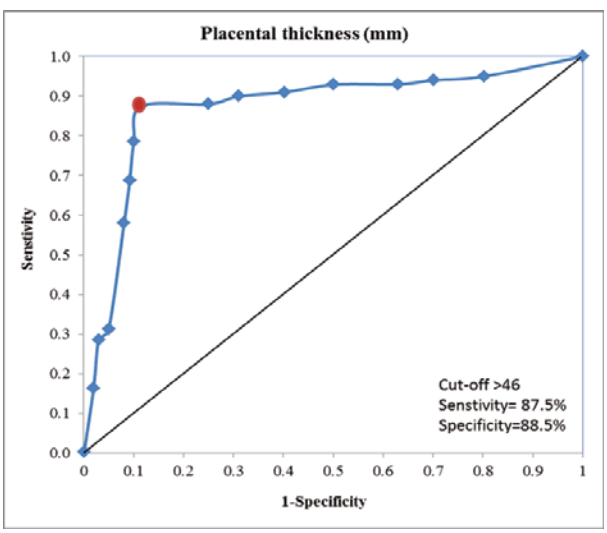

Figure 1. ROC Curve for PT in Prediction of Macrosomia.

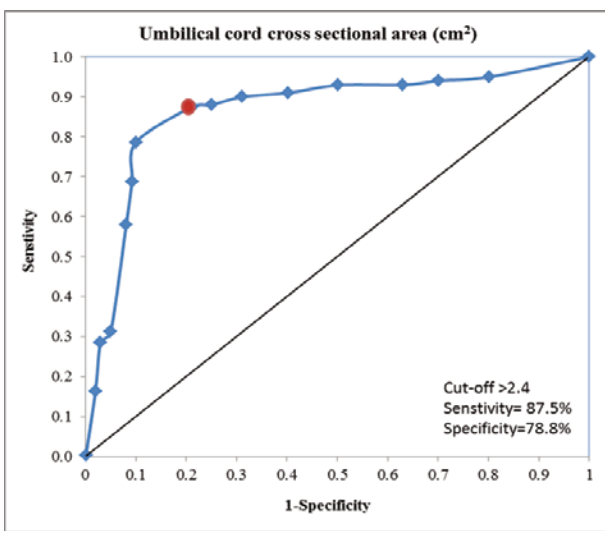

Figure 2. ROC Curve for UCA in Prediction of Macrosomia.

Table 2. Groups comparison according to placental thickness and umbilical cord.

		Group A Macrosomic group	Group B non-macrosomic group	p-value
Placental thickness (mm)	Range	43 – 64	31 – 47	<0.001
	Mean±SD	49.67±2.69	38.97±4.50	
Umbilical cord cross-sectional area (cm^2)	Range			
	Mean±SD	2.3 – 4.0	1.0–3.0	<0.001
		3.61±0.38	2.10±0.31	

Using: Independent Sample t-test; p-value <0.001

blinded to clinical features of women under study, with a standard Voluson 730 pro V; GE Medical Systems, USA (2D abdominal transducer probe, using the frequency of 4-8 MHZ) After positioning the probe on the abdomen, we digitally took sonographic measurements by marking the outer edges of the umbilical cord, noting the length in centimeters to the smallest millimeter. For the cross-sectional area (CSA), we encircled the outer edge of the same cord loop in a transverse section and recorded the value given by the software in square centimeters. The placental thickness was measured longitudinally from the lateral chorionic plate to the umbilical cord insertion with an accuracy of 1 mm at the level of umbilical cord insertion. The insertion of the umbilical cord was verified utilizing the color Doppler of the umbilical artery.

Primary outcomes: The primary outcome of the current study was the possibility of prediction of macrosomia using the fetal placental thickness (PT) at cord insertion and cross-sectional area of the umbilical cord (CSA)

Secondary outcomes include mode of delivery, use of instrumentation, actual fetal weight, shoulder dystocia, Apgar scoring, and the neonatal outcome of admission to the incubator or need for NICU.

Sample Size Justification

This study, based on the study carried out by *Mittal et al.*, 2022, Epi Info STATCALC, was used to calculate the sample size by considering the following assumptions: 95% two-sided confidence level, with a power of 80% & α error of 5%. The final maximum sample size from the Epi-Info output was 50. Thus, the sample size was increased to 60 patients to assume any dropout cases.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20 (SPSS Inc., Chicago, Illinois, USA). The comparison between two groups regarding quantitative data with parametric distribution was done by using an independent t-test, and Receiver operating characteristic curve (ROC) was used to assess the best cut-off point with its sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and area under the curve (AUC). The confidence interval was 95%, and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following (p<0.05, Significant).

Results

Table 1 shows the Mean ± SD and range of demographic data, ultrasonographic findings, and neonatal outcome.

Among the 60 women included in this study, 40 (66.7%) delivered by CS, 19 (31.7%) delivered vaginally delivery and 1 (1.7%) delivered by forceps-assisted vaginal delivery.

Among 60 pregnant women, 41 (68.3%) were in labor, and 19 (31.7%) were not in labor, 21 (51.2%)

Table 3. Multiple linear regression model for prediction of the macrosomic among studied patients.

	β	±SE	t	Sig.
(Constant)	179.332	54.410	4.343	<0.001**
Placental thickness (mm)	10.134	1.531	2.346	0.018*
Umbilical cord cross-sectional area (cm^2)	14.253	2.453	2.195	0.026*

of those who were in labor delivered by CS. In comparison, 20 (48.8%) of them delivered vaginally (19 women delivered normally and one delivered forceps-assisted vaginal delivery).

The macrosomia was 13.3% in this study (8 neonates); 7/8 (87.5%) of the newborns weighed ≥ 4000 gm and < 4500 gm, and 1/8 (12.5%) of the newborns weighed ≥4500 gm. Of the 60 women in this study, there are 3/60 (5%) were neonates of diabetic mothers where, two of them were macrosomic newborns, and one newborn had an average birth weight.

Among eight macrosomic neonates, 6 (75%) women were delivered by CS, 1 (12.5%) was delivered vaginally, and 1 (12.5%) was delivered by forceps-assisted vaginal delivery; none of the included women developed shoulder dystocia.

Table (2) compares two groups according to placental thickness and umbilical cord cross-sectional area (cm^2).

Table 2 compares the placental thickness at cord insertion and ultrasound-estimated fetal weight between women who delivered macrosomic fetuses and those who delivered non-macrosomic fetuses. We found statistically significant differences between both groups, with higher values in the macrosomic group. Similarly, we compared the umbilical cord cross-sectional area and ultrasound-estimated fetal weight between women who delivered macrosomic fetuses and those who delivered average-weight fetuses. We found statistically significant differences between both groups, with higher values in the macrosomic group.

We compared the neonatal outcomes (NICU admission) between women who delivered macrosomic fetuses and those who delivered average-weight fetuses. Out of the macrosomic neonates, 1 (12.5%) needed NICU admission for at least 12 hours and not more than two days, and out of the average-weight neonates, 2 (25%) required NICU admission for the same duration. All neonates admitted to the NICU were there because of transient tachypnea of the newborn (TTN), and there were no statistically significant differences between both groups. (Data not tabulated).

In our study, we found that a placental thickness of 46 mm or more had the best sensitivity (87.5%), specificity (88.5%), and accuracy (88.3%). Additionally, an umbilical cord area of 2.4 cm2 or more had the best sensitivity (87.5%), specificity (78.8%), and accuracy (80%). This shows that placental thickness (PT) and umbilical cord area (UCA) are more sensitive parameters for predicting fetal macrosomia compared to other parameters (BPD, AC, and FL). PT is also more specific than BPD, AC, and FL, while UCA is more specific than BPD and FL but less specific than AC. Regarding accuracy, PT and UCA are more accurate than other parameters, except that UCA's accuracy is equal to that of AC for predicting fetal macrosomia (Figure 1,2)

This implies that when UCA is equal to or more than 2.4 cm2, the fetus should be diagnosed to be a macrosomic fetus and should be closely monitored carefully to eliminate the adverse outcomes of macrosomia of both maternal and fetal complications for the higher likelihood of failed progress of labor that may end into delivery by CS.

The association between placental thickness and birth weight was significant. We found that for each mm increase in placental weight, birth weight in-

creases by 17.70 g (SE=1.531, p=0.018). Similarly, there was a significant association between umbilical cord cross-sectional area and fetal birth weight. We found that for each cm2 increase in umbilical cord cross-sectional area, birth weight increases by 12.58 g (SE=2.453, p=0.026).

Discussion

The occurrence of fetal macrosomia and its associated risks for both the mother and the child have been increasing in recent years. Risks include prolonged labor, maternal trauma, postpartum hemorrhage, and shoulder dystocia. The risk of shoulder dystocia is 0.2% for all births and increases to 5% and 30% for babies with a birth weight of 4000–4500 g and over 4500 g, respectively.

Accurate prenatal weight estimation is crucial for choosing the best obstetric management. A history of macrosomia can impact future pregnancies, as women who previously delivered a macrosomic baby are 5-10 times more likely than those without such a history to deliver a large-for-gestational-age baby in subsequent pregnancies. Previous macrosomic baby delivery is a strong risk factor for high birthweight, influenced by genetic and environmental factors.

Macrosomic babies are at a higher risk of experiencing labor complications such as shoulder dystocia, birth trauma, and permanent injury. Therefore, accurately predicting birth weight is essential for making timely decisions and ensuring better management to avoid these complications. The umbilical cord and placenta remain easily accessible and assessable organs for predicting birth weight accurately in a shorter time than conventional biometry, which requires a longer time and a learning curve.

In this study, 60 women were examined by abdominal ultrasound, and an ultrasonographically estimated fetal weight was reported). Among the 60 cases met the inclusion criteria enrolled in the study. The macrosomia was 13.3% in this study (8 neonates); 7/8 (87.5%) of the newborns weighed ≥ 4000g and < 4500 gm, and 1/8 (12.5%) of the newborns weighed ≥4500 gm. Of the 60 women in this study, there are 3/60 (5%) were neonates of diabetic mothers where, two of them were macrosomic newborns, and one newborn had an average birth weight. Our study found that a placental thickness of 46 mm or more and an umbilical cord area of 2.4 cm2 or more were the most accurate predictors of fetal macrosomia, with high sensitivity and specificity. In sensitivity, specificity, and accuracy, these parameters outperformed others, such as BPD, AC, and FL.

Comparison of our Results to similar studies

Weissman and colleagues conducted the first study to establish reference measures for the umbilical cord and its components. Their research determined reference measures for the diameter of the cord, umbilical vein, and arteries. They found that the diameter of the cord increased with gestational age up to the 32nd week and remained constant until the end of the gestation period[9].

Raio and his team conducted the initial study to establish standard measures for the cross-sectional area of the umbilical cord. Their findings revealed a consistent increase up to the 32nd week of gestation, followed by a subsequent decrease. Additionally, they identified a strong correlation between the cross-sectional area of the umbilical cord and fetal anthropometric parameters[10.]

In the study conducted by *Pandey et al.* in 2022, 40 pregnant women with gestational diabetes (group I) were compared to 40 pregnant women without gestational diabetes or any other medical issues (group II). The study included two measurements of the umbilical cord: cord thickness and cross-section area. A cord parameter value (CT/CSA)

higher than the 90th centile indicated a large cord. The researchers calculated the predictive accuracy of these cord parameters in predicting macrosomia. They found that the cut-off for identifying large cords was 2.8 cm for CT and 3.56 cm^2 for CSA. Similar to their results, 70% of the study group had large cords. They also discovered that umbilical cord parameters detected via sonography were significantly larger in macrosomic fetuses compared to non-macrosomic fetuses. Macrosomia was observed in 17.5% of cases in the study group (in our study, it was 13.3%). The sensitivity, specificity, and positive and negative predictive values of cord parameters in predicting macrosomia were 57.1%, 96.9%, 80%, and 91.4% for CT, and 65.7%, 63.6%, 46.2%, and 87.5% for CSA, respectively[11].

In a study by *Cromi et al*. (2007) with 1026 patients, 5.2% of newborns had a birth weight exceeding 4000 g, and 2.1% weighed over 4500 g. Among pregnancies complicated by diabetes mellitus, 17.8% of neonates weighed over 4000 g, and 12.2% weighed 4500 g or more. An ultrasound examination found a large umbilical cord in 11.1% of fetuses. The presence of a large umbilical cord was much higher in macrosomic fetuses compared to non-macrosomic ones (54.7% vs. 8.7%). The sensitivity, specificity, and positive and negative predictive values of a sonographic large umbilical cord in predicting birth weight over 4000 g and over 4500 g were 54.7%, 91.3%, 25.4%, and 97.4%, respectively[6].

In a study by *Shinde et al*. in 2021, 116 pregnant women were examined. Placental thickness was measured by ultrasound at 24 and 36 weeks and categorized into three groups: Group A (normal placenta), Group B (thin placenta), and Group C (thick placenta), and then correlated with neonatal weight. During the 2nd and 3rd trimesters, most cases had normal placental thickness (Group A; 93.1% and 92.7%), followed by thin placenta (Group B; 5.2% and 7.3%) and thick placenta (Group C; 1.7% and 0), respectively. Two patients with thin placentas experienced neonatal death. The study found a significant positive correlation between birth weight and placental thickness (at 24 weeks; 0.516r, P< 0.00001, and at 36 weeks, 0.669r, P< 0.00001)[12].

In 2019, *Hamidi et al*. conducted a retrospective descriptive study analyzing 200 term, singleton pregnant women. They measured the maximal placental thickness in the sagittal plane from ultrasound images of the placenta obtained during the 18-21-week fetal anatomy screen. The study found that placental thickness positively correlates with neonatal birthweight [r=0.18, 95% CI=(0.05, 0.32)]-the mean placental thickness measured 34.2±9.7 mm. The strength of the correlation remained consistent when adjusting for gestational age (r=0.20) or excluding medical comorbidities (r=0.19)[13.]

Abu et al. 2009 conducted a cross-sectional prospective study on 645 normal pregnant women; they investigated the relationship between placental thickness and estimated fetal weight. They showed that the maximum placental thickness of 45.10 mm was recorded at 39 weeks of gestation, while the maximum estimated fetal weight was recorded at 41 weeks. It is possible that while the fetus continues to gain weight up to 41 weeks, there is a fall in placental increase in thickness at term[14].

Strengths and Limitations of our study

This study's strength lies in using a simple and easily measurable sonographic parameter to predict fetal macrosomia. This method requires minimal training compared to fetal biometry and is less time-consuming. Thus, it can be used as a predictor of macrosomia. Most studies only investigated umbilical cord cross-sections or placental thickness, not their combination.

Our study's limitation is that we did not include diabetic patients. Instead, we included normal pregnant women to predict macrosomia, as this problem

may be less predictable in low-risk populations. Additionally, the relatively small sample size limits the generalizability of the findings.

Recommendation for further studies

The predictive accuracy of sonographic cord cross-section and placental thickness can be tested by using them and conventional biometry to detect macrosomia. Thus, further studies can be planned along these lines.

Implications for clinical practice

The cord and placenta parameters can be used in routine third-trimester ultrasounds to predict macrosomia in healthy pregnancies. This and other factors can help identify potential issues early and prompt timely transfer from low-resourced hospitals to a specialized center for the best outcomes.

Conclusion

We concluded that placental thickness (PT) and umbilical cord area (UCA) are more sensitive parameters for predicting fetal macrosomia than other parameters (BPD, AC, and FL) when using a cutoff value of 46 mm for placental thickness and 2.4 cm^2 for umbilical cord cross-section area.

Authors contributions

All authors jointly contributed to the conception and design of the study.

Elgendy Hatem: Design of the study, helped in review of literature, revision of results and data analysis, writing the manuscript and submission to journal

Ahmed Tarek; design of the study , revision of review of literature and revision of manuscript

Moahmed Shahatt: registration of trial, obtaining ethical committee approval, reviewed the literature, sharing in collection of Data, patient recruitment

Moahmed Shahat: design of the study , revision of review of literature and revision of manuscript

Elgendy Hatem : Design of the study, helped in review of literature, revision of results and data analysis and contributed in writing the manuscript.

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Study registration

The study was registered in the Pan-African Clinical Trial

Disclosure of Interest

The authors declare no conflict of interest.

Ethics Approval

Ethics Approval and Informed Consent to Participate Following local regulations, the protocol gainedEthical and research approval from the Faculty of Medicine Banha University Research Ethical Committee.

RC952024. We Confirm that all methods were performed according to the relevant guidelines and regulations according to the Declaration of Helsinki.

Data Sharing

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

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Not applicable .

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