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ORIGINAL ARTICLE

The Relationship Between Placenta and Umbilical Cord Characteristics and Fetal Distress

Plasenta ve Umblikal Kord Özellikleri ile Fetal Distress Arasındaki İlişki

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ABSTRACT

Aim: In our study, we investigated the relationship between placental thickness and weight, umbilical cord diameter and length, and placental cord insertion site with fetal distress, and its effects on the baby's APGAR score and cord blood gas.
Materials and methods: In our study, the data of the patients who gave birth in our hospital, whose gestational patient was between 37+0- 41+6 weeks, and between the ages of 18-45 were recorded prospectively. 385 patients (196 patients fetal distress and 189 patients elective cesarean section) were included in the study. Demographic characteristics, placental thickness and weight, umbilical cord diameter and length, insertion site of the umbilical cord into the placenta, newborn gender, first- and fifth-minute. Apgar score, and umbilical cord blood gas values were recorded. All parameters were compared between both groups.
Results: When both groups were compared, Maternal age (29.13 ± 5.20 vs. 25.67 ± 5.27, p<.001) and body mass index (30.10 ± 4.20 vs. 27.15 ± 3.97, p<.001) were found statistically lower in Group I than Group II. Placental weight (515 [IQR, 430 – 582.5] vs. 610 [IQR, 520 – 710], p<.001) and thickness (2.42 ± 0.91 vs. 2.72 ± 0.91, p<.001) were found statistically lower in Group I than Group II. In Group I patients, umbilical cord length (24.02 ± 10.02 vs. 57.35 ± 13.95, p=.008) was found significantly shorter than Group II.
Conclusion: Young maternal age, low body mass index, short umbilical cord, low placental weight and thin placenta were positively correlated with fetal distress. More careful follow-up of pregnant women with these features in terms of fetal distress is important for better perinatal and neonatal outcomes.

Keywords: Fetal distress, placenta thickness, placenta weight, umbilical cord length, umbilical cord diameter.

ÖZ

Amaç: Çalışmamızda; plasenta kalınlığı ve ağırlığı, umblikal kord çapı ve uzunluğunun ve plasentanın kord insersiyo bölgesinin fetal distress ile ilişkisini ve bunun bebeğin doğum APGAR skoru ve kord kan gazı üzerindeki etkilerini araştırdık.
Gereç ve yöntem: Çalışmamızda hastanemizde doğum yapan, gestasyonel hastası 37+0- 41+6 hafta arasında olan, 18-45 yaş arasındaki hastaların verileri prospektif olarak kayıt altına alındı. Fetal distress nedeni ile sezaryen yapılan 200 hasta (Grup I) ve daha önce sezaryen ile doğum yapması nedeni ile elektif sezaryen planlanan 200 hasta (Grup II) olmak üzere toplam 400 hastanın verileri kayıt altına alındı, 15 hasta çalışma dışı bırakıldı, 385 hasta çalışmaya dahil edildi. Olguların demografik özellikleri, plasenta kalınlığı ve ağırlığı, umblikal kord çapı ve uzunluğu, umblikal kordun plasentaya insersiyo bölgesi, yenidoğanın cinsiyeti, birinci ve beşinci dakika Apgar skoru, ve umblikal kord kan gazı değerleri kaydedildi. Tüm parametreler her iki grup arasında karşılaştırıldı.
Bulgular: Her iki grup karşılaştırıldığında Grup I'deki anne yaşının (29.13 ± 5.20 vs. 25.67 ± 5.27, p<.001) ve body mass index (30.10 ± 4.20 vs. 27.15 ± 3.97, p<.001) değerinin Grup II' den istatistiksel olarak daha düşük olduğu saptandı. Hemoglobin (11.83 ± 1.27 vs. 12.16 ± 1.41, p=.019) ve white blood cell (10.17 ± 2.37 vs. 10.76 ± 2.57, p=.020) değerinin ise Grup I'de Grup II'den daha yüksek olduğu görüldü. Plasenta ağırlığının (515 [IQR, 430 – 582.5] vs. 610 [IQR, 520 – 710], p<.001) ve kalınlığının (2.42 ± 0.91 vs. 2.72 ± 0.91, p<.001) Grup I hastalarda Grup II hastalara göre daha düşük olduğu görüldü. Grup I hastalarda umblikal kord uzunluğunun (24.02 ± 10.02 vs. 57.35 ± 13.95, p=.008) Grup II'den anlamlı olarak kısa olduğu görüldü.
Sonuç: Genç anne yaşı, düşük body mass index, kısa umblikal kord, düşük plasental ağırlık ve ince plasentanın fetal distress ile pozitif korelasyon gösterdiği saptanmıştır. Bu özellikleri taşıyan gebelerin fetal distress açısından daha dikkatli takip edilmesi, daha iyi perinatal ve neonatal sonuçlar için önem taşımaktadır.

Anahtar kelimeler: Fetal distress, Plasenta kalınlığı, Plasenta ağırlığı, Umblikal kord uzunluğu, Umblikal kord çapı

Introduction

The placenta is the most important fetomaternal structure that provides circulatory, excretory, immunological and hormonal support of the fetus during the intrauterine period (1-3). While the placenta provides oxygen and nutritional support to the fetus, it also ensures the transfer of carbon dioxide and waste products produced by the fetus into the maternal circulation (4, 5). Examination of the morphology and functions of the placenta during the intrauterine and postnatal periods gives information about the health of the fetus (6). The placenta may be morphologically round, oval, circumvallate, bilobed, multilobed, stellate, or irregular. Round (93%) was the most common, followed by oval (7%) (6). In a term pregnant, the placenta was reported as weighing 500 g on average, with a diameter of 18.5 cm and a thickness of 2.3 cm (7).

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The umbilical cord is a vital spiral link that connects the fetus to the mother (8-10).

The umbilical cord may enter the placenta centrally, marginally, laterally, or velamentous. Central insertion was defined as the termination of the umbilical cord in the central point of the placental disc, in the region 2 cm inward from the marginal insertion placental disc margin, and in the region between the center and edge of the lateral insertion placental disc. Velamentous insertion is considered a termination anomaly and the umbilical cord terminates directly in the placental membranes (11).

The APGAR score is used as an easy and fast method to predict the condition of the baby during labor (12). Electronic fetal heart rate changes, umbilical artery blood pH, catecholamines in blood taken from the umbilical cord, vasopressin, lactate, arginine, fetal scalp blood samples, and evaluations are frequently used parameters in the evaluation of intrauterine fetal status and distress (13). Umbilical cord blood taken without breathing during birth is an objective indicator of fetal acid-base balance (14).

In our study, we aimed to evaluate the relationship between placental thickness and weight, umbilical cord length and diameter, insertion of the umbilical cord into the placenta and fetal distress. In addition, we evaluated the relationship between the baby's APGAR score and blood gas taken from the umbilical cord and these parameters.

Materials and Methods

This study included women who gave birth in our hospital between September 1, 2022, and April 1, 2023, had a gestational week of 37 weeks and above, had a singleton pregnancy, gave birth to a live baby, and gave consent to participate in the study, and did not have any additional disease. Patients with additional disease, congenital anomaly, multiple pregnancies, placental anomaly, intrauterine growth retardation, and gestational week less than 37 were excluded from the study. The sample size calculation was made by examining the international studies. Although the sample number was 384 with a 95% confidence interval and a 5% margin of error, as a result of the correlation analysis performed by considering all births in the region (less than 10,000 in total), the sample number was found as n=256. In order to evaluate the data of more patient groups, the number of samples increased to 400. 200 of these were determined as pregnant women who developed fetal distress (Group I), and 200 as pregnant women who gave birth by planned cesarean section (Group II). Four patients from Group I and 11 patients from Group II were excluded due to missing data.

In our study, the diagnosis of fetal distress was made according to the non-stress test (NST) evaluation. Absence of basal heart variability, presence of recurrent late or variable deceleration, bradycardia, and sinusoidal pattern in NST were accepted as fetal distress and these pregnant women underwent cesarean section. After draining the blood of the placenta separated from the uterus at birth, placenta shape (oval, round, etc.), placenta weight, placenta thickness, place of insertion of the cord into the placenta, umbilical cord length, umbilical cord diameter were measured and recorded.

The umbilical cord was cut in such a way that 5 cm remained in each baby. The remaining umbilical cord length was measured in centimeters with a tape measure and 5 cm was added to it. After draining the blood in the cord, the diameter of the cord was measured with a tape measure. The placenta was washed with saline solution after delivery, and the placenta weight was weighed in grams with the aid of a scale 20 minutes later. The shape of the placenta was recorded as round, oval, or irregular. The placenta was divided into three annular segments equidistant from the center to the marginal. Cord insertion from the outermost region was recorded as marginal, and cord insertion in the inner two rings was recorded as central. The placenta was cut along its thickest and longest diameter on a flat surface with a scalpel and the thickest part was measured with a tape measure and recorded.

Newborn, gender, APGAR score, and 1st and 5th-minute scores were evaluated. Cord blood gas was taken within two minutes after birth, ABL90 Flex 2010 model device of Radiometer brand blood gas was studied and pH level was recorded. At birth; maternal age, gravida/parity information, body mass index (BMI), gestational week, hemoglobin, and leukocyte values were recorded. No invasive procedures were performed on the maternal and newborn for this study. Laboratory tests are routine tests in our hospital.

This study was approved by the local ethical committee (2022/3878) and the procedures were according to the ethical standards of the responsible committee on human experimentation.

Statistical analysis

All statistical analysis was performed using R version 4.1.2 (The R Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org). To check the normality of the data, Shapiro-Wilk's normality test and Q-Q plots were used. Levene's test was also used to assess the homogeneity of the variances. Numerical variables presented as mean ± standard deviation, median with ranges (min – max) or median with quartiles (25th percentile – 75th percentile), as appropriate. Categorical variables were also described as count (n) and percentage (%). An independent samples t-test, Mann-Whitney U test, Welch's t-test and Pearson chi-square test were run to determine if there was a statistically significant difference or association between Group I and Group II according to the demographical and clinical characteristics of the patients. Besides, Pearson and Spearman's rho correlation coefficients were used to examine the relationship between umbilical cord length and placental weight, pregnancy maternal BMI, and placental thickness both all cases and in each group. Maternal age, pregnancy maternal BMI, WBC, HB, umbilical cord length, placenta thickness and placenta weight variables which were found statistically significant (p<.05). Univariate analysis was included in multiple logistic regression analysis to determine whether they were independent risk factors for fetal distress. Odds ratios were calculated with 95% confidence intervals. Then, receiver operating characteristic curves (ROC) analysis was performed to evaluate the diagnostic performance on fetal distress of placental thickness, placental weight and predictive model that was obtained in the multiple logistic regression model. The optimal cut-off values were determined using Youden index. To determine optimal cut-off values, sensitivity, specificity, negative and positive predictive values were calculated. A two-tailed p-value less than 5% was considered as statistically significant.

Results

Maternal and neonatal birth characteristics according to the study groups are given in Table 1. Compared with mothers of Group II, Mothers of Group I were younger (29.13 ± 5.20 vs. 25.67 ± 5.27, p<.001), had lower BMI (30.10 ± 4.20 vs. 27.15 ± 3.97, p<.001), and higher WBC (10.17 ± 2.37 vs. 10.76 ± 2.57, p=.020) and hemoglobin (11.83 ± 1.27 vs. 12.16 ± 1.41, p=.019) values. However, besides, the thrombocyte and HCT levels were similar between the groups (p=.884 and p=.123, respectively).

Among the 385 infants, 210 (54.5%) were males and 175 (45.5%) were females. Of the 196 infants with fetal distress, 116 (59.2%) were males and 80 (40.8%) females. The gender distribution of the groups was similar (p=.063). Group I had lower placental thickness (2.42 ± 0.91 vs. 2.72 ± 0.91, p<.001, Figure 1-A) and lower placental weight (515 [IQR, 430 – 582.5] vs. 610 [IQR, 520 – 710], p<.001, Figure 1-B) than Group II. In this study majority of the shape of the placenta was round in shape with a rare case of multi-lobed. Apgar scores at 1 and 5 minutes respectively ranged from 1–10 and 5–10 with a median of 9 and 10. No significant differences were found between Group I and Group II for Apgar score at 1 as well 5 minutes (p=.626 and p=.195, respectively).

Group I had significantly shorter umbilical cord length than Group II (24.02 ± 10.02 vs. 57.35 ± 13.95, p=.008, Figure 1-C). The median [IQR] umbilical cord thickness of Group II and Group I was 1.3 [IQR, 1 – 2] versus 1.4 [IQR, 1 – 2.5], respectively, and this difference was not statistically significant (p=.249, Figure 1-D). Moreover, the umbilical cord length was positively correlated with pregnancy maternal BMI (Pearson's r=0.126, p=.014, Figure 2-B) and placental weight (Spearman's rho=0.202, p<.001, Figure 2-A), but only umbilical cord length and placental weight were positively correlated in infant's fetal distress (Spearman's rho=0.159, p=.026, Figure 2-A). No significant relationship between umbilical cord length and placental thickness of both all cases and patients with and without fetal distress (Figure 2-C).

Table 1. Demographical and clinical characteristics of the study groups

	Group I (*n*=196)	Group II (*n*=189)	*p*-value
Maternal age (years), mean ± SD	25.67 ± 5.27	29.13 ± 5.20	<.001[1]
Pregnancy maternal BMI (kg/m^2), mean ± SD	27.15 ± 3.97	30.10 ± 4.20	<.001[1]
Gravidity, median (range)	1 (1 – 10)	3 (1 – 8)	<.001[2]
Parity, median (range)	0 (0 – 5)	2 (0 – 6)	<.001[2]
History of surgery, *n* (%)	0 (0)	170 (89.9)	<.001[3]
WBC, mean ± SD	10.76 ± 2.57	10.17 ± 2.37	.020[3]
HB, mean ± SD	12.16 ± 1.41	11.83 ± 1.27	.019[3]
Thrombocyte, median [IQR]	221 [182 – 268]	225 [189 – 264]	.884[2]
HCT, median [IQR]	37 [35 – 39]	36.7 [34.1 – 38.6]	.123[2]
Insertion, *n* (%)			.657[3]
Central	49 (25)	51 (27)	
Marginal	147 (75)	138 (73)	
Type of placenta, *n* (%)			.065[3]
Oval	41 (20.9)	56 (29.6)	
Multi-lobed	7 (3.6)	11 (5.8)	
Round	148 (75.5)	122 (64.6)	
Gender of infant, *n* (%)			.063[3]
Male	116 (59.2)	94 (49.7)	
Female	80 (40.8)	95 (50.3)	
Umbilical Cord length (cm), mean ± SD	24.02 ± 10.02	57.35 ± 13.95	.008[4]
Umbilical Cord thickness, median [IQR]	1.4 [1 – 2.5]	1.3 [1 – 2]	.249[2]
Placental thickness, mean ± SD	2.42 ± 0.91	2.72 ± 0.83	<.001[4]
Placental weight (g), median [IQR]	515 [430 – 582.5]	610 [520 – 710]	<.001[2]
Apgar score 1 minute, median (range)	9 (1 – 10)	8 (2 – 9)	.626[2]
Apgar score 5 minute, median (range)	10 (5 – 10)	9 (6 – 10)	.195[2]
PH, median [IQR]	7.33 [7.30 – 7.36]	7.34 [7.32 – 7.38]	<.001[2]

[1]Independent samples *t*-test; 2 Mann-Whitney *U* test; 3 Pearson chi-square test; 4 Welch's *t*-test

Table 2. Multiple logistic regression analysis result for factors associated with fetal distress

Independent factors	Adjusted OR (95% CI)	***p*-value**
Maternal age (years)	0.880 (0.839 – 0.923)	<.001
Pregnancy maternal BMI (kg/m^2)	0.856 (0.803 – 0.912)	<.001
HB	1.392 (1.150 – 1.684)	<.001
Placental thickness	0.653 (0.488 – 0.874)	.004
Placental weight (g)	0.994 (0.992 – 0.996)	<.001
Hosmer & Lemeshow χ^2=9.127, *p*=.332; Nagelkerke R^2=0.428; AUC (95% CI)=0.837 (0.796 – 0.872); Accuracy=76.4%; Sensitivity=78.1%; Specificity=74.6%		

Maternal age, pregnancy maternal BMI, WBC, HB, umbilical cord length, placenta thickness and placenta weight variables which were found statistically significant (p<.05) in univariate analysis (Table 1) were included in multiple logistic regression analysis (Table 2) to determine whether they were independent risk factors for fetal distress. The multiple logistic regression analysis showed that only maternal age, pregnancy maternal BMI, placental weight, hemoglobin and placental thickness were associated with fetal distress. Young mothers (OR:0.880, 95%CI: 0.839 – 0.923, p<.001), mothers with low gestational BMI (OR:0.856, 95%CI: 0.803 – 0.912, p<.001) and lower placental weight (OR:0.994, 95%CI: 0.992 – 0.996, p<.001), mothers with high hemoglobin levels (OR:1.392, 95%CI: 1.150 – 1.684, p<.001) and low placental thickness (OR:1.913, 95%CI: 1.472 – 2.486, p<.001) were more associated with Group I than Group II. Receiver operating characteristic curves (ROC) analysis was performed to evaluate the diagnostic performance on fetal distress of placental thickness, placental weight and predictive model that was obtained in the multiple logistic regression model (Figure 3). In ROC analyses 1.8 cm was determined as cut-off for placental thickness (AUC:0.589, 95% CI:0.538-0.639, p=.002; sensitivity:31.6%, specificity:86.2%, PPV:70.5%, NPV:54.9%) and 540 g was determined as cut-off for placental weight (AUC:0.740, 95% CI:0.693-0.783, p<.001; sensitivity:69.90%, specificity:69.84%, PPV:70.62%, NPV:69.11%). Besides, the predictive model (Table 3) predicted to fetal distress with a sensitivity of 78.1%, a specificity of 74.6% and an accuracy of 76.4% (AUC: 0.837, 95% CI: 0.796-0.872).

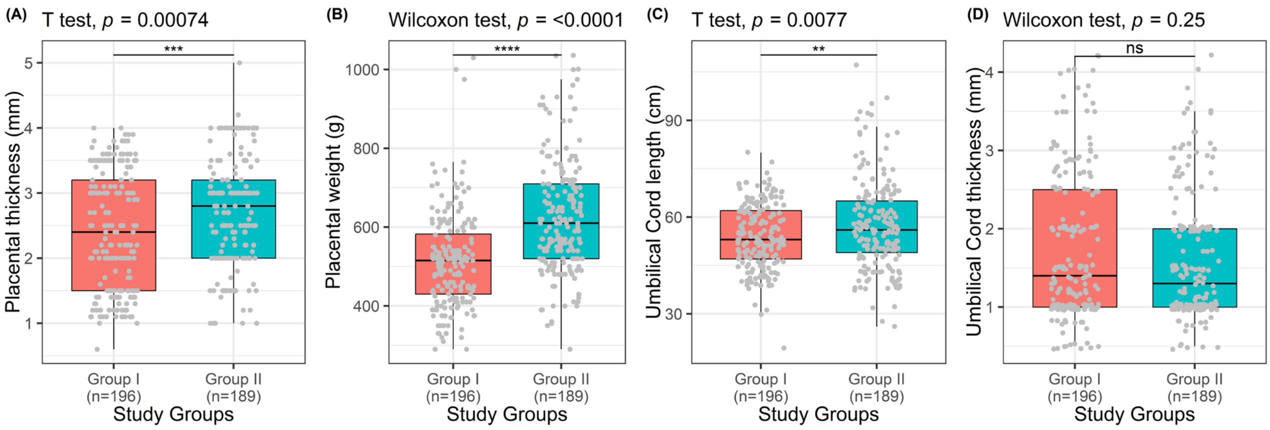

Figure 1. Comparison of (A) placental thickness, (B) placental weight, (C) umbilical cord length, (D) umbilical cord thickness between Group I and Group II. *p*-values calculated using independent samples t-test and Wilcoxon test (Un-paired Mann-Whitney *U* test)

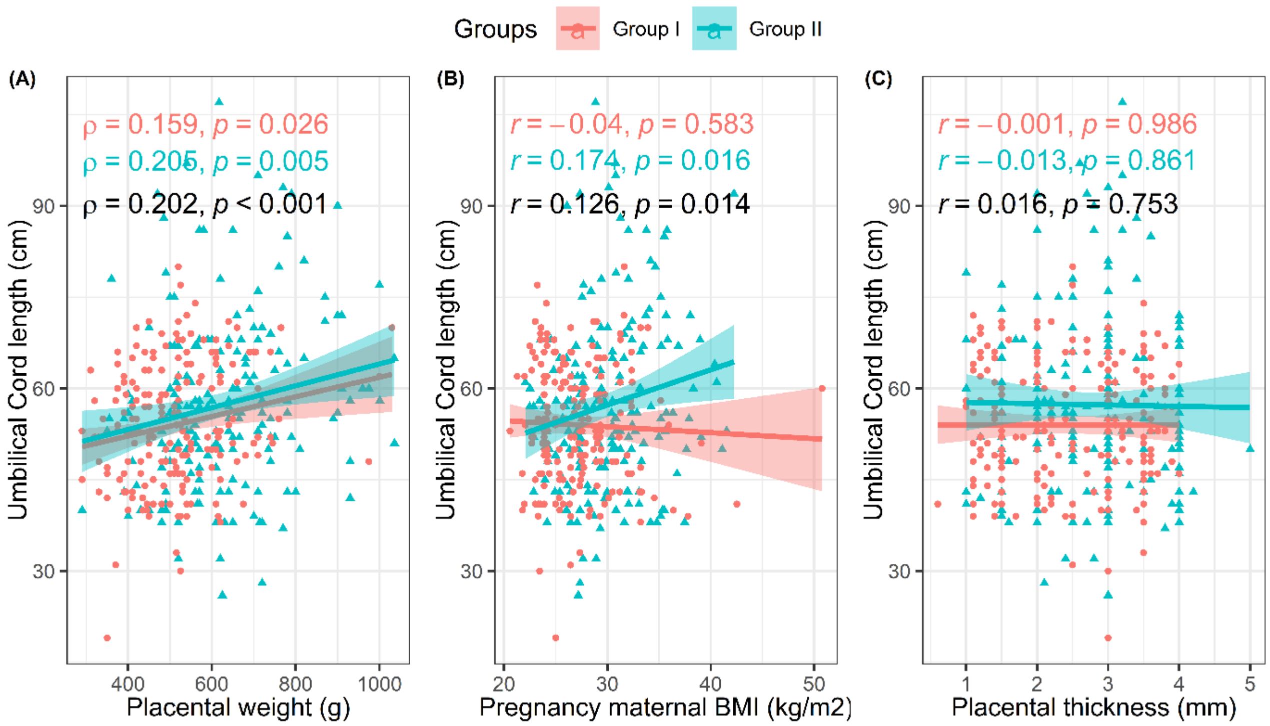

Figure 2. Scatter plots of umbilical cord length and (A) placental weight (Spearman's *rho*), (B) pregnancy maternal BMI (Pearson *r*), and (C) placental thickness (Pearson *r*) both all cases and stratified study groups. Red color indicates Group, green color indicates Group II and black color indicates all cases.

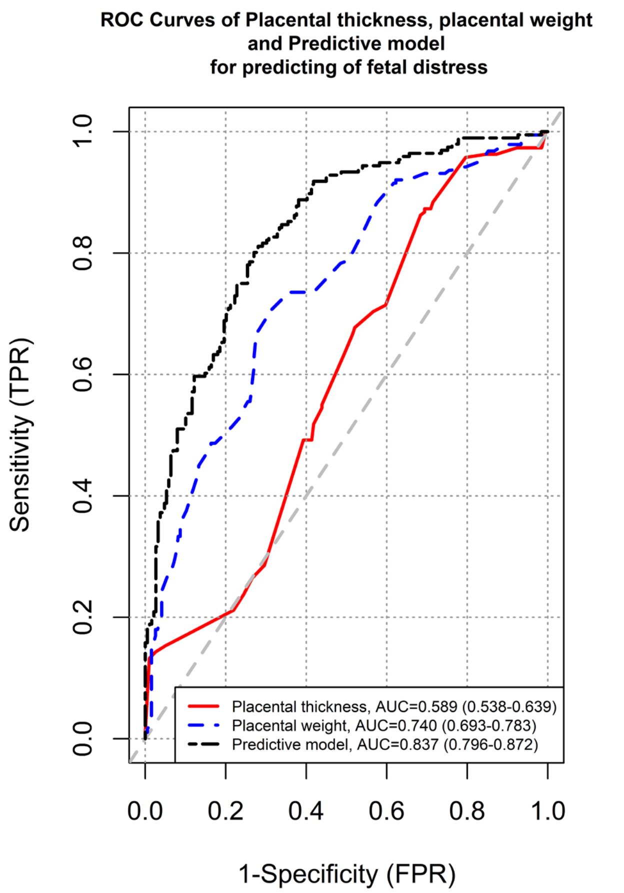

Figure 3. ROC Curves for placental thickness, placental weight and predictive model to predict fetal distress.

Discussion

Placenta and umbilical cord are the main structures involved in fetomaternal circulation during the intrauterine period. Examination of the morphology and functions of the placenta and umbilical cord during the intrauterine and postnatal periods gives information about the health of the fetus. In our study, we examined the relationship between placenta and umbilical cord characteristics and fetal distress.

In a study, it was shown that a thin placenta may be associated with an increased probability of fetal distress, which can be explained in terms of the structural organization of chorionic plate vessels resulting from high capacitance and low resistance of fetoplacental vascularization. Therefore, any potential limitation on the placenta's ability to transfer any fetal requirement may affect the overall condition of the fetus, which could lead to fetal distress (15). In our study, we found that thin placenta was associated with fetal distress, which was consistent with the literature.

The placenta may be round, oval, circumvallate, unilobed or multilobed. In the studies, the most common shape of the placenta was found round (6, 15). In our study, the most common placental shape was round, which is consistent with the literature, and there was no statistical difference between the shape of the placenta and those with or without fetal distress.

A length of more than 100 cm was defined as a long umbilical cord, and a length of less than 30 cm was defined as a short umbilical cord (9). It has been found that the shortness of the umbilical cord is associated with fetal growth and developmental retardation, congenital anomalies, fetal distress, and increased fetal death risk (10). It has been shown that excessive pulling of the short cord during fetal descent leads to occlusion of the cord vessels, inability to progress, and cord rupture (16). There are studies showing that the presence of a long umbilical cord is associated with complications such as cord prolapse, cord knots, and intrapartum fetal distress (9, 16, 17). In our study, umbilical cord length in cases with fetal distress was found statistically significantly shorter than in patients who delivered by elective cesarean section.

There are studies showing that umbilical cord diameter is correlated with fetal weight (10, 18, 19). Thin umbilical cord is associated with an increased risk of fetal distress (10). Udoh et al. reported poor fetal outcomes in 50 pregnant women whose umbilical cord diameter was below the average in the first and second trimesters (11, 20). In our study, no statistically significant difference was found between the umbilical cord thickness and the development of fetal distress.

The umbilical cord may enter the placenta centrally, marginally, laterally, or velamentous (11). In our study, in accordance with the literature, the most common placental insertion region was marginal. However, there was no statistical difference between the placenta insertion region and the patients with and without fetal distress.

Intrapartum maternal hemoglobin level may influence fetal oxygenation before and during labor (21). Anemia in the first or second trimester of pregnancy was linked to a higher risk of low birth weight and preterm birth, according to a systematic study (22). Additionally, elevated hemoglobin levels are linked to poor perinatal outcomes (23, 24). Reduced blood flow and fetomaternal exchange of oxygen and nutrients in the placenta are caused by inadequate plasma expansion or increased blood viscosity (24, 25). Thus, maternal hemoglobin level influences the risk of adverse pregnancy outcomes. In our study, hemoglobin and wbc values of patients with fetal distress were statistically higher than patients with elective cesarean section. We think that this is the result of increased blood viscosity and poor plasma expansion.

Fetal blood gas is an objective method used to reveal the biochemical status of the fetus (26, 27). Unlike the APGAR score, which is easily affected by the events that occur in the transition to extrauterine life, blood gas can better reflect this period (28, 29). In terms of both reflecting the fetal status and demonstrating the management of labor, blood gases provide time-specific data according to the APGAR score. Even if the APGAR score is low, the absence of acidosis in the umbilical artery excludes the presence of asphyxia and may lead the physician's attention to other causes that may cause depression in the newborn (28). Malin et al. associated a pH of <7.0 in cord blood gas with mortality (30). In the study of Yeh et al. with a very large case series, a pH value below 7.0 was determined as the threshold value for negative neurological outcomes (31). Although fetal acidemia is defined as umbilical artery pH<7.10 in general, the risk of mortality and morbidity does not change unless pathological fetal acidemia decreases in the umbilical artery PH 7.0 or below (32). In our study, the pH value of blood gas taken from the umbilical cord of the patients who had cesarean section due to fetal distress was found significantly lower than the patients who had elective cesarean section, in line with the literature (pH<7,3). However, when the 1st and 5th-minute APGAR scores were compared between the groups, no significant difference was found.

Conclusion

Early recognition of fetal distress is very important for the prevention of perinatal complications. In our study, we found that young maternal age, low BMI, thin placenta, low-weight placenta, and short umbilical cord were positively correlated with fetal distress. Close follow-up of patients with these features in terms of fetal distress is of great importance for the improvement of perinatal complications.

Conflict of interest: The authors declare no conflict of interest.

Contribution of authors: All the authors undertook the literature review, planned the study, wrote, and reviewed the manuscript.

Informed consent: This study was approved by the local ethical committee of the Necmettin Erbakan University Meram Medical Faculty Hospital (2022/3878) and the procedures were according to the ethical standards of the responsible committee on human experimentation. Written informed consent was obtained from each patient who participated in the study

Authors' Contributions

Idea/Concept: S.S., E.U., Design: S.S., Data Collection and/or Processing: S.S., E.U., A.M., M.K.K., O.G., B.S., S.C., E.C.S., Analysis and/or Interpretation: S.S., A.M., M.K.K., O.G., B.S., S.C., E.C.S., Literature Review: S.S., E.U., A.M., M.K.K., O.G., B.S., S.C., E.C.S., Article Writing: S.S., E.U., M.K.K., O.G., Critical Review: S.S., E.U., A.M., M.K.K., O.G., B.S., S.C., E.C.S.

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