The effect of biacromial and bideltoid distance on shoulder dystocia and birth weight in newborns

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Abstract

Objective: To evaluate the relationship between neonatal biacromial and bideltoid diameter (BDD), birth weight and shoulder dystocia (SD).

Material and Methods: This was a prospective observational study conducted on 161 pregnancies who applied to Private Lokman Hekim Hospital for follow-up between February 2021 and August 2021. Maternal height, weight, parity, and presence of SD in the second stage of labor were evaluated in the patients included in the study. The weight, height, head circumference, biacromial and BDD measurements of newborn babies were taken within the first two hours after birth. The primary purpose of the study was to evaluate the relationship between the biacromial and BDD and SD. The secondary purpose of the study was to evaluate the relationship between the biacromial and BDD and macrosomia.

Results: The mean age and post-pregnancy body mass index of the participants were 31.3±4.4 years and 29.0±4.0 kg/m^2, respectively, and 42.9% (n=69) delivered vaginally. The incidence of macrosomia was 6.8% (n=11) in all women and the incidence of SD was 7.2% (n=5) in women who had vaginal deliveries. The mean biacromial diameter (BAD) was 12.4±1.0 cm and the mean BDD was 18.2±1.7 cm. A correlation rate of 0.373 was found between SD and the BAD, and 0.484 between SD and the BDD. The correlation coefficients between macrosomia and the biacromial and BDD were 0.213 and 0.420, respectively. In cases in which the BDD was ≥21 cm, the sensitivity for SD was 100%, the specificity was 90.63%, and the accuracy was 91.30%. The cut-off point for the BAD was ≥14 cm, and the sensitivity and specificity for SD was 63.64% and 89.33%, respectively. The highest correlation for SD was obtained in cases in which there was a history of SD (0.648).

Conclusion: The relationship between neonatal biacromial and BDD, and macrosomia and SD were significant. There was no difference between the correlation values of the two measurements in terms of SD. However, the correlation coefficient of the BDD was greater for macrosomia. (J Turk Ger Gynecol Assoc 2022; 23: 241-8)

Keywords: Neonatal shoulder width, macrosomia, shoulder dystocia, delivery

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Introduction

Shoulder dystocia (SD) can be defined as difficulty or failure to deliver the fetal shoulders after delivery of the fetal head. It has different definitions according to the time required for the trunk to be delivered after the fetal head has emerged or the need for auxiliary maneuvers (1,2). According to the first definition, SD is seen at a rate of about 2-3% in all deliveries (1). It occurs unpredictably at birth and is a medicolegal problem due to its consequences in newborns (2).

The most common and known risk for SD is macrosomia. Macrosomia can be defined as a birth weight above the 90th percentile or over 4000-4500 g according to gestational age (3). In addition to many maternal factors, such as maternal weight before pregnancy, weight gain during pregnancy, increasing parity, and fetal factors, such as fetal sex, genetic and environmental factors also have an effect on macrosomia (4). It is important to detect macrosomia in the antenatal period, since maternal and fetal complications, SD risk and need for cesarean section increase with macrosomia (5). However, although it is known that it is more common in macrosomic infants, it is also seen in non-macrosomic infants, making the antenatal detection of SD difficult (1). Therefore, studies have

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been performed to investigate antenatal parameters other than fetal weight to predict SD (6,7).

In anthropometric evaluations performed on newborns, the fetal shoulder circumference was found to be significantly larger in pregnancies complicated with SD when compared to cases without SD (8). However, measurement of the shoulder circumference is difficult in antenatal ultrasonographic evaluation. To obtain information about the shoulder circumference, fetal biacromial diameter (BAD) measurement was investigated. Calculations were made for BAD based on different measurements taken from the fetus, but it was reported that the correlation of fetal measurements with actual postnatal measurements was not accurate (9). Since SD arises as a result of incompatibility between fetal BAD and maternal pelvic outlet, the relationship between neonatal BAD and bideltoid diameter (BDD) and SD was investigated herein. The primary purpose of the study was to evaluate the relationship between BAD and BDD with SD, and the secondary purpose was to evaluate the relationship between BAD and BDD in cases of macrosomia.

Material and Methods

This study was a prospective, cross-sectional study conducted with 161 patients who came to Private Lokman Hekim Hospital pregnancy outpatient clinic between 02.2021 and 08.2021.

Following the approval of the Lokman Hekim University Non-Interventional Clinical Research Ethics Committee (approval number: 2021/013, date: 19.01.2021), full term singleton pregnancies without fetal anomaly, regardless of parity and previous delivery type, were included in the study. Patients with a history of type 1 or type 2 diabetes mellitus, gestational diabetes, antepartum hemorrhage, intrauterine growth restriction, intrauterine exitus and musculoskeletal pathology that may cause complications during normal delivery were not included in the study.

The purpose of the study and what would be done within the scope of the study were explained to all the patients, and written consent was obtained from participants. The study was conducted in accordance with the Principles of the Helsinki Declaration. Information about age, parity, height, pre-pregnancy and birth weight, macrosomia and SD history of previous deliveries were obtained from all the participants. Body mass index (BMI) was calculated in kg/m^2.

Mode of delivery, need for episiotomy, vacuum-assisted delivery, presence of SD, and maneuvers to release the affected shoulder were recorded. The presence of SD was accepted as any case in which the contraction that came after the uterine contraction leading to the delivery of the fetal head, and pushing by the mother, was insufficient for the delivery of the shoulders (1).

The weight, height, and head circumference of all newborns were recorded by the neonatal nurse. The neonatal weight was measured with a digital scale with a sensitivity of ±50 g (Medika plus, Turkey). A birth weight of 4000 g and above was accepted as macrosomia. The baby's head circumference was measured from the glabella to the occiput with an inflexible tape measure and recorded in the nearest whole cm. The baby's height was measured with an inflexible tape measure between the tip of the head and the heel while the baby was in the supine position on a flat surface and was recorded as the nearest whole cm. BAD and BDD was measured with an inflexible tape measure when the baby was in the supine position on a flat surface and recorded in cm by the author in accordance with the definition of Şener and Alpa (10). These definitions are: distance between the outermost parts of the acromial processes for BAD; and the distance between the origin of the most prominent point of the deltoid muscles for BDD (10). In all the measurements, the average of three consecutive measurements was taken.

Delivery was performed using the McRoberts' maneuver (hyperflexing the mother's legs tightly to her abdomen) in three of the SD cases and using the Rubin's 1 maneuver (the rotation of anterior shoulder under pubic symphysis by giving suprapubic pressure) following the McRoberts' maneuver in the other two (1). All the newborns were delivered without any complications, such as clavicle fracture and brachial plexus paralysis. All the newborns were examined by a pediatrician within the first hour after delivery and were found to be normal.

Statistical analysis

For the statistical analysis and calculations, IBM SPSS for Windows, version 21.0 (IBM Corp., Armonk, NY, USA) and MS-Excel 2016 (Microsoft, Redmond, VA, USA) programs were used. Statistical significance level was accepted as $p<0.05$. Qualitative data were expressed as the frequency and percentage. Quantitative data were summarized as the median (quartile 1-3), minimum, maximum, and mean ± standard deviation. To compare between the patients with and without SD (or macrosomia), the categorical variables were analyzed using the Fisher's exact test and the numeric variables were analyzed using the Mann-Whitney U test. The point biserial, phi, and Cramer V correlation coefficients were calculated with a 95% confidence interval (CI) to measure the relationship between SD (or macrosomia) and a continuous, a binary (or more than two category) variable. If the CI for the correlation coefficient includes zero, then the relevant coefficient is meaningless. Correlation coefficient values were interpreted as: 0.00-0.29 negligible; 0.30-0.49 low; 0.50-0.69 moderate; 0.70-0.89 high; and 0.90-1.00 very high correlation (11). The "cocor" R package was used to test significance for

the difference between two correlations with one common variable (12). The receiver operating characteristic (ROC) curves were constructed to determine the cut-off points using the Youden index. The sensitivity, specificity, positive predictive value (PPV), negative predictive value, and accuracy value of the BAD and BDD for detecting SD (or macrosomia) were obtained.

Results

Descriptive information and birth data of the 161 women included in the study are given in Table 1. The incidence of macrosomia was 6.8% (n=11) in the whole cohort. The mean, median and minimum-maximum values are given Table 2. The mean age and post-pregnancy BMI of the participants were 31.3±4.4 years and 29.0±4.0 kg/m^2, respectively, and 42.9% (n=69) delivered vaginally. SD was observed only in women who had vaginal deliveries and the incidence of SD was 7.2% (5/69). The mean BAD was 12.4±1.0 (minimum: 10, maximum: 14) cm, and the mean BDD was 18.2±1.7 (minimum: 14, maximum: 23) cm. The correlation between gender and BAD was -0.066 (95% CI: -0.22 to 0.09; p=0.407) and between gender and BDD was -0.024 (95% CI: -0.18 to 0.13; p=0.766); neither were significant.

Results regarding the comparison of maternal and neonatal clinical information that may be associated with SD risk are given in Table 3. SD was observed only for women who had vaginal deliveries, so the SD results included only these women's findings. Presence of a history of SD, a history of macrosomia, high birth weight of the baby, high BAD, high BDD, large baby head circumference, high maternal BMI value, and low maternal height/infant weight ratio were observed in cases with SD (p<0.05). The highest correlation was with a history of SD (0.648). The correlation coefficient was 0.373 between the incidence of SD and BAD, and 0.484 between the incidence of SD and BDD. When the relevant coefficients were compared, there was no significant difference in relation to SD (p=0.264).

The results regarding the comparison of the maternal and neonatal clinical information that may be associated with macrosomia are given in Table 4. Macrosomia was observed in babies born by both delivery methods, and there was no difference in terms of the delivery rate of those with macrosomia (45.5% vs. 54.5% of macrosomic neonates were born by caesarean section and vaginal delivery, respectively). There was no difference between the parity, number of pregnancies, type of delivery, sex, maternal height variables, and macrosomia groups (p>0.05). When the correlations were examined, the correlation between macrosomia and history of dystocia was 0.584. The correlation coefficients between macrosomia and BAD and BDD variables were 0.213 and 0.420, respectively. There was a significant difference between these two coefficients (p=0.004).

Table 1. The descriptive statistics of the maternal and neonatal characteristics (n=161)

Variable	n (%)	Variable	n (%)
Parity		**Biacromial diameter (cm)**	
Primiparous	73 (45.3)	10 - <12	29 (18.0)
Multiparous	88 (54.7)	12 - <14	109 (67.7)
History of dystocia#		14 - <16	23 (14.3)
Yes	4 (5.8)	**Bideltoid diameter (cm)**	
No	65 (94.2)	14 - <16	8 (5.0)
History of macrosomia		16 - <18	51 (31.6)
Yes (>4000 gr)	15 (9.3)	18 - <20	75 (46.6)
No	146 (90.7)	20 - <22	22 (13.7)
Shoulder dystocia#		22 - <24	5 (3.1)
Yes	5 (7.2)	**Delivery method**	
No	64 (92.8)	Vaginal delivery	69 (42.9)
Macrosomia		Caesarean section	92 (57.1)
Yes (>4000 gr)	11 (6.8)	**Gender**	
No	150 (93.2)	Boy	82 (50.9)
Vacuum-assisted delivery#		Girl	79 (49.1)
Yes	5 (3.1)	**Episiotomy#**	
No	64 (39.8)	Yes	25 (36.2)
		No	44 (63.8)

#(n=69) on women who have vaginal delivery

In this cohort, SD developed in 1 (1.6%) of 63 non-macrosomic infants and 4 (66.7%) of 6 macrosomic infants (p<0.05). Macrosomia was seen in 4 (80.0%) of 5 infants with SD and 2 of 64 (3.1%) infants without SD.

The ROC analysis results for BAD and BDD on SD development and the incidence of macrosomia are given in Table 5. The areas under the curve (AUC) for both cases were shown in Figure 1a, b. ROC analysis of the association of BAD, BDD and SD gave AUC values of 0.930 and 0.966, respectively (p=0.001 and p<0.001). The sensitivity rate according to the cut-off point determined for both variables was 1.00 (100.00%). A cut-off of ≥21 cm for BDD yielded a sensitivity for SD of 100%, the specificity was 90.63% and the accuracy was 91.30%. Similarly, for macrosomia, a significant cut-off point was identified for both variables (p<0.05). The cut-off point for the BAD was ≥14 cm, and the sensitivity and specificity for SD was 63.64% and 89.33%, respectively.

Table 2. The minimum, maximum, median and mean values of variables (n=161)

Variable	Minimum; maximum	Median (Q_1-Q_3)	Mean ± SD
Birthweight (g)	2235; 4590	3350 (3065-3620)	3349.7±436.3
Biacromial diameter (cm)	10; 14	12 (12-13)	12.4±1.0
Bideltoid diameter (cm)	14; 23	18 (17-19)	18.2±1.7
Head circumference (cm)	31; 39	35 (34-36)	34.9±1.5
Neonatal length (cm)	42; 56	50 (49-51)	50.0±2.0
Maternal age (years)	20; 42	31 (28-34)	31.3±4.4
Non-pregnant weight (kg)	46; 97	64 (57-70)	64.3±10.9
Prepartum weight (kg)	57; 115	76 (70-86)	78.7±11.8
Weight gain (kg)	3; 35	14 (10.5-17)	14.4±5.4
Maternal height (cm)	148; 178	165 (160.5-168)	164.6±5.2
Maternal BMI (kg/m^2)	20; 42.2	28.2 (26.2-31.6)	29.0±4.0
Maternal height/infant weight ratio	0.04; 0.08	0.049 (0.046-0.053)	0.05±0.01
Infant weight/maternal BMI ratio	68.9; 181.32	116.83 (105.11-129.32)	116.96±18.48

Data are presented as frequency (percentage) for categorical variables and minimum; maximum, median (Q1-Q3), mean ± SD for numeric variables.
SD: Standard deviation, BMI: Body mass index, Q_1-Q_3: Quartile 1-Quartile 3

Table 3. The maternal and neonatal characteristics of patients with and without SD#

Variable	Without SD, (n=64)	With SD, (n=5)	p*	r** (95% CI lower; upper bound)
Parity (multiparous)	39 (60.9)	4 (80.0)	0.643	0.102 (-0.138; 0.331)
History of dystocia#	1 (1.6)	3 (60.0)	**0.001**	0.648 (0.486; 0.767)
History of macrosomia	4 (6.3)	3 (60.0)	**0.006**	0.462 (0.253; 0.630)
Gender (girl)	29 (45.3)	3 (60.0)	0.657	0.076 (-0.164; 0.307)
Birthweight (g)	3365 (3117.5-3603.8)	4140 (3847.5; 4345)	**<0.001**	0.496 (0.294; 0.656)
Biacromial diameter (cm)	13 (12; 13)	14 (14; 14)	**<0.001**	0.373 (0.150; 0.560)
Bideltoid diameter (cm)	18 (17; 19)	21 (21; 22.5)	**<0.001**	0.484 (0.279; 0.647)
Head circumference (cm)	34 (34; 36)	36 (35; 37.5)	**0.031**	0.285 (0.052; 0.489)
Neonatal length (cm)	50 (49; 51.8)	51 (50; 53)	0.181	0.153 (-0.087; 0.376)
Maternal age (years)	32 (28; 34)	31 (29.5; 36)	0.711	0.050 (-0.189; 0.283)
Weight gain (kg)	13 (10; 15)	14 (11.5; 25)	0.261	0.196 (-0.043; 0.414)
Maternal BMI (kg/m^2)	27.4 (26.2-30.4)	30.8 (29.9-33.8)	**0.019**	0.254 (0.018; 0.463)
Maternal BMI (>30 kg/m^2)	20 (31.3)	4 (80.0)	**0.046**	0.265 (0.030; 0.472)
Maternal height (<155 cm)	2 (3.1)	1 (20.0)	0.205	0.215 (-0.023; 0.43)
Maternal height/infant weight ratio	0.049 (0.047-0.053)	0.042 (0.039-0.043)	**<0.001**	-0.398 (-0.58; -0.178)
Infant weight/maternal BMI ratio	120.69 (109.54-131.68)	138.47 (113.97-142.59)	0.189	0.168 (-0.072; 0.389)

#(n=69) on women who have vaginal delivery. Data are presented as frequency (percentage) and median (Quartile 1-Quartile 3). *The Fisher's exact test and Mann-Whitney U test are used to compare groups with respect to categorical and numeric variables, respectively. Bold values denote statistical significance at the p<0.05 level. **The point biserial, phi and Cramer's V correlation coefficient are calculated with their 95% CI.
SD: Shoulder dystocia, CI: Confidence interval, BMI: Body mass index

Post-hoc power results: The effect sizes from the non-parametric approaches for the BAD and the BDD variables were determined as d=0.87 and 0.93 for SD and as 0.42 and 0.80 for macrosomia, respectively. The post-hoc power values calculated, based on the determined effect size, 0.05 type 1 error, two tails, and sample size were 0.44, 0.49, 0.26, and 0.70. The post-hoc power was found to be low in all three cases, except for the BDD variable in macrosomia.

Discussion

Despite the use of advanced technological facilities, it is still a troublesome situation for clinicians in terms of the difficulty in predicting macrosomia and SD in obstetric practice and the medicolegal problems it may create (2). SD occurs as a result of incompatibility between fetal BAD and maternal pelvis and is more common in macrosomic infants (1). The relationship between newborn weight and SD has been reported to be significant previously (p<0.001) (13). In the present study, 1 (1.6%) of 63 non-macrosomic infants and 4 (66.7%) of 6 macrosomic infants had SD and the correlation coefficient between macrosomia and SD was found to be 0.496. Although different results have been obtained in studies due to the lack of a standard definition, the rate of SD is reported to be around 3% (1) and the rate of macrosomia around 7.74% (3). In the cohort of the present study the SD rate was 7.2% in women who had vaginal deliveries and the macrosomia rate was 6.8%

Table 4. The maternal and neonatal characteristics of patients with and without macrosomia

Variable	Without macrosomia (n=150)	With macrosomia, (n=11)	p*	r** (95% CI lower; upper bound)
Parity (multiparous)	81 (54.0)	7 (63.6)	0.755	0.049 (-0.106; 0.202)
History of dystocia#	1 (1.6)	3 (50.0)	**0.001**	0.584 (0.403; 0.721)
History of macrosomia	9 (6.0)	6 (54.5)	**<0.001**	0.421 (0.285; 0.54)
Delivery method (VD)	63 (42.0)	6 (54.5)	0.532	0.064 (-0.092; 0.217)
Gender (girl)	74 (49.3)	5 (45.5)	>0.999	-0.02 (-0.174; 0.135)
Biacromial diameter (cm)	12 (12; 13)	14 (12; 14)	**0.010**	0.213 (0.06; 0.356)
Bideltoid diameter (cm)	18 (17; 19)	21 (20; 22)	**<0.001**	0.42 (0.284; 0.54)
Head circumference (cm)	35 (34; 36)	36 (36; 38)	**<0.001**	0.319 (0.173; 0.451)
Neonatal length (cm)	50 (49; 51)	53 (51; 53)	**<0.001**	0.347 (0.203; 0.476)
Maternal age (years)	31 (28; 34)	35 (31; 36)	**0.018**	0.175 (0.021; 0.321)
Weight gain (kg)	14 (10; 16)	20 (13; 24)	**0.010**	0.254 (0.103; 0.393)
Maternal BMI (kg/m^2)	27.93 (26.10; 31.59)	30.82 (30.10; 34.06)	**0.009**	0.168 (0.014; 0.315)
Maternal BMI (>30 kg/m^2)	52 (34.7)	9 (81.8)	**0.003**	0.245 (0.094; 0.385)
Maternal height (<155 cm)	4 (2.7)	0 (0.0)	**>0.999**	-0.043 (-0.196; 0.112)
Maternal height/infant-weight ratio	0.05 (0.047; 0.054)	0.039 (0.037; 0.041)	**<0.001**	-0.441 (-0.558; -0.307)
Infant weight/maternal BMI ratio	115.97 (104.54; 128.41)	138.47 (128.00; 142.85)	**<0.001**	0.285 (0.136; 0.421)

#(n=69) on women who have vaginal delivery. Data are presented as frequency (percentage) and median (Quartile 1-Quartile 3). *The Fisher's exact test and Mann-Whitney U test are used to compare groups with respect to categorical and numeric variables, respectively. Bold values denote statistical significance at the p<0.05 level. **The point biserial, phi and Cramer's V correlation coefficient are calculated with their 95% CI.
VD: Vaginal delivery, CI: Confidence interval, BMI: Body mass index

Table 5. Predictive value of biacromial and bideltoid diameter for prediction of SD and macrosomia at birth

	Variable (cm)	AUC (95% CI lower; upper bound)	Cut-off point	p	Sen., (%)	Spe., (%)	PPV, (%)	NPV, (%)	Accuracy, (%)
Shoulder dystocia	Biacromial diameter	0.930 (0.866; 0.993)	≥14	**0.001**	100.00	85.94	35.71	100.00	86.96
	Bideltoid diameter	0.966 (0.922; 0.999)	≥21	**<0.001**	100.00	90.63	45.46	100.00	91.30
Macrosomia	Biacromial diameter	0.723 (0.522; 0.925)	≥14	**0.014**	63.64	89.33	30.44	97.10	87.58
	Bideltoid diameter	0.916 (0.854; 0.978)	≥20	**<0.001**	81.82	88.00	33.33	98.51	87.58

(n=69) for shoulder dystocia and (n=161) for macrosomia.
AUC: Area under the curve, CI: Confidence interval, Sen.: Sensitivity, Spe.: Specificity, PPV: Positive predictive value, NPV: Negative predictive value SD: Shoulder dystocia

for all women, which was consistent with other studies. It was also observed that the relationship of both macrosomia and SD risk with neonatal BAD and BDD was significant (p<0.001).

Factors that contribute to macrosomia are expected to increase the risk of SD. There are studies showing that the risk of macrosomia and SD increases with increasing parity. A weight gain of 100 to 150 g can be observed in each pregnancy due to an increase in parity, which increases the risk of macrosomia in the long run. However, multiparity is not a major risk factor for macrosomia compared to other factors (4). Consistent with these results, no significant relationship was found between parity and macrosomia in our study. However, although there was a statistically significant relationship between multiparity and SD risk in previous studies (p=0.006) (14), no such relationship was found in the present study. Similarly, macrosomia was more common in male fetuses than female fetuses due to the fact that male fetuses are generally approximately 150 g heavier than female fetuses (4). However, no statistically significant relationship was found between sex and macrosomia or SD. Maternal obesity is associated with 4-12 times increase in the probability of macrosomia (4). In addition, previous studies have found a significant relationship between maternal obesity and SD (p<0.001) (14). Our results were consistent with this as the risk of macrosomia and SD in cases in which the maternal BMI was >30 kg/m^2 was significant (p=0.003 and p=0.046, respectively).

In anthropometric studies evaluating the risk of SD in non-macrosomic newborns, it was observed that the risk of SD increased with a low maternal height-newborn weight ratio (14). In keeping with this, the ratio of maternal height-newborn weight was lower in cases with SD in our study. As another anthropometric value, a high newborn weight-maternal BMI ratio also increased the risk of SD (p<0.001) (14). However, in the current study, no statistically significant relationship was found between the ratio of newborn weight-maternal BMI and SD. It has been reported that the risk of SD increased, especially in cases in which the maternal height was <1.55 m (p=0.03) (14), although we found no such association, possibly because of differences in sample populations or sample sizes.

In another study conducted by Bahar (15) on newborns with and without SD, but with similar birth weight, SD risk indicators were evaluated. These authors reported that the presence of a history of SD increased the risk of subsequent birth SD by six-fold, and our findings were consistent with this. In the same study, while no difference was observed between the case and control groups with regard to the newborn head and chest circumference measurements, a statistically significant difference was found between the case and control groups with regard to BAD and head circumference/BAD ratio. The BAD was 15.16 cm in the case group and 14.61 cm in the control group (p<0.001) (15).

In a study conducted by Winn et al. (9) in order to investigate the relationship between newborn BAD and some fetal measurements, it was stated that the strongest correlation with newborn BAD was with fetal chest circumference (r=0.67, p=0.003), followed by arm circumference. Winn et al. (9) reported mean BAD to be 15.5 (±0.9) cm, and that newborn BAD measurement was equal to half of the shoulder circumference. Another study was conducted by Youssef et al. (7) to evaluate the effect of fetal BAD measurement on the prediction of macrosomia. In the ROC analysis of fetal BAD and abdominal circumference in predicting macrosomia and SD

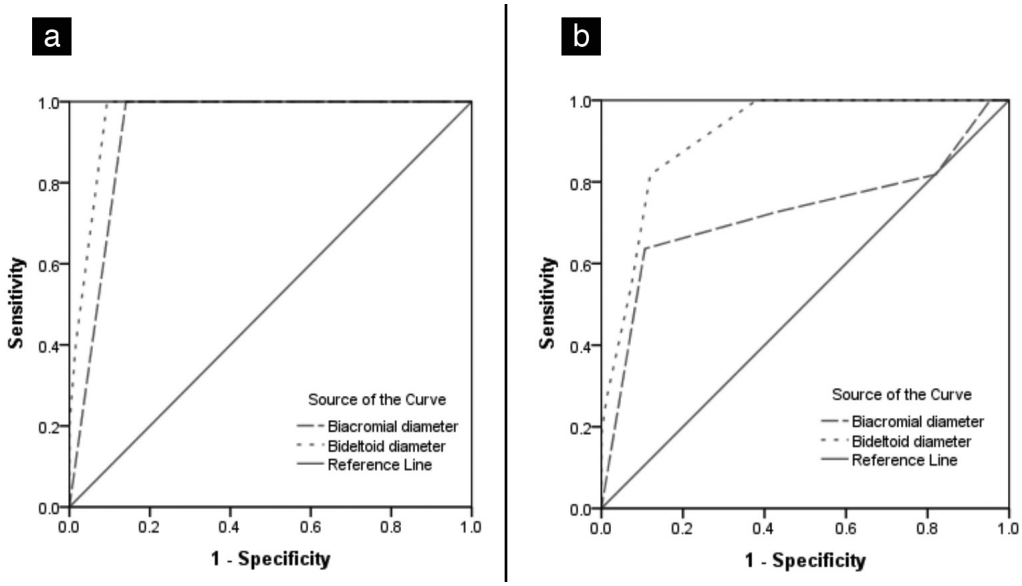

Figure 1. (a,b) Receiver operating characteristic curve analysis of the predictive value of biacromial diameter and bideltoid diameter for prediction of shoulder dystocia and macrosomia at birth, respectively

risk, the AUC was found to be >0.90 in all of the results. When the cut-off value for fetal BAD was taken as 15.4 cm, the PPV for macrosomia was 88.4%, sensitivity was 96.4%, and accuracy was 96.4% (7).

In a study conducted on 2,222 cases in which factors that may be associated with neonatal BAD and SD were evaluated, maternal weight gain, gestational week, BAD and birth weight were determined as predisposing factors for SD. No relationship was found between maternal age, parity, pre-pregnancy weight, maternal height, infant sex, and SD. Significant correlations were found between newborn BAD and parity, non-pregnant weight, weight gain during pregnancy, maternal height, fasting and one-hour glucose values, gestational week, and newborn weight. The strongest correlation was reported between newborn BAD and birth weight ($r=0.59$, $p<0.001$). In that study, the mean BAD was 122.1 mm, and if it was >140 mm, it was considered as the 90th percentile. Again, in that study, the newborn BAD measurement was found to be significantly higher in cases with SD (13).

In the current study, the AUC values for SD and BAD and BDD were 0.930 and 0.966, respectively. The sensitivity rate according to the cut-off point that was determined for both variables was 1.00 (100.00%). For BDD the best cut-off determined for BDD was ≥21 cm. Similarly for macrosomia, a significant cut-off point was determined for both variables ($p<0.05$). The optimal cut-off point for BAD was ≥14 cm, while the optimal cut-off point for BDD was ≥20 cm. We suggest that the relationship between BAD and BDD in predicting the risk of SD and macrosomia makes it important to take these measurements in the antenatal period.

Study limitations

As the definition of SD varies according to the knowledge and skills of the physician, evaluations on this subject are generally subjective. The small sample size was the most important limitation of the study, which is why we preferred non-parametric methods in the analysis phase to minimize the effect of low sample size and imbalance in groups. However, there is a need for much larger, multi-center studies to better investigate the relationships identified in this study, particularly antenatal measurements for predictive purposes.

Conclusion

We have shown in that there is a significant relationship between neonatal BAD and BDD measurements and SD and macrosomia, and that the relationship between BDD and macrosomia is relatively strong. There is a need for future studies that will further explore BAD and BDD measurements in the antenatal period to predict complications.

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Informed Consent: *The purpose of the study and what would be done within the scope of the study were explained to all the patients, and written consent was obtained from participants.*

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