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Prediction of macrosomia by fetal biacromial diameter among term neonates

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ABSTRACT

Objectives: Although clinical and ultrasonographic assessments are implemented to predict fetal macrosomia, there are still lots of controversies regarding to using different predictive parameters. The aim of present study was to compare the mean of biacromial diameters in macrosomic and non-acrosomic neonates to determine the accuracy of this predictive parameter. *Methods*: A multicenter, cross sectional study was carried out in two Iranian hospitals in 2019. The study population consisted of 37-42 weeks pregnant women attending in labor room for delivery. After admission, a transabdominal ultrasound examination was performed. All fetal parameters including estimated fetal weight, biparietal diameter (BPD), head circumstance, chest circumstance, abdominal circumstance (AC), mid arm diameter, transverse thoracic diameter, femur length, were measured. Fetal biacromial diameter was also determined using formula and recorded. After delivery, the neonates' birth weights were measured. Based on birth weight, neonates were divided into 2 macrosomic and non-macrosomic groups. The mean of biacromial diameter in macrosomic and non-acrosomic neonates was compared, sensitivity and specificity associated the biacromial diameter in prediction of fetal macrosomia among term neonates were also determined. *Results:* The mean of biacromial diameter in macrosomic group was significantly higher than counterpart group (18.72±0.94 mm vs. 15.27±1.64 mm; P= 0.0001). Based on ROC curves, Area under curve (AUC) for biacromial diameter as a significant diagnostic value for macrosomia was 0.979 (p=0.0001, 95% CI: 0.954, 1.000). AUC for abdominal circumference was also 0.857 (p=0.0001, 95% CI: 0.717, 0.998). *Conclusion*: biacromial diameter index with high sensitivity, specificity values and its significant correlation with birth weight could predict macrosomia. Further studies with larger sample size are strongly suggested.

Keywords: macrosomia; biacromial diameter; abdominal circumference; birth weight, sensitivity; specificity

1. INTRODUCTION

Macrosomia with an increasing prevalence (approximately 10%) defined as birth weight >4000 grams. Fetal macrosomia is associated with increased rates of maternal and neonatal morbidities. The risks of caesarean section, prolonged labor, post-partum hemorrhage, birth canal and perineal injuries, shoulder dystocia, brachial plexus injury (OBPI), fractures of the humerus and clavicles, neonatal seizures, meconium aspiration syndrome and birth asphyxia maybe increased with macrosomia (LI et al., 2014; Araujo Júnior et al., 2017; Beta et al., 2019).

Clinical and ultrasonographic assessments as prenatal prediction tools are implemented preventing macrosomia-related adverse outcomes (Aviram et al., 2017). The association between macrosomia with maternal fundal height has been demonstrated (Araujo Júnior et al., 2017). A study pointed to alterations of some biomarkers like glucose, 1,5-anhydroglucitol, glycosylated hemoglobin, adiponectin and insulin-like growth factor-1 as predictive factors for macrosomia in pregnancies affected by diabetes (Nahavandi et al., 2018). Different fetal biometrical measurements by ultrasound examination have been also proposed to improve the prediction of fetal macrosomia. The abdominal fetal fat layer with high sensitivity and specificity was introduced as a useful tool in prediction of macrosomia in pregnant women with gestational diabetes mellitus (Elessawy et al., 2017). An investigation showed an association between estimated fetal weights (EFW) between 4000 and 5000gr before 38 weeks of gestation with macrosomia (Parikh et al., 2019). A study demonstrated a formula integrating abdominal circumference (AC) and femur length (FL) as the most sensitive and other formula integrating AC, Femur Length (FL) and biparietal diameter (BPD) as the most specific predictive parameters for macrosomia (Aviram et al., 2017). Antenatal magnetic resonance imaging MRI was implemented measuring EFW for predicting neonatal macrosomia, however, the results could not indicate higher sensitivity related measurement of EFW by MRI compared to measurement of abdominal circumference (AC) by 2-Dimensional ultrasound (Malin et al., 2016).

Different results from former studies have shown that there are still lots of controversies regarding to using different parameters predicting macrosomia. Due to the potentially serious maternal and neonatal complications, more research is needed. Recently, an investigation proposed that fetal biacromial diameter could be used as a new predictive measure for macrosomia (Youssef et al., 2019). The aim of present study was to compare the mean of biacromial diameters in macrosomic and non-acrosomic neonates to determine the accuracy of fetal biacromial diameter in predicting of macrosomia. Determining the sensitivity, specificity, positive and negative predictive values associated the biacromial diameter in prediction of fetal macrosomia among term neonates were also assessed

2. MATERIALS AND METHODS

A multicenter, cross sectional study was carried out in two Iranian hospitals (Shariaty and Vali e Asr) affiliated to Tehran University of Medical Sciences (Tehran-Iran) from January to September 2019. The study population consisted of 37-42 weeks pregnant women attending in labor room for delivery.

The inclusion criteria were singleton and term pregnancy with gestational age between 37 to 42 weeks. Women with antepartum hemorrhage, preterm labor pain, intra uterine growth restriction (IUGR), intra uterine fetal death (IUFD), multi gestations, and major congenital anomalies were excluded. After admission, all participants' demographic, obstetric and clinical data were gathered and recorded in checklists. A transabdominal, 2-Dimensional ultrasound examination (with a transabdominal convex probe 3.5-5.5 MHz; Philips ultrasound machine; America) was performed by an expert perinatologist. All fetal parameters including estimated fetal weight (EFW) based on Hadlock's formula, biparietal diameter (BPD), head circumstance (HC), chest circumstance, abdominal circumstance (AC), mid arm diameter, transverse thoracic diameter (TTD), femur length (FL), placental site, and amniotic fluid index(AFI) were measured and recorded. Fetal biacromial diameter was also determined using formula (Tranverse thoracic diameter + 2 mid arm diameter) (Aviram et al., 2017) and recorded.

After delivery, the neonates' birth weights were measured (using weighing). Based on birth weight, neonates were divided into 2 macrosomic and non-macrosomic groups. Birth weight > 4000 gr and birth weight<4000 were considered as macrosomia and non-macrosomia values (Araujo Júnior et al., 2017).

Our primary objective was comparison of the mean of biacromial diameter in macrosomic and non-acrosomic neonates. Determining the accuracy, sensitivity, and specificity associated the biacromial diameter in prediction of fetal macrosomia among term neonates were considered as our secondary objectives.

Sample size

Based on former investigations by Youssef et al. in 2019 (Youssef et al., 2019) and using formula, the proposed sample size was considered 116 subjects. With the proposed sample size, the study had a power of 95% and an alpha error of 0.05.

$$\mathrm{n} = \frac{\left[Z1 - \frac{\propto}{2}\right] \times sen(1 - sen)}{d2 \times prevulunce}$$

Z1 $-\frac{\propto}{2}$=1.96

Sen=0.97

(1-sen)=0.03

D=0.10

Prevalence=0.10

n=116

Ethical considerations

The present study was taken from a fellowship medical thesis. Ethics approval was obtained from the institutional review board of Tehran University of Medical Sciences according to Helsinki declaration (ID;TUMS.IKHC.REC.1398.215). All participants' women gave written consent before enrollment. All gathered data were considered confidential and no extra cost was imposed on our participants.

Data Analysis

Detailed ultrasound findings related neonates' parameters were recorded in checklists. Analyses were performed by using software package SPSS Inc. Version 16. Chicago, IL. Quantitative and qualitative variables were reported by mean+SD and percent, respectively. Considering normal distribution of data Student t test, Univariate and Linear Regression tests were used for comparing quantitative data. Chi square test was also used to analyze the differences between qualitative variables. Correlations between quantitative variables were assessed by Pearson Correlation test. Specificity and sensitivity of determining macrosomia were assessed by Receiver-Operating Characteristic (ROC) curves. Area under the curve (AUC) was also considered as a diagnostic index. Moreover, the level of significance was considered as $P < 0.05$.

3. RESULTS

In the study, 162 term pregnant women were considered. The mean age, gravid, BMI and gestational age were 31.85±6.07 years, 1.95±1.05, 27.82±4.79 kg/m^2, and 38.21±2.195 weeks, respectively. Data related to ultrasound examinations before delivery are shown in Table 1.

Table 1 Participants' ultrasound findings

Variables	Mean	SD
Biacromial diameter (mm)	15.7232	1.95292
Biparietal diameter (mm)	113.5247	147.40669
Biparietal diameter (week)	37.8623	4.64061
Head Circumference (mm)	332.5710	226.33311
Head Circumference (week)	37.6420	1.47933
Abdominal Circumference (mm)	316.9804	84.75785
Abdominal Circumference (week)	38.0444	3.18840
Femur Length (mm)	70.8959	25.36753
Femur Length (week)	37.0358	2.71514
Estimated Fetal Weight	3321.1358	476.04126
Amniotic Fluid index	14.3836	12.21528
Maximum Vertical Pocket	6.1501	9.35957
Birth weight (gr)	3324.5309	527.24790

Of all participants, 21 mothers (12.96%) delivered macrosomic neonates while the others had neonates with normal birth weights. Results have shown that there was a significant difference between macrosomic and non-macrosomic neonates regarding to the mean of biacromial diameter (P= 0.0001). The mean of biacromial diameter in macrosomic group (18.72±0.94 mm) was significantly higher than counterpart group (15.27±1.64 mm) (Table 2).

Table 2 Comparison of the means and medians of biacromial diameter in neonates with and without macrosomia

Variables	Macrosomic neonates n=21	Non-macrosomic neonates n=141	P-value
Biacromial diameter (Mean ±SD; mm)	18.72±0.94	15.27	0.0001
Biacromial diameter (Median)	18.60±1.64	15.40	

Univariate Analysis showed that the means of biacromial diameter were significantly different in neonates with different birth weights (P=0.0001) (Table 3). Further analysis by Post HOC-Boneferroni test also indicated that these differences between all groups were significantly notable except from between groups with birth weight<2500 grand other group with birth weights <4000 gr. Detailed data are shown in table 4.

Table 3 The means of biacromial diameter in neonates with different birth weights

Groups based on birth weight	Number	Mean±SD	Median	P-value
<2500	5	14.78±2.01916	14.3000	0.0001
2500-3000	40	13.97±1.33695	13.9600	
3000-3500	67	15.60±1.40615	15.9000	
3500-4000	29	16.39±1.33317	16.5000	
>4000	21	18.72±.94250	18.6000	

Table 4 Comparison of the means of biacromial diameter in neonates with different birth weights

Groups' birth weights (gr) (I)	(J)	Mean Difference (I-J)	Std. Error	P-value	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
<2500	2500-3000	.8087	.63803	1.000	-1.0079	2.6254
	3000-3500	-.8275	.62358	1.000	-2.6029	.9480
	3500-4000	-1.6197	.65133	0.139	-3.4742	.2348
	>4000	-3.9400*	.66933	0.000	-5.8457	-2.0343
2500-3000	<2500	-.8087	.63803	1.000	-2.6254	1.0079
	3000-3500	-1.6362*	.26876	0.000	-2.4015	-.8710
	3500-4000	-2.4284*	.32805	0.000	-3.3625	-1.4944
	>4000	-4.7488*	.36247	0.000	-5.7808	-3.7167
3000-3500	<2500	.8275	.62358	1.000	-0.9480	2.6029
	2500-3000	1.6362*	.26876	0.000	0.8710	2.4015
	3500-4000	-.7922	.29898	0.089	-1.6435	.0591
	>4000	-3.1125*	.33639	0.000	-4.0703	-2.1548
3500-4000	<2500	1.6197	.65133	0.139	-.2348	3.4742
	2500-3000	2.4284*	.32805	0.000	1.4944	3.3625
	3000-3500	.7922	.29898	0.089	-.0591	1.6435
	>4000	-2.3203*	.38541	0.000	-3.4177	-1.2230
>4000	<2500	3.9400*	.66933	0.000	2.0343	5.8457
	2500-3000	4.7488*	.36247	0.000	3.7167	5.7808
	3000-3500	3.1125*	.33639	0.000	2.1548	4.0703
	3500-4000	2.3203*	.38541	0.000	1.2230	3.4177

Based on the results, there were significant correlations between neonate's birth weight and several fetal parameters including head circumference (HD) P=0.0001; r=0.409, abdominal circumference: P=0.0001; r=0.531, femur length (FL): P=0.0001; r= 0.316, estimated fetal weight: P=0.0001; r=0.572 and biacromial diameters: P=0.0001; r=0.694. The strongest correlation by about 70% was observed between birth weight and biacromial diameter.

Linear Regression Analysis also demonstrated significant linear correlations between neonate's birth weight with estimated fetal weight, head circumference and biacromial diameter (Table 5).

Table 5 Correlations between neonate's birth weight with different parameters

variables	Standardized Coefficients Beta	t	P-value	95.0% Confidence Interval for B Lower Bound	95.0% Confidence Interval for B Upper Bound
Biparietal diameter (mm)	-0.088	-1.696	0.092	-0.681	0.052
Head Circumference (mm)	-0.147	-2.797	0.006	-0.585	-0.101
Abdominal Circumference (mm)	-0.064	-1.168	0.245	-1.072	0.275
Femur Length (mm)	-0.035	-0.647	0.519	-2.969	1.504
Estimated Fetal Weight	0.309	4.946	<0.001	0.206	0.479
Biacromial diameter (mm)	0.557	9.396	<0.001	118.735	181.953

Receiver-Operating Characteristic (ROC) curves calculating sensitivity and specificity for different parameters are shown in table 6 and Fig 1; based on ROC curves, Area under curve (AUC) for biacromial diameter was 0.979. This level was statistically significant as a diagnostic value for macrosomia; p=0.0001, 95% CI: (0.954, 1.000). AUC for abdominal circumference (AC) was also 0.857, demonstrating another statistically significant predictive parameter; p=0.0001, 95% CI: (0.717, 0.998). On the other hand, other measures did not show any predictive values.

Table 6 Area Under the Curve for each parameter

Test Result variable(s)	Area	Std. Error[a]	P-value	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Biacromial diameter (mm)	0.979	0.013	0.0001	0.954	1.000
Biparital diameter (mm)	0.557	0.060	0.402	0.438	0.675
Head circumference (mm)	0.554	0.062	0.422	0.433	0.676
Abdominal circumference (mm)	0.857	0.072	0.0001	0.717	0.998
Femur length (mm)	0.580	0.064	0.239	0.454	0.706

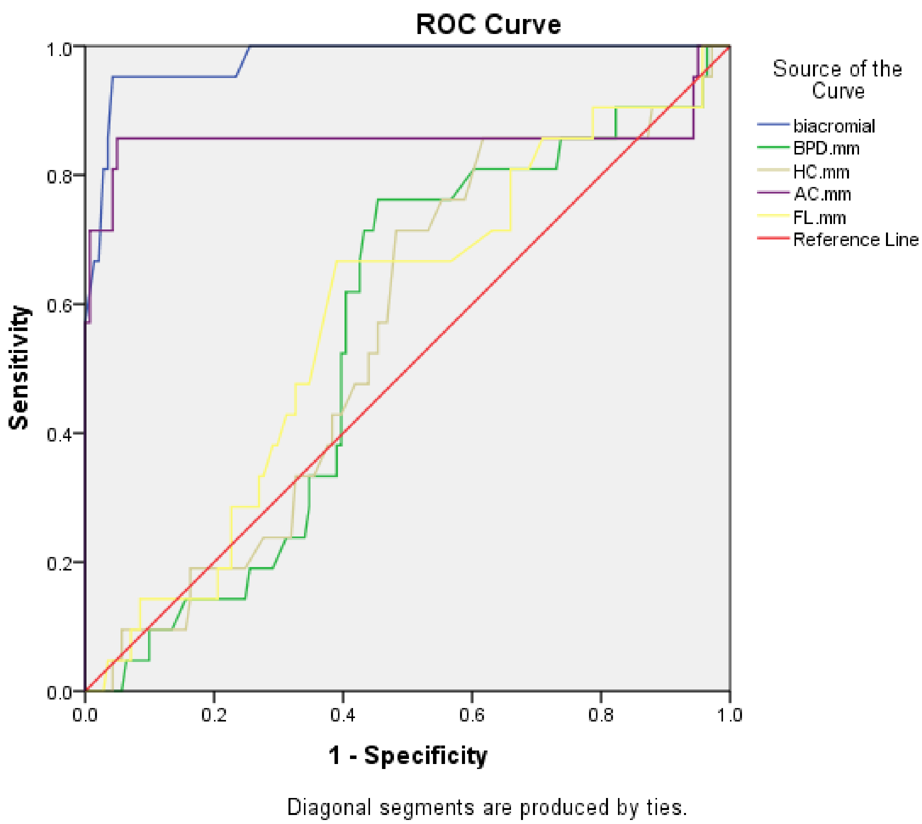

Figure 1 ROC curve for macrosomia based on different parameters; Biparietal diameter (BPD), Head circumstance (HC), Abdominal circumstance (AC), Femur length (FL)

Our results have shown that Cut off>16.65 Cm for biacromial diameter was the best diagnostic value for prediction of macrosomia. Sensitivity and specificity with the Cut off>16.65Cm were 95% and 75%. These macrosomia predictive values related to abdominal circumference were Cut off >395.65 mm with sensitivity and specificity 86% & 95%.

4. DISCUSSION

Macrosomia is one of the main causes of neonatal and maternal morbidities. Early perinatal diagnosis of macrosomia would be of value in implementing some preventive strategies to improve outcomes. Ultrasound examination has been implemented as a standard way for predicting fetal macrosomia for recent decades. On the other hand, wide variations in accuracy and reliability regarding measurement of different parameters like estimated fetal weight, head circumference, abdominal circumference and femur length have been reported in prediction of macrosomia by ultrasound examination (Maternal, Neonatal & Gynaecology Community of Practice, 2017). Up to our knowledge there are very few studies (Youssef et al., 2019) assessing the correlation between macrosomia and biacromial diameter. Hence, in this study we evaluated the value of biacromial diameter and its accuracy in prediction of fetal macrosomia among term neonates.

Based on the results, the incidence of fetal macrosomia in our study was 12.96% which is higher than former reported rates by 10%. This difference in incidence may associate to the number of sample sizes, using different weight thresholds as macrosomia criteria, time or regional diversities and so on. Zhang et al. indicated higher incidence rate of fetal macrosomia in the central district of cities compared to the rural-urban areas (10.5% vs. 8.6%). They also showed a higher incidence rate by 10.1% in 2013 compared to 8.1% in 2011 (Zhang et al., 2016). Aviram et al. indicated that different studies have implemented different macrosomic thresholds including 4000, 4250 or 4500 grams that could affect the incidence rate (Aviram et al., 2017).

According to our results, there was a significant association between macrosomia and biacromial diameter. Moreover, based on ROC curves, Area under curve (AUC) for predicting macrosomia related biacromial diameter was 0.979. Our results have shown that Cut off>16.65 Cm for biacromial diameter was the best diagnostic value for prediction of macrosomia with high sensitivity and specificity (95% and 75%). These findings could suggest a new index for early diagnosis of macrosomia that may certainly enhance therapeutic efforts preventing difficulties like shoulder dystocia and leading better outcomes. Our finding was confirmed by Menticoglou et al. They have reported that biacromial diameter in normal sized fetuses was 12–15 cm and in subjects with shoulder dystocia was more than 16 cm (Menticoglou et al., 2018). Accordance to results, Youssef et al. have also demonstrated that among 600 subjects there was a significant relationship between macrosomia and fetal biacromial diameter. They also reported that the area under the curve (AUC) for prediction of macrosomia according biacromial diameter was 0.987. The cutoff 15.4 cm of biacromial diameter had the highest sensitivity (96.4%) and accuracy (97%) (Youssef et al., 2019).

The results of present study showed that AUC for abdominal circumference predicting macrosomia was also 0.857, demonstrating another statistically significant predictive parameter. This value related to abdominal circumference with Cut off>395.65 mm had high sensitivity and specificity with 86% & 95%, respectively. Compatible to this result, the relationship between macrosomia in neonates with birth weight >4500 grams and abdominal circumference> 360 mm has been indicated by Menticoglou (Menticoglou, 2018). Consistent to our findings, Yan et al. demonstrated a significant difference in abdominal circumference diameter between macrosomic and non-macrosomic groups (Yan et al., 2018). Youssef et al. have also shown the AUC for prediction of macrosomia based on abdominal circumference was 0.989 and with the cutoff of 355 mm, the sensitivity and accuracy were 96.4% and 96.83% (Youssef et al., 2019).

Based on the results, there were significant correlations between neonate's birth weight and fetal parameters including head circumference, abdominal circumference, femur length, estimated fetal weight and biacromial diameters. Several studies confirmed our findings; a linear relation between abdominal circumference and birth weight was demonstrated by Smith (Smith et al., 1997) and an association between birth weight and head circumference was indicated by Shirazi et al. (Shirazi et al., 2019). Honarva et al. showed a positive but non-linear relationship between fetal femur length growth and fetal weight from 25 to 40 weeks of gestation (Honarva et al., 2001). Stephens et al. demonstrated a significant correlation between the EFW assessed by ultrasound examination within last weeks of gestation and neonate's birth weight (Stephens et al., 2019). Finally, significant association between neonate's birth weight and biacromial diameter was confirmed by Youssef et al. (Youssef et al., 2019). The main limitation of present study was small sample size due to reluctance of mothers in participation in our research study.

5. CONCLUSION

Our results showed that biacromial diameter index with high sensitivity, specificity values and its significant correlation with birth weight could predict macrosomia. The early diagnosis of macrosomia complications certainly enhances therapeutic efforts leading better outcomes. Further studies with larger sample size are strongly suggested.

Authors' contributions

Dr. Azadi and Khazardoost carried out the design and coordinated the study, participated in the most of experiments. Dr Shariat coordinated and carried out all the experiments, Analysis of data. All authors have read and approved the content of the manuscript.

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