

Impact of Maternal Body Mass Index on Umbilical Artery Indices and Neonatal Outcome

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Abstract

Objectives: This study was designed to clarify the relationship between maternal body mass index (BMI) and umbilical artery (U.A) indices and to evaluate the effect of maternal BMI on the neonatal outcome. **Study Design:** This was a prospective cohort study. **Patients and Methods:** This study included 121 pregnant women with uncomplicated, singleton pregnancy between 18 and 35 years, at 32 weeks of gestation, seen in Al-Yarmouk Teaching Hospital antenatal care. Women were divided according to the BMI into underweight (BMI <18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obese women (BMI ≥30). U.A velocity was recorded by Doppler ultrasound, and the women were followed till the time of delivery, mode of delivery, 5 min Apgar score, and birth weight were also recorded. **Results:** Obese women had significantly higher pulsatility index, resistance index, and systolic-diastolic ratio compared to overweight and normal weight groups ($P < 0.001$), cesarean section (C/S) rate was significantly higher ($P < 0.001$), and 5 min Apgar score was significantly lower ($P < 0.001$). **Conclusion:** The current study showed the negative impact of increasing BMI on fetoplacental circulation and increased risk of C/S. Neonates of obese mothers had low 5 min Apgar score.

Keywords: Apgar score, birth weight, body mass index, cesarean section, umbilical artery indices

INTRODUCTION

Body mass index (BMI) is an internationally accepted method that provides a reliable way to assess obesity-related health problems. Individuals are classified according to the Institute of Medicine (IOM) into four groups: underweight (BMI <18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obese (BMI ≥30).^[1]

The weight gained during pregnancy arises from the products of conception, increased size of maternal tissues, and the greater maternal fat stores. Achieving optimal weight gain during pregnancy is associated with improved outcomes for the mother and the baby regardless of the mother's existing BMI.^[2]

The IOM guidelines recommend a total weight gain of about 9.5–18 kg in a woman of normal BMI,^[3] 6.8–11.3 kg (15–25 lb) for overweight women, and 5–9.1 kg (11–20 lb) in obese women.^[3]

Maternal obesity has become one of the most commonly occurring risk factors in obstetric practice. Obesity in pregnancy is usually defined as a BMI of ≥30 kg/m² at the

first antenatal consultation. There are three different classes of obesity: BMI 30.0–34.9 (Class I); BMI 35.0–39.9 (Class 2); and BMI ≥40 (Class3 or morbid obesity).^[4] The worldwide prevalence of obesity had been increased more than double between 1980 and 2014, particularly among women of childbearing age.^[1]

In addition to the adverse effect on the maternal and fetal outcome, obesity has a negative impact on ultrasound evaluation of fetal structures. Approximately 15% of normally visible structures will be suboptimally seen in women with a BMI above 30 kg/m². In women with a BMI above 40 kg/m², only 63% of structures are well visualized. The anatomic structures commonly less well seen with increasing BMI include the fetal heart, spine, kidneys, diaphragm, and umbilical cord.^[5]

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Access this article online

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Website:
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DOI:
10.4103/MJ.MJ_29_18

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How to cite this article: Alizzi FJ, Ahmad B. Impact of maternal body mass index on umbilical artery indices and neonatal outcome. Mustansiriya Med J 2018;17:93-7.

Underweight is defined as pre-BMI $<18.5 \text{ kg/m}^2$. The prevalence of underweight is low in developed countries, but it remains high in developing countries.^[6]

Underweight women who become pregnant are at a higher risk for delivery of low birth weight infants, retarded fetal growth, and perinatal mortality. Prepregnancy underweight is also associated with a higher incidence of various pregnancy complications, such as antepartum hemorrhage, premature rupture of membranes, anemia, and cesarean delivery.^[7]

The use of Doppler ultrasound allows the assessment of the velocity of blood within fetal and placental vessels and provides an indirect assessment of fetal and placental condition. Umbilical artery (U.A) Doppler velocimetry measurement is widely used to monitor high-risk pregnancies and is considered to be the best method of fetal surveillance available. The use of U.A Doppler velocimetry in high-risk pregnancies showed a significant reduction in the number of antenatal admissions, inductions of labor, and cesarean sections (C/Ss) for fetal distress and reduction in perinatal deaths.^[8]

The indices of UA Doppler (pulsatility index [PI], resistance index [RI], systolic-diastolic ratio [SDR]) have been found to decline gradually with gestational age due to the maturation of placenta and increase numbers of stem villi with a progressive rise in the end-diastolic velocity.^[9]

Many studies showed that obesity is associated with increased risk of many pregnancy complications, but it remains uncertain that obesity *per se* increases the risk of adverse pregnancy outcome,^[10-13] and there are very few studies discussing the effect of BMI on U.A Doppler indices.^[14]

The aim of our study was to clarify the relationship between maternal BMI and U.A indices and to evaluate the effect of maternal BMI on the neonatal outcome.

PATIENTS AND METHODS

This prospective, cohort study was conducted at Al-Yarmouk Teaching Hospital from February 2016 to August 2016 after approval by the committee of Iraqi Board of Obstetrics and Gynecology, and informed consent was obtained from the entire participants. One hundred and twenty-three pregnant women aged between 18 and 35 years at 32 weeks of gestation were enrolled in our study. The gestational age was confirmed by the last menstrual period and early first-trimester ultrasound.

All of those women were seen in outpatients clinic of Al-Yarmouk Teaching Hospital, and follow-up was done twice per week until their time of delivery. Uncomplicated pregnancies with a single viable fetus at 32 weeks of gestation were included. Maternal complications (hypertension, diabetes, and anemia) and fetal complications (congenital anomaly, intrauterine growth restriction, intrauterine demise), smoking, RH incompatibility, multiple pregnancies, previous C/S, and preterm labor were excluded. Full history and examination and baseline investigations (blood group, Hb,

General Urine Examination (GUE), random blood sugar) were obtained from each woman. Data were collected about height and weight, and BMI was calculated according to the formula: weight in kg/(height in m²). The women were divided according to BMI into four groups: Group 1-underweight BMI $<18.5 \text{ kg/m}^2$ include two women. Group 2-normal weights BMI $18.5\text{--}24.9 \text{ kg/m}^2$ include 62 women. Group 3-overweight BMI $25.0\text{--}29.9 \text{ kg/m}^2$ include 33 women. Group 4-obese BMI $\geq 30 \text{ kg/m}^2$ include 26 women. In Group 1, there were only two women underweight, so we exclude them from our study. The ultrasonographic evaluation (R7, Samsung, Korea) was done in Al-Yarmouk outpatient ultrasound clinic to all women to assess fetal biometry (biparietal diameter, head circumference, abdominal circumference, and femoral length) and to exclude congenital fetal anomalies. Pulsed wave Doppler ultrasound examination of the U.A was performed using color Doppler (GE 700 MR with 3.5 MHz convex probe). The U.A was identified, and flow velocity waveforms were obtained from the free-floating loop of the umbilical cord during fetal quiescence. The angle between the ultrasound beam and the direction of the blood flow was less than 60°.

Doppler waveform indices were calculated from the maximum velocity waveform with the following computerized planimetry: PI = (peak systolic velocity end-diastolic velocity)/time-averaged maximum velocity, RI = (peak systolic velocity end-diastolic velocity)/peak systolic velocity, and SDR = peak systolic velocity/end-diastolic velocity.

All women had been followed till the time of delivery; the outcome of pregnancy was noted and included gestational age at the time of delivery, mode of delivery, neonatal birth weight, and Apgar score in 5 min.

Statistical analysis

All data were analyzed using SPSS 20.0 software (IBM, Armonk, NY, USA) and Minitab® 17.1.0 software (Pennsylvania, USA); *P* value was considered to be significant if it was less than 0.05. One-way ANOVA used to compare between more than two groups for parametric data, while Kruskal–Wallis test used for nonparametric data. Chi-square test used to compare between discrete variables

Quadratic polynomial regression analysis was used to test the correlation between two variables, and its correlation coefficient was used as measure the direction of the relationship (positive sign mean direct while negative sign mean inverse relationship), and the magnitude of the relationship (<0.25 weak, $0.25\text{--}0.49$ mild, $0.5\text{--}0.74$ moderate, and >0.75 strong relationship).

RESULTS

The current study had included 121 pregnant women presented to the obstetrics and gynecology department at their 32 weeks of gestation. The mean age was 26.7 years ranging from 18 to 35 years; there was no significant difference between the three groups; the mean of gestational

Table 1: Maternal demographic characters

Variables	Normal BMI (n=62)	Overweight women (n=33)	Obese women (n=26)	All (n=121)	P
Maternal age (mean±SD)	26.8±5.6	26.5±5.1	26.7±5.2	26.7±5.3	0.968
Parity (1–6), median	2 (1-3)	2 (1-4)	1 (1-2)	2 (1-3)	0.189
Null parity, n (%)	27 (43.5)	13 (39.4)	15 (57.7)	55 (45.5)	0.341
Gestational age at delivery (mean±SD)	38.9±1.4	39.2±1.4	39.2±1.3	39.1±1.4	0.515

BMI: Body mass index, SD: Standard deviation

Table 2: Pulsatile index of the women in three groups

	Normal	Overweight	Obese	All	P
PI (mean±SD)	0.79±0.08	0.95±0.10	1.07±0.09	0.89±0.14	<0.001
RI (mean±SD)	0.61±0.08	0.74±0.12	0.82±0.12	0.69±0.13	<0.001
SDR (mean±SD)	2.64±0.50	3.30±0.76	3.45±0.68	3.00±0.72	<0.001

One-way ANOVA. PI: Pulsatility index, RI: Resistance index, SDR: Systolic-diastolic ratio, SD: Standard deviation

Table 3: Correlation between pulsatility index, resistance index, systolic-diastolic ratio and body mass index

UA	R	R ²	P
PI	0.775	0.601	<0.001
RI	0.645	0.416	<0.001
SDR	0.495	0.245	<0.001

R, R²: Quadric polynomial regression. PI: Pulsatility index, RI: Resistance index, SDR: Systolic-diastolic ratio, UA: Umbilical artery

age at delivery was 39.1 ± 1.4 weeks ranging from 37 to 41 weeks; and no significant difference between gestational ages with BMI was observed. Regarding parity ranges from 1 to 6 parity with a median of two parties, no difference between each BMI was found in the distribution of parity as illustrated in Table 1.

In Table 2, we can see the correlation between U.A indices and BMI. Obese women had significantly higher PI, RI, and SDR compared to both overweight and normal weight groups ($P < 0.001$); PI, RI and SDR was not significantly different between overweight and normal weight group, as illustrated in Table 2.

In our study, we use quadric polynomial regression model to determine the relationship between PI and BMI because the coefficient of determination (R^2) was higher in that model, in which as BMI increases, the PI will increase [Table 3], as illustrated in the next equations:

- $PI = -0.16 + 0.06 \text{ BMI} - 0.0007 \text{ BMI}^2$
- $RI = 0.0091 + 0.03613 \text{ BMI} - 0.000371 \text{ BMI}^2$
- $SDR = -1.296 + 0.2581 \text{ BMI} - 0.003451 \text{ BMI}^2$

In Table 4, we can see the neonatal characteristics and mode of delivery. Obese women had slightly elevated birth weight at delivery; however, there was no significant difference between the three groups. Obese women had significantly lower Apgar score at 5 min compared to both normal and overweight; also, the proportion of women with Apgar score ≤ 7 is higher in obese women.

In our study, 73.6% of women had vaginal delivery (VD), and 26.4% had C/S delivery, C/S significantly associated with obese women, and VD associated with normal weight, as illustrated in Table 4.

The quadric polynomial regression is the best model for describing the relationship between SDR and Apgar score at 5 min, in which as SDR increases, Apgar score 5 min decreased (inverse relationship), as illustrated in Table 5.

$SDR = 5.359 - 0.4971 \text{ Apgar score 5 min} + 0.02515 \text{ Apgar score 5 min}^2$.

Table 6 shows the indications of C/S in obese women; failure of progress in the first and second stages of labor constitute two-thirds of the causes of C/S.

DISCUSSION

Obesity is a major global public health problem that has received much attention for the past two decades. It is associated with adverse health problems for mother and fetus. The prevalence of obesity has increased dramatically in recent decades.^[1]

This study included 121 pregnant women with mean age 26.7 years ranging from 18 to 35 years; we exclude the women more than 35 years intendedly to eliminate the possible effect of maternal age on U.A indices. The current study showed no significant difference in maternal ages, parity, and weeks of gestation at the time of delivery between the three groups.

In our study of women with a normal weight, the mean of PI, RI, and SDR of U.A was 0.79, 0.61, and 2.62, respectively; this agrees with the results of Pharuhas *et al.* in 2000, who did a study on U.A waveform in normal pregnant women and found that the mean indices of U.A at 32 weeks were RI 0.646, PI 1.05, and SDR 2.71, respectively;^[15] also agrees with the results of Acharya *et al.* in 2004, who did a study on U.A indices at 32 weeks and found that the mean of PI was 0.75, RI was 0.61, and SDR was 2.61,^[16] and regarding obese women, the mean of PI, RI, and SDR was significantly higher in comparison with normal and overweight women as $P < 0.001$; and agrees with Sarno *et al.*, who did a study on 185 normal, uncomplicated pregnant women at 2014 and found that the mean of PI of U.A at 32 weeks was significantly higher in obese women, i.e., 0.95 ± 0.01 , while in overweight was 0.87 ± 0.01 and in normal weight was 0.67 ± 0.01 as $P < 0.05$.^[14]

Furthermore, our study agrees with Kovalchuk *et al.*, who did a study in 2016 and found higher SDRs of U.A in the obese

Table 4: Neonatal characteristics and mode of delivery

	Normal (n=62)	Overweight (n=33)	Obese (n=26)	All (n=121)	P
Birth weight (kg), mean±SD	3.49±0.37	3.48±0.45	3.70±0.39	3.53±0.41	0.054
Apgar 5 min	8.8±0.8	9.0±1.0	6.9±1.4	8.5±1.3	<0.001
>7	49	24	11	104	-
≤7	13	9	15	17	-
Mode of delivery (%)					
NVD	54 (87.1)	25 (75.8)	10 (38.5)	89 (73.6)	<0.001
C/S	8 (12.9)	8 (24.2)	16 (61.5)	32 (26.4)	

One-way ANOVA test. NVD: Normal vaginal delivery, C/Ss: Cesarean sections, SD: Standard deviation

Table 5: Correlation between systolic diastolic ratio and Apgar score 5 min

Model	R	R ²	P
Quadric	-0.199	0.04	0.092

R, R²: Quadric polynomial regression

Table 6: Indications of cesarean sections in obese women

Indications	n=16, n (%)
Failure of progress in the first stage	6 (37.5)
Failure of descending in the second stage	5 (31.25)
Meconium staining with fetal distress	3 (18.75)
Chorioamnionitis in the latent phase	2 (12.5)

group in comparison with normal BMI group (3.6 ± 0.01 and 2.4 ± 0.03 , respectively; $P < 0.050$); also, RI values of U.A revealed a dropping in fetal blood circulation of obese group 0.8 ± 0.1 and 0.6 ± 0.07 in the normal BMI group ($P < 0.050$).^[17]

In our study, we found that PI of U.A was more of value than RI and SDR value because the coefficient of determination (r) was higher in PI 0.775 while in RI and SDR 0.645 and 0.495, respectively.

In our study, obese patient had significantly lower 5 min Apgar score (less than 7) compared to both overweight and normal weight; this agrees with Chen *et al.*'s study in 2010, who found that maternal obesity was significantly associated with increased risk for decreased 5 min Apgar score but not achieve significant correlation in overweight women.^[18] Zhu *et al.* in 2015 found that there was a strong correlation between low Apgar score and obese women with $P < 0.001$.^[19]

Chalouhi *et al.* in 2013 did a study on the effect of maternal BMI on 5 min Apgar score and blood gas analysis of 100 pregnant women and found no significant difference in 5 min Apgar score and blood gas parameters of U.A at delivery in normal and obese women.^[20] This disagreement might be due to the absence of randomization and differences in neonatal resuscitation.

In our study, we found a strong inverse correlation between SDR of U.A and 5 min Apgar score ($r = 0.199$) means when

SDR increases, 5 min Apgar score decreases; this agrees with Brar *et al.* in 1989, who found that after 30 weeks of gestation, SDR should be less than 3, so when SDR more than 3 was significantly related to an increase incidence of small for gestational age, infant present of meconium staining, rate of C/S, and 5 min Apgar score less than 7;^[21] also agrees with Deveno *et al.* in 1992 which was found increase in SDR even within the institutional (normal) range may indicate fetus at increased risk of mortality, fetal distress, 5 min Apgar score below 7, metabolic acidosis, and neonatal intensive care unit admissions.^[22]

In our study, obese women had slightly higher birth weight of neonate with mean od 3.70 kg and standard deviation of 0.39 kg than the normal and overweight women, however; it failed to reach statistically significant ($P = 0.543$), although obese women are predicted to give bigger babies as in many studies as Kiran *et al.*^[23] and Hayward *et al.*^[24] Hence, our finding suggests that the neonate of obese women may be growth restricted due to placental hypoxia, and this finding was supported by Morales-Roselló *et al.* in 2014, who showed that a fetus does not have to be small to be growth impaired and fetal Doppler indices had given more clue than fetal size for placental insufficiency, fetal hypoxemia, and failure to reach the potential growth,^[25] and also supported by Hehir *et al.*, who found that in obese women, U.A tone is altered due to secretory product of adipose tissue and causing adverse effects on the fetoplacental vasculature.^[26] Regarding the mode of delivery, the current study found that C/S significantly increased in obese women in comparison with others as $P = 0.001$; this agrees with Kiran *et al.*'s study which found that the rate of C/S was 1.6 times higher than vaginal delivery in obese women,^[23] and also agrees with Doherty *et al.* in 2006 and Abenhaim and Benjamin in 2011; both of them were found significant correlation between obesity and increase risk of C/S.^[27,28] Fyfe *et al.* in 2011 found that the rate of C/S in the first stage of labor was double in obese women independent of other recognized risk factors for C/S delivery.^[29] In addition, Berendzen and Howard found an increased rate of C/S delivery as maternity BMI increased.^[30]

CONCLUSION

The current study showed the negative impact of increasing BMI on fetoplacental circulation and increased risk of C/S. Neonates of obese mothers had low 5 min Apgar score.

Recommendations

Prepregnancy BMI and weight gain during pregnancy should be considered in the evaluation of U.A Doppler indices. Further studies with large sample should be performed to confirm our study and to show the relationship between maternal BMI with each week of gestational age and to extend this analysis to the other fetoplacental vessels and to pathologic fetuses.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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