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Does predelivery body mass index really matter in pregnancy?

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ABSTRACT

Objectives: The aim of the study was to compare the perinatal outcome between the normal weight, overweight and obese pregnant women who delivered in the third-level center of reference. Moreover, the objective was to analyze the usefulness of predelivery body mass index (BMI) in prediction of preterm delivery, prolonged second stage of labor, instrumental vaginal delivery, cesarean section, fetal macrosomia, dystocia and newborn acidosis.

Material and methods: The retrospective study included 2104 patients, divided into three groups, with BMI between 18.5 and 24.9; 25.0 and 29.9; higher than or equal 30.0 kg/m^2, respectively. The data were assessed from the medical history.

Results: The predelivery obesity increases the risk of cesarean section (aOR 1.63), macrosomia (aOR 8.89) and dystocia (aOR 3.40) in comparison to normal weight women. Moreover, the obese females had three times greater risk of having a macrosomic child (aOR 3.57) and 1.5 times greater risk of cesarean section (aOR 1.52) than overweight group. The role of predelivery BMI in the prediction of cesarean delivery (AUC 0.550; sensitivity 0.39; specificity 0.71, $p < 0.001$, cut-off value 28.7 kg/m^2), macrosomia (AUC 0.714; sensitivity 0.66; specificity 0.70; $p < 0.001$, cut-off value 29.0 kg/m^2) and dystocia (AUC 0.658; sensitivity 0.77; specificity 0.53, $p < 0.001$, cut-off value 27.0 kg/m^2) was significant.

Conclusions: The predelivery obesity increases the risk of cesarean section, macrosomia and shoulder dystocia and is a useful parameter in the prediction of perinatal outcomes. The establishing cut-off value for predelivery BMI was the lowest in prediction of shoulder dystocia.

Key words: predelivery body mass index; perinatal outcomes; maternal obesity; maternal overweight; newborn weight; cesarean section

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INTRODUCTION

According to the World Health Organization (WHO) report, the worldwide prevalence of obesity nearly tripled between 1975 and 2016 and it is considered a global epidemic [1]. Approximately 27% and 37% of reproductive-aged women in the United States are overweight and obese, respectively [2–4]. One of the main reasons for so high widespread, which has influenced the economic condition of health system worldwide, is the modern lifestyle related to an unbalanced calorie intake and insufficient physical activity [5]. That exposes most fetuses to maternal overnutrition and high-fat diet during the key period of *in utero* development [6]. Despite the overweight and obesity rates are lower in Europe, the trend is also increasing, suggesting occurrence of maternal obesity above 20% in six European countries [7]. Moreover, about 50–60% of overweight and obese pregnant women gain on weight more than Institute of Medicine recommends, what leads to the postpartum weight retention, later cardiovascular diseases and inappropriate body mass index (BMI) in future pregnancies [8].

Several studies underline the influence of high maternal BMI in pregestational or gestational period on obstetric and post-partum complications, such as gestational diabetes mellitus (GDM) [9, 10], pregnancy induced hypertension (PIH), preeclampsia (PE) [11, 12], cesarean sections [13],

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urinary and genital tract infections, post-partum wound infection, chorioamnionitis [14–16], venous thromboembolism [17], breastfeeding difficulties [18] and depression [19].

Despite many perinatal and post-partum consequences, the maternal obesity impacts also fetal programming and effects in offspring disorders [20]. It increases the neonatal morbidity because of preterm deliveries and congenital anomalies [8] but also in future life offspring are themselves at higher risk of obesity and cardiometabolic morbidity [21, 22]. As mentioned above, maternal obesity increases the risk of GDM, what correlates positively with adiposity in both young and adult offspring. Saucedo et al. found that maternal adipokines and inflammatory cytokines secreted from adipose tissue in GDM, such as C-reactive protein (CRP), monocyte chemotactic protein-1 (MCP-1) and tumor necrosis factor-alpha (TNF-alpha), may regulate fetal growth [23].

The long-term consequences of prenatal and lactational exposure to maternal excessive weight and inappropriate nutrition are psychiatric and neurodevelopmental offspring's diseases which include cognitive impairment, autism spectrum disorders, attention deficit hyperactivity disorder, cerebral palsy, anxiety, depression, schizophrenia and eating disorders [24]. Furthermore, the maternal obesity affects the maturation and development of the newborn immune system increasing the susceptibility to pathogens, changing the vaccines response and resulting in immunopathological disturbances, such as development of asthma or allergy [25].

Objectives

The aim of this study was to compare the perinatal outcome between the normal weight, overweight and obese pregnant women, who delivered in the third-level reference center. Moreover, the objective was to evaluate predelivery BMI in prediction of preterm delivery, prolonged 2nd stage of labor, instrumental vaginal delivery, cesarean section, fetal macrosomia, dystocia, and newborn acidosis. Furthermore, the risk of preterm labor, cesarean delivery, macrosomia, and dystocia was assessed.

MATERIAL AND METHODS

The retrospective study included 2104 women, who gave birth to a child in the Obstetrics and Gynecology Hospital of Medical Sciences University in Poznan. The patients were divided according to predelivery BMI into three age-matched groups, as follows: the I group consisted of 614 women with BMI between 18.5 and 24.9, the II group included 964 patients with BMI ranged 25.0 to 29.9 and the III group was composed of 526 females with BMI equal or greater than 30.0 kg/m^2. The BMI was measured in the antepartum period, what constitutes some limitation of the study due to the lack of established norms for BMI in pregnancy. The gravidity and parity were comparable between groups.

The characteristics of study groups are presented in the Table 1. The data were collected from medical history. The analyzed parameters included age, predelivery BMI,

Table 1. The general characteristics of study groups

Characteristics	Group I (n = 614)	Group II (n = 964)	Group III (n = 526)	p
Age [years] (Mean ± SD)	30 ± 5	31 ± 5	31 ± 5	* ns ** ns *** ns
Predelivery BMI [kg/m^2]	23.3 ± 1.3	27.2 ± 1.4	33.5 ± 3.5	* **< 0.01** ** **< 0.01** *** **< 0.01**
Gravidity (n) (Median, Min-Max)	2 (1–7)	2 (1–11)	2 (1–8)	* ns ** ns *** ns
Parity (n) (Median, Min-Max)	0 (0–6)	0 (0–9)	1 (0–5)	* ns ** ns *** ns
PIH [%]	1.1	2.3	11.6	* **< 0.05** ** **< 0.0001** *** **< 0.0001**
GDM [%]	6.0	7.6	8.8	* ns ** ns *** ns
FGR [%]	3.3	2.3	2.9	* ns ** ns *** ns

SD — standard deviation; ns — not significant; BMI — body mass index; PIH — pregnancy induced hypertension; GDM — gestational diabetes mellitus; FGR — fetal growth restriction

pregnancy complications such as PIH, GDM, fetal growth restriction (FGR), the term and mode of delivery, duration of the 1st and the 2nd stage of labor, perinatal blood loss, perinatal hemorrhage, perineal incision and rupture, newborn weight, Apgar score, umbilical venous and artery pH and base excess (BE). The gestational age was set according to the last menstrual period or ultrasound examination from the 1st trimester of pregnancy. The preterm delivery was diagnosed between 22 and 36 + 6-weeks' gestation. The prolonged second stage of labor was defined as: for nulliparous women > 3 h with epidural anesthesia or > 2 h without it, for multiparous women > 2 h with epidural anesthesia or > 1 h without it. The postpartum hemorrhage was determined as blood loss of equal or more than 500 mL during spontaneous or assisted vaginal delivery and equal or more than 1000 mL during cesarean section. The macrosomia was diagnosed as the birth weight equal or above 4500 g. The newborn acidosis was diagnosed as umbilical arterial pH below 7.2.

The statistical analysis was performed in GraphPad InStat 3, Statistica StatSoft 13.1, MedCalc 19.5.3 and PQStat 1.8.0. The Kruskal-Wallis test (nonparametric ANOVA) with subsequently Dunn's Multiple Comparisons was used to analyze the results in interval and ordinal scale. Mean (M) and standard deviation (SD) were used to describe the interval variables, while Median, Minimum (Min), Maximum (Max) value referred to ordinal data. The results in nominal scale were analyzed using the Chi-square test and presented in percentages. The regression analysis was described using coefficient of multiple correlation (R) and adjusted coefficient of determination (R^2_{adj}). The unadjusted odds ratios (ORs) and adjusted odds ratios (aOR) were calculated using logistic regression and the Wald Chi-square test. The 95% confidence interval (95% CI) was designated to estimate the precision of the ORs and aORs. The usefulness of predelivery BMI in the prognosis of preterm delivery, prolonged second stage of labor, instrumental vaginal delivery, cesarean section, fetal macrosomia, dystocia, and newborn acidosis was specified with receiver operating curve (ROC). The prediction analysis concerned area under curve (AUC), sensitivity, specificity, and cut-off value. The significance level for all calculations was assumed as p-value below 0.05.

RESULTS

The normal weight women delivered significantly earlier comparing to overweight (38.3 ± 2.6 vs 38.7 ± 2.4 weeks, $p < 0.001$), and obese females (38.3 ± 2.6 vs 38.7 ± 2.2 weeks, $p < 0.001$). The frequency of preterm labor was statistically higher among normal weight group comparing to the overweight one (11.4 vs 6.9%, $p < 0.01$) (Tab. 2).

The spontaneous vaginal delivery occurred significantly more often in group I comparing to III (60.3 vs 47.5%, $p < 0.0001$), and in group II comparing to III (57.1 vs 47.5%, $p < 0.001$). The incidence of instrumental vaginal deliveries did not differ between groups. Cesarean sections were observed significantly more often in the obese group compared to normal weight (42.6 vs 32.4%, $p < 0.001$), and overweight females (42.6 vs 32.4%, $p < 0.0001$) (Tab. 2).

The first stage of labor lasted significantly longer in overweight women compared to the obese ones (4.6 ± 4.0 vs 4.1 ± 4.3 hours, $p < 0.05$). The second stage of labor was also longer in group II when compared to the I (36 ± 34 vs. 33 ± 34 minutes, $p < 0.05$) (Tab. 2).

In the obese patients, greater perinatal blood loss was noticed compared to the normal weight women (356 ± 154 vs 321 ± 132, $p < 0.001$). The incidence of postpartum hemorrhage, perineal incision and perineal rupture was comparable between groups (Tab. 2).

The newborns of obese mothers had significantly higher birth weight compared to overweight (3451 ± 648 vs 3383 ± 560 g, $p < 0.05$), and normal weight group (3451 ± 648 vs 3197 ± 616 g, $p < 0.001$). Also, overweight women gave birth to larger children compared to females with normal predelivery BMI (3383 ± 560 vs 3197 ± 616 g, $p < 0.001$) (Tab. 3). In regression analysis, the birth weight was dependent on predelivery BMI and gestational age at delivery ($R = 0.65$, $R^2_{adj} = 0.43$, $p < 0.000001$).

The frequency of 5-minute Apgar score < 7 points was comparable in all analyzed groups. The newborns of normal weight mothers more often showed the 1-minute Apgar < 7 points than those from overweight group (6.0 vs 3.9%, $p < 0.05$). Though, the offspring of normal weight women had higher arterial pH (7.26 ± 0.09 vs 7.25 ± 0.08, $p < 0.05$) compared to overweight group. Furthermore, the newborns of normal weight females had significantly higher venous (7.34 ± 0.08 vs 7.33 ± 0.09, $p < 0.01$), and arterial pH (7.26 ± 0.09 vs 7.25 ± 0.08, $p < 0.05$) compared to the group with obesity. The umbilical venous or arterial BE, and the incidence of newborn acidosis did not differ between groups (Tab. 3).

The overweight (aOR = 0.55; $p < 0.01$) females, in the multivariable logistic regression model controlling for PIH and FGR, had nearly 40% reduced chance of preterm delivery, if we compared to normal weight group. Significant difference in occurrence of preterm delivery was also observed between the group III and I. The obese women were approximately 40% less likely to deliver prematurely (aOR = 0.59; $p < 0.05$) (Tab. 4). After adjustment for gestational age at delivery, PIH and FGR, the logistic regression analysis revealed that predelivery BMI ≥ 30.0 kg/m^2 was independent predictive factor for cesarean delivery com-

Table 2. Comparison of labor outcomes between study groups

Parameters	Group I (n = 614)	Group II (n = 964)	Group III (n = 526)	p
Gestational age at delivery [weeks]	38.3 ± 2.6	38.7 ± 2.4	38.7 ± 2.2	* **< 0.001** ** **< 0.001** *** ns
Preterm delivery [%]	11.4	6.9	8.6	* **< 0.01** ** ns *** ns
Spontaneous vaginal delivery [%]	60.3	57.1	47.5	* ns ** **< 0.0001** *** **< 0.001**
Instrumental vaginal delivery [%]	9.3	12.1	10.8	* ns ** ns *** ns
Cesarean section [%]	32.4	32.4	42.6	* ns ** **< 0.001** *** **< 0.0001**
1st stage of labor [hours]	4.1 ± 3.6	4.6 ± 4.0	4.1 ± 4.3	* ns ** ns *** **< 0.05**
2nd stage of labor [min]	33 ± 32	36 ± 34	33 ± 32	* **< 0.05** ** ns *** ns
Prolonged 2nd stage of labor [%]#	2.4	2.8	3.3	* ns ** ns *** ns
Perineal incision [%]#	63.6	67.5	62.2	* ns ** ns *** ns
Perineal rupture [%]#	6.0	9.2	9.8	* ns ** ns *** ns
Blood loss [mL]	321 ± 132	342 ± 161	356 ± 154	* ns ** **< 0.001** *** ns
Postpartum hemorrhage [%]	5.1	6.9	5.7	* ns ** ns *** ns

*comparison between groups I–II; **comparison between groups I–III; ***comparison between groups II–III; #it refers to vaginal deliveries

pared to overweight (aOR = 1.52, $p < 0.001$), and normal BMI (aOR = 1.63, $p < 0.001$) (Tab. 4). Moreover, the logistic regression, after correction for gestational age at delivery, showed that obese females were nearly 9-fold (aOR = 8.89, $p < 0.01$) more likely to deliver a macrosomic newborn, when we compared to normal weight women, and about 3.5-fold (aOR = 3.57, $p < 0.01$) more probable than overweight ones (Tab. 4). The predelivery obesity was also associated, after adjustment for gestational age at delivery and macrosomia, with more than 3-fold (aOR = 3.40, $p < 0.05$) higher chance of shoulder dystocia than normal predelivery BMI group (Tab. 4).

The role of predelivery BMI in the prediction of cesarean delivery (AUC 0.550; sensitivity 0.39; specificity 0.71, $p < 0.001$, cut-off value 28.7 kg/m^2) (Fig. 1), fetal macrosomia (AUC 0.714; sensitivity 0.66; specificity 0.70; $p < 0.001$, cut-off value 29.0 kg/m^2) (Fig. 2), and shoulder dystocia (AUC 0.658; sensitivity 0.77; specificity 0.53, $p < 0.001$, cut-off value 27.0 kg/m^2) (Fig. 3) was found. The predelivery BMI was not useful in the prognosis of preterm delivery, prolonged second stage of labor, instrumental vaginal delivery, and newborn acidosis.

DISCUSSION

Although the relationship between perinatal outcome, and prepregnancy BMI or gestational weight gain has been defined, only a few studies analyzed the impact of maternal BMI in the antenatal period on labor, and neonatal outcome.

Table 3. Comparison of neonatal outcomes between study groups

Parameters	Group I (n = 614]	Group II (n = 964]	Group III (n = 526]	p
Birth weight [g]	3197 ± 616	3383 ± 560	3451 ± 648	* **< 0.001** ** **< 0.001** *** **< 0.05**
1-minute Apgar < 7 points [%]	6.0	3.9	4.4	* **< 0.05** ** ns *** ns
5-minute Apgar < 7 points [%]	3.8	2.3	2.5	* ns ** ns *** ns
Umbilical venous pH	7.34 ± 0.08	7.33 ± 0.08	7.33 ± 0.09	* ns ** **< 0.01** *** ns
Umbilical venous BE	–3.67 ± 3.04	–3.99 ± 3.00	–3.87 ± 2.88	* ns ** ns *** ns
Umbilical arterial pH	7.26 ± 0.09	7.25 ± 0.08	7.25 ± 0.08	* **< 0.05** ** **< 0.05** *** ns
Umbilical arterial BE	–4.15 ± 3.37	–4.35 ± 3.35	–4.23 ± 3.49	* ns ** ns *** ns
Newborn acidosis [%]	23.9	28.2	25.7	* ns ** ns *** ns

* comparison between groups I–II; ** comparison between groups I–III; *** comparison between groups II–III; BE — base excess

Table 4. The association between predelivery BMI and perinatal outcomes expressed as the ORs and aORs for obese and overweight women

Parameters	III vs II		III vs I		II vs I	
	OR (95% CI) p-value	aOR (95% CI) p-value	OR (95% CI) p-value	aOR (95% CI) p-value	OR (95% CI) p-value	aOR (95% CI) p-value
Preterm delivery	1.25 (0.85–1.86) ns	1.08 (0.71–1.64) ns	0.73 (0.49–1.08) ns	0.59 (0.39–0.91) **< 0.05**	0.58 (0.41–0.82) **< 0.01**	0.55 (0.38–0.78) **< 0.01**
Cesarean section	1.55 (1.24–1.93) **< 0.0001**	1.52 (1.21–1.90) **< 0.001**	1.55 (1.22–1.97) **< 0.001**	1.63 (1.26–2.10) **< 0.001**	0.99 (0.80–1.24) ns	1.07 (0.85–1.34) ns
Macrosomia	2.89 (1.35–6.23) **< 0.01**	3.57 (1.57–8.09) **< 0.01**	6.80 (1.98–23.34) **< 0.01**	8.89 (2.03–38.82) **< 0.01**	2.35 (0.65–8.46) ns	2.49 (0.53–11.59) ns
Dystocia	1.62 (0.78–3.34) ns	1.80 (0.82–3.96) ns	4.17 (1.36–12.75) **< 0.05**	3.40 (1.08–10.62) **< 0.05**	2.57 (0.86–7.74) ns	1.88 (0.60–5.81) ns

Models controlling for: preterm delivery — PIH, FGR; cesarean section — gestational age at delivery, PIH, FGR; macrosomia — gestational age at delivery; dystocia — gestational age at delivery, macrosomia; OR — odds ratios; CI — confidence interval; aOR — adjusted odds ratios

In addition, some researchers focused mainly on the super obesity defined as the BMI > 50 kg/m^2 or weight > 140 kg at any point of pregnancy in 20 or more weeks of gestation [26–28].

We proved the role of predelivery BMI in the prediction of cesarean section but the sensitivity was very low (39%) and specificity was 71%. The cut-off value was set as BMI 28.7 kg/m^2. Morais et al. [29] observed higher risk of cesar-

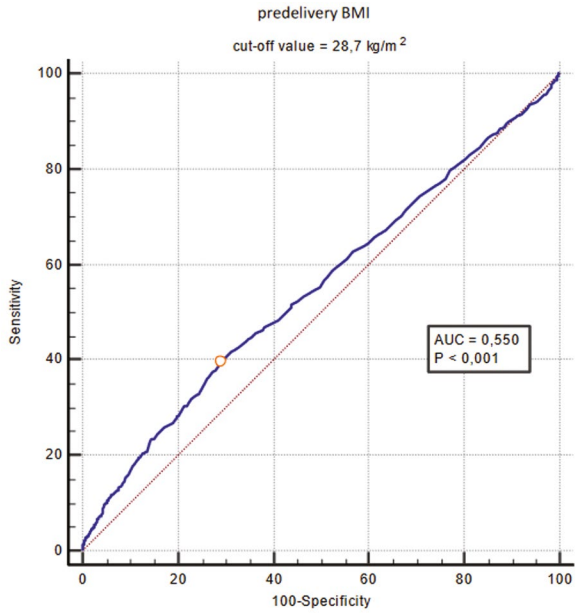

Figure 1. Predelivery body mass index in the prediction of cesarean section; AUC — area under curve

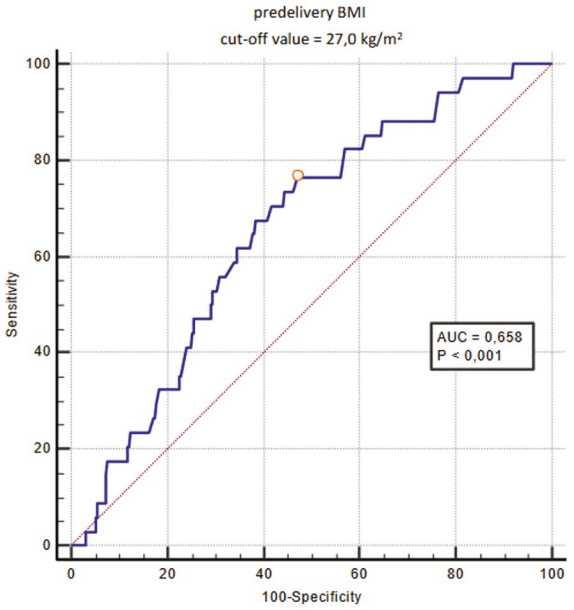

Figure 3. Predelivery body mass index in the prediction of shoulder dystocia; AUC — area under curve

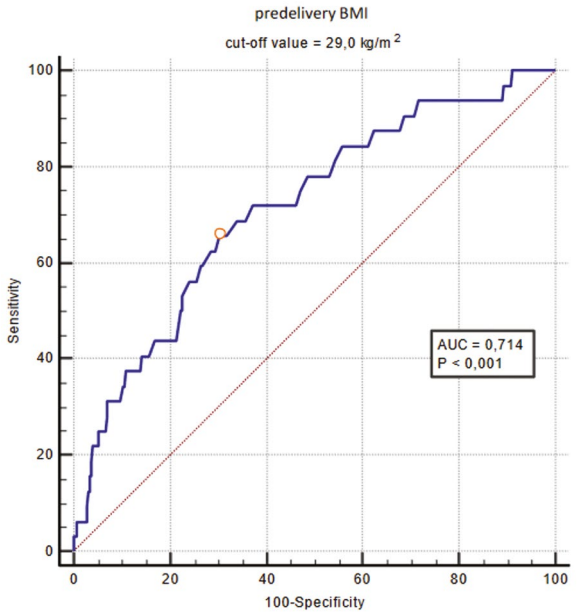

Figure 2. Predelivery body mass index in the prediction of fetal macrosomia (birth weight ≥ 4500 g); AUC — area under curve

ean section (OR = 1.97) in women, who were classified as normal weight on the first prenatal visit, and until the last prenatal examination, increased in the BMI classification. Also, firstly overweight patients, who significantly gained on weight during pregnancy and became obese, had a higher chance of cesarean delivery (OR = 2.28) comparing to constantly overweight women [29]. In our study, obesity raised the chance of cesarean delivery nearly 1.5-fold comparing to as well overweight (aOR = 1.52) or normal weight women (aOR = 1.63). Arora et al. [30] also noticed the association between predelivery BMI, and higher risk of cesarean section. The authors emphasized that high prepregnancy BMI or high gestational weight gain stronger affected the risk of cesarean delivery. Sullivan et al. [27] observed, in extremely obese women, the higher risk of obstetric complications (aOR = 2.42), including higher frequency of cesarean delivery (51.6 vs 31.7%) comparing to the representative group for general population in Australia and New Zealand. The McCall's et al. [26] international collaborative study proved the significantly higher chance of cesarean section in the group of women with super obesity (aOR = 2.77). Alanis et al. [28] presented similar results, and observed the highest rate of cesarean delivery among extremely obese patients comparing to less obese women (56.0 vs 30.9%, aOR = 2.86).

Neonatal macrosomia is diagnosed in about 10% of all pregnancies, what is much higher incidence than in our study (1.5%). In the literature there are several definitions of macrosomia. Birth weight of 4000–4500 g or greater than 90th percentile for gestational age (with correction for neonatal sex, and ethnicity) is presented. This can lead to discrepancies in the assessment of the frequency of this pathology. Moreover, several studies refer to the frequency of the prenatally diagnosed macrosomia, but this condition must be obligatory confirmed after delivery [31]. The obese, and overweight women delivered newborns of higher birth weight, which was associated with predelivery BMI and gestational age at delivery. Our research revealed the useful-

ness of predelivery BMI in the prognosis of fetal macrosomia with sensitivity of 66%, and specificity of 70%. The cut-off value was set as maternal BMI equal 29.0 kg/m^2. Asplund et al. reported the incidence of macrosomic newborns about 15.6%. 86.2% of these mothers had equal or greater than 25% increase in BMI during pregnancy. These raises of maternal BMI revealed sensitivity of 86.2% and specificity of 93.6% in prediction of macrosomia. After adjustment for maternal age, race, parity, and gravidity, these women had more than 200 times (aOR = 219.3) higher probability for delivering macrosomic newborn [32]. Swank et al. [33] reported that women with moderate and excessive BMI changes in pregnancy had aOR of 1.66 and 3.21, accordingly, for macrosomia in comparison to females with minimal BMI change. The study of Sullivan et al. [27] observed that extremely obese patients delivered newborns with birth weight equal or more than 4500 g significantly more often than normal weight women (9.8 vs 0.8%). McCall's et al. [26] international collaborative study proved the increased risk for fetal macrosomia in superobese women. Furthermore, Alanis et al. [28] observed that extreme obesity increased 3.5- and 2-fold the risk of delivering the large for gestational age (LGA) infant compared to non-obese patients and less obese women, respectively. In comparison, our study revealed, after adjustment for gestational age at delivery, about 3.5-fold (aOR = 3.57), and nearly 9-fold (aOR = 8.89) higher chance of postanal macrosomia in obese women comparing to overweight and normal weight females, accordingly. Morais et. al. [29] classified pregnant women on the first and last prenatal visit as low weight, adequate weight, overweight, and obese. The researchers reported that patients whose BMI acquired an increase in the classification, according to the Atalah curve, from the first until the last prenatal visit, had a higher chance of delivering LGA newborn (OR = 2.88). Also, women with firstly adequate BMI, who increased in their classification, were nearly four times more likely to give a birth to a macrosomic infant (OR = 4.13). Furthermore, overweight women, who evolved an increase of their BMI, had raised odd ratio of fetal macrosomia (OR = 12.54) than those with stagnant BMI [29].

To our knowledge, until now no study evaluated the association between predelivery BMI, and shoulder dystocia. Our results proved the usefulness of maternal BMI in the prognosis of dystocia with sensitivity of 77%, and specificity of 53%. The cut-off value for predelivery BMI was set as 27.0 kg/m^2. The obese women were, after adjustment for term of delivery and macrosomia, about 3-fold more likely to experience obstructed labor (aOR = 3.40) than patients with normal BMI. Through the probability of prognosis both macrosomia and shoulder dystocia, the predelivery BMI can be helpful parameter in the prediction of that adverse perinatal outcomes, and making the decision about the most favorable mode of delivery.

The only adverse perinatal outcome, in our study, with higher frequency in normal weight women comparing to overweight females was preterm delivery (11.4 vs 6.9%). Both obese (aOR = 0.59, $p < 0.05$) and overweight (aOR = 0.55, $p < 0.01$) mothers had approximately 40% lower chance of preterm delivery, using regression model adjusted for PIH and FGR diagnosis. The trend of higher incidence for preterm birth among normal weight women was similar to Alanis et al. results (25.0 vs 16.6%) [28].

Although both the first and second stage of labor lasted longer in overweight mothers than in obese and normal weight patients, respectively, the proportion of prolonged second labor stage was comparable between groups. The I group had higher percentage of 1-minute Apgar score below 7 points than the II one. Moreover, there was no significant difference in diagnosis of 5-minute Apgar below 7 points between groups. These results are similar to Alanis et al. observations [28].

We observed higher frequency of PIH among overweight and obese mothers comparing to normal weight women. Interestingly, nearly similar incidence of GDM and FGR in all groups was noticed. The newborns of obese mothers had lower umbilical venous and arterial pH with similar incidence of newborn acidosis compared to normal weight and overweight group, respectively. Finally, we did not observe the differences in frequency of instrumental vaginal delivery, perineal incision, perineal rupture, postpartum hemorrhage, umbilical venous or arterial BE between groups. To our knowledge, until now, there are no studies in the literature assessing perinatal outcome in relations to predelivery BMI. Future studies, considering the predelivery obesity grading, and the long-term consequences of inappropriate maternal BMI, are needed.

CONCLUSIONS

The predelivery BMI is a useful parameter in the prediction of cesarean section, macrosomia, and shoulder dystocia. The establishing cut-off value for predelivery BMI was the lowest in prediction of shoulder dystocia.

The obese women are at higher risk of cesarean section comparing to overweight, and normal weight women. Predelivery obesity increases the chance of macrosomia compared to normal weight women, and to overweight females. Moreover, the obese patients are more likely to experience shoulder dystocia comparing to normal weight group.

The antenatal obesity is associated with higher perinatal blood loss, slightly lower umbilical venous and arterial pH in comparison to women with appropriate BMI. Moreover,

the overweight mothers present significantly lower umbilical arterial pH than normal weight females. Furthermore, predelivery obesity and overweight are related to lower risk of preterm delivery than normal BMI. Additionally, the first and the second stage of labor last longer among overweight women comparing to obese, and normal weight mothers, respectively.

Awareness, that obesity and overweight are major risk factors for many obstetrical complications, imposes clinicians to implement the unique management, including special recommendations for prenatal care.

Conflict of interest

The authors declare no conflict of interest

REFERENCES

1. World Obesity Federation: Global Prevalence of Adult Overweight & Obesity. Whttp://www.worldobesity.org/site_media/library/resource_images/Global_prevalence_of_Adult_Obesity_23rd_October_2015_WO.pdf. (16.12.2021).
2. Flegal KM, Kruszon-Moran D, Carroll MD, et al. Trends in Obesity Among Adults in the United States, 2005 to 2014. JAMA. 2016; 315(21): 2284–2291, doi: 10.1001/jama.2016.6458, indexed in Pubmed: 27272580.
3. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of childhood and adult obesity in the United States, 2011-2012. JAMA. 2014; 311(8): 806–814, doi: 10.1001/jama.2014.732, indexed in Pubmed: 24570244.
4. CDC Health, United States 2015. https://www.cdc.gov/nchs/data/hus/hus15.pdf (16.12.2021).
5. Radzicka-Mularczyk SA, Pietryga M, Brazert J. How mother's obesity may affect the pregnancy and offspring. Ginekol Pol. 2020; 91(12): 769–772, doi: 10.5603/GP.2020.0116, indexed in Pubmed: 33447997.
6. Gluckman PD, Hanson MA, Cooper C, et al. Effect of in utero and early-life conditions on adult health and disease. N Engl J Med. 2008; 359(1): 61–73, doi: 10.1056/NEJMra0708473, indexed in Pubmed: 18596274.
7. Devlieger R, Benhalima K, Damm P, et al. Maternal obesity in Europe: where do we stand and how to move forward?: A scientific paper commissioned by the European Board and College of Obstetrics and Gynaecology (EBCOG). Eur J Obstet Gynecol Reprod Biol. 2016; 201: 203–208, doi: 10.1016/j.ejogrb.2016.04.005, indexed in Pubmed: 27160501.
8. Catalano PM, Shankar K. Obesity and pregnancy: mechanisms of short term and long term adverse consequences for mother and child. BMJ. 2017; 356: j1, doi: 10.1136/bmj.j1, indexed in Pubmed: 28179267.
9. Chu SY, Callaghan WM, Kim SY, et al. Maternal obesity and risk of gestational diabetes mellitus. Diabetes Care. 2007; 30(8): 2070–2076, doi: 10.2337/dc06-2559a, indexed in Pubmed: 17416786.
10. Torloni MR, Betrán AP, Horta BL, et al. Prepregnancy BMI and the risk of gestational diabetes: a systematic review of the literature with meta-analysis. Obes Rev. 2009; 10(2): 194–203, doi: 10.1111/j.1467-789X.2008.00541.x, indexed in Pubmed: 19055539.
11. Salihu HM, De La, Rahman S, et al. Does maternal obesity cause preeclampsia? A systematic review of the evidence. Minerva Ginecol. 2012; 64(4): 259–280, indexed in Pubmed: 22728572.
12. Wang Z, Wang P, Liu H, et al. Maternal adiposity as an independent risk factor for pre-eclampsia: a meta-analysis of prospective cohort studies. Obes Rev. 2013; 14(6): 508–521, doi: 10.1111/obr.12025, indexed in Pubmed: 23530552.
13. Chu SY, Kim SY, Schmid CH, et al. Maternal obesity and risk of cesarean delivery: a meta-analysis. Obes Rev. 2007; 8(5): 385–394, doi: 10.1111/j.1467-789X.2007.00397.x, indexed in Pubmed: 17716296.
14. Robinson HE, O'Connell CM, Joseph KS, et al. Maternal outcomes in pregnancies complicated by obesity. Obstet Gynecol. 2005; 106(6): 1357–1364, doi: 10.1097/01.AOG.0000188387.88032.41, indexed in Pubmed: 16319263.
15. Korkmaz L, Baştuğ O, Kurtoğlu S. Maternal Obesity and its Short- and Long-Term Maternal and Infantile Effects. J Clin Res Pediatr Endocrinol. 2016; 8(2): 114–124, doi: 10.4274/jcrpe.2127, indexed in Pubmed: 26758575.
16. Salim R, Braverman M, Teitler N, et al. Risk factors for infection following cesarean delivery: an interventional study. J Matern Fetal Neonatal Med. 2012; 25(12): 2708–2712, doi: 10.3109/14767058.2012.705394, indexed in Pubmed: 22746352.
17. Malinowski AK, Bomba-Opoń D, Parrish J, et al. Venous thromboembolism in obese pregnant women: approach to diagnosis and management. Ginekol Pol. 2017; 88(8): 453–459, doi: 10.5603/GP.a2017.0083, indexed in Pubmed: 28930373.
18. Marshall NE, Lau B, Purnell JQ, et al. Impact of maternal obesity and breastfeeding intention on lactation intensity and duration. Matern Child Nutr. 2019; 15(2): e12732, doi: 10.1111/mcn.12732, indexed in Pubmed: 30345729.
19. Kumpulainen SM, Girchenko P, Lahti-Pulkkinen M, et al. Maternal early pregnancy obesity and depressive symptoms during and after pregnancy. Psychol Med. 2018; 48(14): 2353–2363, doi: 10.1017/S0033291717003889, indexed in Pubmed: 29338797.
20. Neri C, Edlow AG. Effects of Maternal Obesity on Fetal Programming: Molecular Approaches. Cold Spring Harb Perspect Med. 2015; 6(2): a026591, doi: 10.1101/cshperspect.a026591, indexed in Pubmed: 26337113.
21. Stuebe AM, Forman MR, Michels KB. Maternal-recalled gestational weight gain, pre-pregnancy body mass index, and obesity in the daughter. Int J Obes (Lond). 2009; 33(7): 743–752, doi: 10.1038/ijo.2009.101, indexed in Pubmed: 19528964.
22. Reynolds RM, Allan KM, Raja EA, et al. Maternal obesity during pregnancy and premature mortality from cardiovascular event in adult offspring: follow-up of 1 323 275 person years. BMJ. 2013; 347: f4539, doi: 10.1136/bmj.f4539, indexed in Pubmed: 23943697.
23. Saucedo R, Valencia J, Moreno-González LE, et al. Maternal serum adipokines and inflammatory markers at late gestation and newborn weight in mothers with and without gestational diabetes mellitus. Ginekol Pol. 2021 [Epub ahead of print], doi: 10.5603/GP.a2021.0083, indexed in Pubmed: 33914332.
24. Edlow AG. Maternal obesity and neurodevelopmental and psychiatric disorders in offspring. Prenat Diagn. 2017; 37(1): 95–110, doi: 10.1002/pd.4932, indexed in Pubmed: 27684946.
25. Godfrey K, Reynolds R, Prescott S, et al. Influence of maternal obesity on the long-term health of offspring. The Lancet Diabetes & Endocrinology. 2017; 5(1): 53–64, doi: 10.1016/s2213-8587(16)30107-3.
26. McCall SJ, Li Z, Kurinczuk JJ, et al. Maternal and perinatal outcomes in pregnant women with BMI >50: An international collaborative study. PLoS One. 2019; 14(2): e0211278, doi: 10.1371/journal.pone.0211278, indexed in Pubmed: 30716114.
27. Sullivan EA, Dickinson JE, Vaughan GA, et al. Australasian Maternity Outcomes Surveillance System. Maternal super-obesity and perinatal outcomes in Australia: a national population-based cohort study. BMC Pregnancy Childbirth. 2015; 15: 322, doi: 10.1186/s12884-015-0693-y, indexed in Pubmed: 26628074.
28. Alanis MC, Goodnight WH, Hill EG, et al. Maternal super-obesity (body mass index > or = 50) and adverse pregnancy outcomes. Acta Obstet Gynecol Scand. 2010; 89(7): 924–930, doi: 10.3109/00016341003657884, indexed in Pubmed: 20438391.
29. Morais SS, Nascimento SL, Godoy-Miranda AC, et al. Body Mass Index Changes during Pregnancy and Perinatal Outcomes - A Cross-Sectional Study. Rev Bras Ginecol Obstet. 2018; 40(1): 11–19, doi: 10.1055/s-0037-1608885, indexed in Pubmed: 29253913.
30. Arora R, Arora D, Patumanond J. High pre-delivery body mass index also caused adverse pregnancy outcomes. Open Journal of Obstetrics and Gynecology. 2013; 03(04): 416–421, doi: 10.4236/ojog.2013.34076.
31. Najafian M, Cheraghi M. Occurrence of fetal macrosomia rate and its maternal and neonatal complications: a 5-year cohort study. ISRN Obstet Gynecol. 2012; 2012: 353791, doi: 10.5402/2012/353791, indexed in Pubmed: 23209925.
32. Asplund CA, Seehusen DA, Callahan TL, et al. Percentage change in antenatal body mass index as a predictor of neonatal macrosomia. Ann Fam Med. 2008; 6(6): 550–554, doi: 10.1370/afm.903, indexed in Pubmed: 19001308.
33. Swank ML, Caughey AB, Farinelli CK, et al. The impact of change in pregnancy body mass index on macrosomia. Obesity (Silver Spring). 2014; 22(9): 1997–2002, doi: 10.1002/oby.20790, indexed in Pubmed: 24890506.