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Effect of body mass index (BMI) on mode of delivery and maternal and neonatal complications in nulliparous women

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SUMMARY

AUTHORS' CONTRIBUTION: (A) Study Design · **(B)** Data Collection . **(C)** Statistical Analysis · **(D)** Data Interpretation · **(E)** Manuscript Preparation · **(F)** Literature Search · **(G)** No Fund Collection

Background and Aim: Over the last decades, overweight and obesity have become an increasing health problem in the world, including Egypt. We attempted to determine the effect of BMI on mode of delivery and maternal and neonatal complications in nulliparous women.

Methods: this comparative cross-sectional observational study was conducted at Ain Shams University Hospitals and performed on total of 330 nulliparous pregnant women who attended the pre-labor unit starting from June 2021 till January 2022 with inclusion and exclusion criteria.

Results: The following outcomes showed the same tendency: underweight group showed the best (the most favorable) outcomes, then increasing worse with the weigh, and the morbid obese group showed worst: 1) Cesarean delivery frequency (least frequent in underweight? most frequent in morbid obese, 2) duration of 1st stage of labor, 3) duration of 2nd stage of labor, 4) APGAR-1 score and APGAR-5 score, 5) NICU admission, 6) postpartum hemorrhage. Neonatal weight was lowest in underweight group then increases gradually to be highest in morbid obese group, the difference statistically was significant.

Conclusion: We here reconfirmed that obese women had poorer pregnancy outcomes and thus weight control before pregnancy may be an important preventative method to reduce poor materno-fetal outcomes.

Keywords: Mode of delivery; Body mass index (BMI); Neonatal complications in nulliparous women

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INTRODUCTION

The BMI is a simple index of the weight-for-height and it is calculated by dividing a person's weight in kilograms by the square of their height in meters (kg/m^2) [1-3].

Underweight (a BMI of < 19.9 kg/m^2) has been shown to be associated with an increased risk of preterm deliveries, low birth weight and anemia, and a decreased risk of pre-eclampsia, gestational diabetes, obstetric intervention and post-partum hemorrhage [4].

In a study from 2006, Barau et al. [5] found a linear association between maternal pre-pregnancy body mass index (BMI) and risk of cesarean section in term deliveries [5].

In addition to an increasing rate of cesarean sections in obese women, some studies have revealed a decrease in use of forceps and vacuum extraction, with increasing BMI [6].

However, a slightly increased risk for instrumental vaginal delivery was reported in a Norwegian study [7] and no significant difference in prevalence of vaginal instrumental delivery is reported in some studies [2]. The aim of the study is to assess the effect of BMI on mode of delivery and maternal and neonatal complications in nulliparous women.

PATIENTS AND METHODS

After ethical committee approval and written consents from the patients, this comparative cross sectional observational study was conducted at tertiary care hospital at Ain Shams University hospitals and performed on total of 330 nulliparous pregnant women who attended the pre-labor unit starting from June 2021 till January 2022.

Study population: Nulliparous pregnant women that categorized into six different BMI (kg/m^2) groups (55 in each group) with the following inclusion criteria:

Inclusion criteria: Age (18-35 years old), Know pre-pregnancy BMI, Nullipara, A living singleton pregnancy, Gestational age (37-40 weeks), Cephalic presentation and No fetal or umbilical cord anomaly.

Exclusion criteria: Deliveries where maternal height or pregestational weight were not recorded, Presence of congenital fetal malformation, Antepartum hemorrhage (placenta previa or accidental hemorrhage) and Any factors that can independently cause adverse perinatal and neonatal outcome and can act as confounding factors like smoking or drugs).

Study Procedures:

- After explaining the procedures of the study, written informed consent was obtained from patients and their basic demographic information such as age, height, weight, gestational age, and cervical dilation were recorded at Ain Shams University Maternity Hospital prelabour ward using ultrasound machine (Sono ACER 5).
- Maternal BMI was calculated from the pre-pregnancy weight recorded in the woman's personal pregnancy health card and at time of delivery.
- A total of 330 term pregnant women were categorized into six different BMI (kg/m^2) classes, determined by their pre-pregnancy and at time of delivery BMI:

1. Underweight: (BMI <18.50)
2. Normal weight: (BMI 18.50 – 24.99; reference group) Controlled one
3. Overweight: (BMI 25.00–29.99)
4. Obese: (BMI 30.00 – 35.00)
5. Severe obesity: (BMI 35.00 – 40.00)
6. Morbid obesity: (BMI > 40.00)

- Data of the study participants was collected through a full history taking (medical, obstetrical and gynecological), clinical and ultra-sonographic findings by using a pre-constructed case record sheet.
- The participants were investigated for routine laboratory tests including: (complete blood count, urine analysis and random blood sugar) & (full liver, kidney profile, PT and PTT in medical disorder).
- Abdominal examination (Leopold maneuver's) to detect both uterine contractions (frequency, intensity and duration) and fetus (lie, presentation, position, engagement of presenting part and fetal heart sound).
- Vaginal examination: for detecting capacity of the pelvis confirming fetal presenting part, position, station, degree of flexion and cervical scoring using (Bishop score) to detect cervical dilatation, effacement, station, consistency and position.
- Routine obstetric ultrasound to detect fetal status, liquor, umbilical cord and placental condition.
- Fetal distress was regarded when fetal bradycardia, variable deceleration or late deceleration is found using partogram and cardiotocography during labor.
- 1st stage of labor (time from the onset of labor until complete cervical dilatation) and prolonged 1st stage < 1.2 cm/hour for nulliparous patients.
- 2nd stage labor (time from complete cervical dilatation to expulsion of the fetus) and prolonged 2nd stage > 2 hours in nulliparous patients.
- Arrest disorder of first stage: no cervical change for ≥ 4 hours despite adequate contractions or ≥ 6 hours with inadequate contractions.
- Arrest disorder of second stage: in nulliparous women no progress after ≥ 4 hours with epidural anesthesia or ≥ 3 hours without epidural anesthesia [8]
- The fetal outcome was assessed by pediatrician regarding the Apgar score and need for NICU admission.

The delivery methods were done by supervisors and expert who categorized into spontaneous vaginal delivery, instrumental vaginal delivery (including vacuum extraction and forceps), planned cesarean section and emergency cesarean section.

Sample Size: Using STATA program, assuming a prevalence rate of maternofetal complication of 90% ranging between 10 and 30%, a sample size of 55 pregnant females in each of the study groups (330 totals) will be enough at 0.05 alpha errors and 0.80 power of the test [3].

Outcome measures

Primary outcome: The mode of the delivery (vaginal and C.S).

Secondary outcome:

- Duration of labour (1^{st} stage & 2^{nd} stage).

Maternal complication:

- Post-partum hemorrhage (traumatic and atonic)

Neonatal complication:

- Birth weight.
- The Apgar score at one and five minutes.
- Perinatal death.
- Admission to the neonatal intensive care unit.
- Neonatal birth injures.

Ethical Considerations: The patient data were anonymous. Data presentation was not being by the patient's name but by diagnosis and patient confidentiality was protected. An informed consent was taken from all participants, it was in Arabic language and confirmed by date and time. Confidentiality was preserved by assigning a number to patient's initials and only the investigator knew it

Conflict of interest: the candidate declared that there is no conflict of interest and the cost of the study was paid by the candidate.

Statistical analysis: Analysis is to be performed using SPSS for windows v20.0, Data to be presented in terms

of range, mean and standard deviation (for numeric parametric variables); range, median and inter-quartile range (for numeric non-parametric variables); or number and percentage (for categorical variables). Difference between two independent groups is to be analyzed using independent student's t-test as well as the mean difference and its 95% CI (for numeric parametric variables); or chi-squared test as well as the risk ratio and its 95% CI (for categorical variables). Binary logistic regression analysis is to be performed for estimating the association between good/poor response and the measured variables ROC curves are to be constructed for estimating the validity of measured variables as predictors of good or poor response validity is to be presented in terms of sensitivity, specificity, positive and negative predictive values and their corresponding 95% CIs significance level is set at 0.05.

RESULTS

During this study, 370 patients were assessed for eligibility and 330 nulliparous pregnant women were included in the study and categorized into six different BMI (kg/m^2) groups (55 in each group). Of all eligible patients, 22 patients were excluded from the study based on the inclusion criteria and 18 patients refused to participate in the study.

Ultimately, the analysis was based on the data of 330 nulliparous pregnant women that categorized into six different BMI (kg/m^2) groups (55 in each group). **Tab.1.** shows that no statistically significant differences between the studied groups regarding maternal age. **Tab. 2.** shows that Maternal BMI among the studied groups. **Tab. 3.** shows that no statistically significant differences between the studied groups regarding neonatal gestational age.

Tab. 4. shows that Cesarean delivery frequency was least frequent in underweight group then increases progressively to be most frequent in morbid obese group, the difference statistically was significant. **Tab. 5.** shows that Duration of 1st stage of labor was shortest in underweight group then increases progressively to be longest in morbid obese group, the difference statistically was significant. **Tab. 6.** shows that Duration of 2nd stage of labor was shortest in underweight group then increases progressively to be longest in morbid obese group, the difference statistically was significant.

Tab. 7. shows that Neonatal weight was lowest in underweight group then increases gradually to be highest

Tab. 1. Maternal age (years) among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	55	26.8 ± 3.5	19.0-35.0	0.282
Normal	55	25.8 ± 3.5	19.0-35.0	
Overweight	55	26.9 ± 3.6	20.0-35.0	
Obese	55	26.5 ± 3.8	18.0-35.0	
Severe obese	55	25.8 ± 3.6	18.0-35.0	
Morbid obese	55	25.7 ± 3.3	19.0-34.0	

Tab. 2. Maternal BMI (kg/m^2) among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	55	38.3 ± 0.9	37.0-40.0	0.420
Normal	55	38.1 ± 0.9	37.0-40.0	
Overweight	55	38.4 ± 0.9	37.0-40.0	
Obese	55	38.1 ± 0.9	37.0-40.0	
Severe obese	55	38.2 ± 0.8	37.0-40.0	
Morbid obese	55	38.3 ± 1.0	37.0-40.0	

Tab. 3. Neonatal gestational age (weeks) among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	55	38.3 ± 0.9	37.0-40.0	0.420
Normal	55	38.1 ± 0.9	37.0-40.0	
Overweight	55	38.4 ± 0.9	37.0-40.0	
Obese	55	38.1 ± 0.9	37.0-40.0	
Severe obese	55	38.2 ± 0.8	37.0-40.0	
Morbid obese	55	38.3 ± 1.0	37.0-40.0	

Tab. 4. Mode of delivery among the studied groups.

Group	Total	Vaginal	Cesarean	#p-value
Underweight	55	48 (87.3%)	7 (12.7%)	<0.001*
Normal	55	47 (85.5%)	8 (14.5%)	
Overweight	55	45 (81.8%)	10 (18.2%)	
Obese	55	36 (65.5%)	19 (34.5%)	
Severe obese	55	26 (47.3%)	29 (52.7%)	
Morbid obese	55	14 (25.5%)	41 (74.5%)	

Tab. 5. Duration of 1st stage of labour (hours) among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	48	3.1 ± 0.9	1.0-4.7	0.004*
Normal	47	3.1 ± 0.8	1.7-5.3	
Overweight	45	3.2 ± 0.9	1.0-5.0	
Obese	36	3.4 ± 1.0	1.8-5.8	
Severe obese	26	3.7 ± 0.9	2.1-5.5	
Morbid obese	14	4.0 ± 1.0	2.4-5.8	

Tab. 6. Duration of 2nd stage of labor (hours) among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	48	23.4 ± 6.7	7.0-36.0	0.009*
Normal	47	23.5 ± 6.5	12.0-39.0	
Overweight	45	23.9 ± 6.8	7.0-37.0	
Obese	36	25.6 ± 7.3	13.0-42.0	
Severe obese	26	27.7 ± 7.0	16.0-40.0	
Morbid obese	14	29.4 ± 7.6	17.0-42.0	

Tab. 7. Neonatal weight (kg) among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	55	2.7 ± 0.3	2.1-3.4	<0.001*
Normal	55	2.9 ± 0.3	2.3-3.8	
Overweight	55	3.0 ± 0.3	2.2-3.7	
Obese	55	3.2 ± 0.3	2.3-3.9	
Severe obese	55	3.3 ± 0.3	2.5-3.9	
Morbid obese	55	3.5 ± 0.4	2.9-4.2	

in morbid obese group, the difference statistically was significant. **Tab. 8.** shows that APGAR-1 score was highest in underweight group then increases gradually to be lowest in morbid obese group, the difference statistically was not significant. **Tab. 9.** shows that APGAR-5 score was highest in underweight group then increases gradually to be lowest in morbid obese group, the difference statistically were not significant. **Tab. 10.** shows that NICU admission frequency was least frequent in underweight group then increases gradually to be most frequent in morbid obese group, the difference statistically was not significant. **Tab. 11.** shows that Neonatal birth injuries not recorded in the studied groups.

DISCUSSION

Since high maternal body mass index (BMI) during pregnancy represents major conflict and often associated with short- and long-term unfavorable health outcomes both for child and mother during pregnancy and delivery, evaluating the effect of maternal body mass index on fetal and maternal outcome during pregnancy was highlighted as a main point of interest [9-11].

In this study, we aimed to assess the effect of BMI on mode of delivery and maternal and neonatal complications in nulliparous women.

This comparative cross sectional observational study was conducted at tertiary care hospital at Ain Shams University hospitals from June 2021 till January 2022 and performed on total of 330 nulliparous pregnant women who attended the pre-labor unit.

During this study, 370 patients were assessed for eligibility and 330 nulliparous pregnant women were included in the study and categorized into six different BMI (kg/m^2) groups (55 in each group). Of all eligible patients, 22 patients were excluded from the study based on the inclusion criteria and 18 patients refused to participate in the study.

Ultimately, the analysis was based on the data of 330 nulliparous pregnant women that categorized into six different BMI (kg/m^2) groups (55 in each group).

- **Underweight:** (BMI <18.50)
- **Normal weight:** (BMI 18.50–24.99) which is a reference group (controlled one)
- **Overweight:** (BMI 25.00–29.99)
- **Obese:** (BMI 30.00 – 35.00)
- **Severe obesity:** (BMI 35.00 – 40.00)
- **Morbid obesity:** (BMI > 40.00)

Different studies were done evaluating the association between pre-pregnancy BMI and obstetric and neonatal outcomes in obese women, some of them agree and others differ from our results**.**

The current study revealed that there were no statistically significant differences between the studied groups regarding maternal age (18-35 years) and neonatal gestational age (37-40 weeks).

Regarding mode of delivery, our study results revealed that Cesarean delivery frequency was least frequent in underweight group then increases progressively to be most frequent in morbid obese group, the differences statistically were significant (p<0.001).

Regarding progression of normal labor, our results

Tab. 8. APGAR-1 score among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	55	7.5 ± 1.3	4.0-9.0	0.069
Normal	55	7.5 ± 1.4	4.0-9.0	
Overweight	55	7.3 ± 1.2	4.0-9.0	
Obese	55	7.0 ± 1.3	4.0-9.0	
Severe obese	55	7.1 ± 1.2	4.0-9.0	
Morbid obese	55	7.0 ± 1.5	4.0-9.0	

Tab. 9. APGAR-5 score among the studied groups.

Group	Total	Mean ± SD	Range	^ p-value
Underweight	55	8.3 ± 1.4	4.0-10.0	0.758
Normal	55	8.3 ± 1.6	4.0-10.0	
Overweight	55	8.2 ± 1.4	4.0-10.0	
Obese	55	8.1 ± 1.4	4.0-10.0	
Severe obese	55	8.0 ± 1.1	5.0-10.0	
Morbid obese	55	8.0 ± 1.5	4.0-10.0	

Tab. 10. NICU admission among the studied groups.

Group	Total	Required	Not required	p-value
Underweight	55	5 (9.1%)	50 (90.9%)	0.803
Normal	55	7 (12.7%)	48 (87.3%)	
Overweight	55	7 (12.7%)	48 (87.3%)	
Obese	55	9 (16.4%)	46 (83.6%)	
Severe obese	55	8 (14.5%)	47 (85.5%)	
Morbid obese	55	10 (18.2%)	45 (81.8%)	

Tab. 11. Neonatal birth injuries among the studied groups.

Group	Total	Present	Absent	p-value
Underweight	55	0 (0.0%)	55 (100.0%)	Not applicable
Normal	55	0 (0.0%)	55 (100.0%)	
Overweight	55	0 (0.0%)	55 (100.0%)	
Obese	55	0 (0.0%)	55 (100.0%)	
Severe obese	55	0 (0.0%)	55 (100.0%)	
Morbid obese	55	0 (0.0%)	55 (100.0%)	

revealed that Duration of 1st stage and 2nd stage of labor were shortest in underweight group then increases progressively to be longest in morbid obese group**,** the differences statistically were significant (p value=0.004, 0.009) respectively.

Pettersen-Dahl et al., [3] conducted a retrospective register study that enrolled 4605 were primiparous singleton deliveries to assess the association between maternal BMI and delivery method in non-breech, singleton deliveries, after 36 weeks of gestation.

In concordance with our results, Pettersen-Dahl et al., [3] revealed that the risk of emergency cesarean delivery increased significantly by 77% with increasing maternal BMI, and increased by more than a twofold in the obese group (BMI ≥ 30) compared with women with underweight or normal weight (p<0.001).

Also, in line with our study, Pettersen-Dahl et al., [3] revealed that Prolonged first stage of labor (34%) and fetal asphyxia (33%) were significantly found in obese women (BMI ≥30) and were the most frequent reasons for emergency cesarean deliveries. Prolonged second stage was the indication in 9.4% of the emergency cesareans.

Our findings are in line with the reported data of Melchor et al., [9] in which a retrospective cohort study was conducted and performed on 16,609 women to examine the association between pre-pregnancy BMI and obstetric and neonatal outcomes and revealed that a higher BMI was associated with a greater risk of induction of labor (delayed spontaneous onset of labor) and increasing BMI correlates linearly with cesarean delivery rates as cesarean sections are almost 3 times more common among obese pregnant women (p<0.001).

Also, Verma et al., [12] conducted a prospective study that enrolled 784 women with singleton pregnancies to evaluate the impact of the maternal body mass index on the pregnancy outcome and revealed that the caesarean section rate was found to be increased with a higher maternal BMI with higher rate of spontaneous normal delivery in the underweight group (BMI> **19**.9kg\m^2) (p<0.001).

Our results are in agreement with results of previous studies done by Kalk et al., [13], Yang et al., [10] who reported that women with body mass index >30 kg/m^2 were at increased risk for cesarean section.

The reasons why an increase in BMI is associated with decrease in spontaneous deliveries and increased risk of cesarean sections have been assumed that fetal hyperglycemia and hyperinsulinemia causes increased fetal

growth and higher risk of macrosomia [14,15]. Macrosomia may lead to an obstructed labor and more frequent need for cesarean delivery. Increased amounts of soft tissue deposits in women with increased BMI may also cause a relative narrowing of the pelvis and genital tract. Increased amounts of soft tissue may also lead to weaker contractions due to the dilution effect, and can lead to labor arrest [3].

Regarding fetal outcomes, our results revealed that Neonatal weight was significantly lowest in underweight group then increases gradually to be significantly highest in morbid obese group ($p<0.001$) with no statistically significant differences as regard APGAR score at 1-min and 5-min between the studied groups with no recorded fetal injuries or fetal mortalities.

Consequently, there were no statistically significant differences as regard NICU admission frequency between the studied groups (p value=0.803).

In agreement with our results, Melchor et al., [9] revealed that a higher BMI was associated with a greater rate of macrosomia ≥ 4000 g. In contrast to our results, the infants of obese women were more likely to be admitted to the NICU which may explained by presence of associated gestational diabetes in the obese women in the study.

In agreement with our results, Verma et al., [12] revealed that growth retardation (17.2%) was more in the underweight group (BMI> **19**.9 kg\m) as compared to those in the normal and the higher BMI groups with a strong association between IUGR and the underweight group (17.2%, as compared to 6-7.5% in the other groups, $p<0.001$).

These results are in agreement with results of previous studies done by Heude et al., [15], Yang et al., [10] who reported that small for gestational age (SGA) was significantly highest in underweight women and large for gestational age (LGA) was significantly highest in obese women which is associated with direct effect of gestational weight gain.

Regarding postpartum hemorrhage, postpartum hemorrhage frequency was least frequent in underweight group then increases gradually to be most frequent in morbid obese group; the difference statistically was not significant.

In agreement with our results, D'Souza et al., [16] conducted a systematic review including 10,258 studies that reported on pregnancy outcomes in women with body mass index ≥ 30 kg/m^2 and revealed that women with body mass index >30 kg/m^2 were at increased risk for cesarean section and there was no increase in the incidence of postpartum hemorrhage with increasing BMI category.

The strength points of this study

The strength points of this study are that it is comparative cross sectional observational study design and having no patients lost to follow-up during the study. It is the first study in Ain shams university maternity hospital to assess the strength of the association between the independent risk factor of obesity and the outcome of mode of delivery in absence of other overlapping risk factors e.g DM and Hypertensive disorders.

The limitations of the study

The limitations of the study are worthy of mention including relatively smaller sample size relative to the previous studies, not being a multicentric study and this represents a significant risk of publication bias. Another limitation is the presence of Covid-19 pandemic which limited the available participants.

CONCLUSION

As evident from the current study, an increased maternal pre-pregnancy BMI is an important and independent risk factor for delivery by cesarean section. A significant difference was observed in risk of cesarean between women with BMI ≥ 30 and women with normal weight in all subgroups of women with significant prolongation in 1st stage and 2nd stage of labor.

Neonatal weight was significantly lowest in underweight group then increases gradually to be significantly highest in morbid obese group.

Maternal overweight and obesity in pregnancy are important contributors to obstetric complications and adverse outcomes, with an associated significant impact on healthcare burden.

Effective interventions to reduce the prevalence of overweight and obesity in pregnant women could have significant beneficial effects on pregnancy outcomes. Public health efforts are urgently required to promote weight management among women of reproductive age before conception and during pregnancy.

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