Original research article

Correlation of body mass index with blood pressure in pregnant patients with severe preeclampsia

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ABSTRACT

Aims: Determine the correlation of pregestational body mass index and body mass index upon admission to the Intensive Care Unit with blood pressure in pregnant patients with severe preeclampsia.

Study design: Retrospective cross-sectional study.

Place and Duration of Study: Intensive Care Unit of the High Specialty Medical Unit Gynecology and Obstetrics Hospital No. 3 of the “La Raza” National Medical Center belonging to the Mexican Institute of Social Security, Mexico City between January 01 and December 30, 2023.

Methodology: A retrospective cross-sectional study was carried out in a cohort of 100 pregnant patients with severe preeclampsia from the Intensive Care Unit. The correlation of pregestational body mass index and Intensive Care Unit admission body mass index with systolic and diastolic blood pressure recorded upon admission was calculated. Descriptive statistics, Student's t test and Pearson's correlation coefficient (*r*) were used.

Results: Maternal age was 29.84±6.60 years and the mean pregnancy was 33.93±4.03 weeks. Pregestational body mass index was 28.17±5.96 (normal 29%, overweight 43%, obesity 28%). Intensive Care Unit admission body mass index was 32.90±5.95 (normal 5%, overweight 26%, obesity 69%). Systolic blood pressure was 161.92±16 and diastolic blood pressure was 101.11±9.75 mmHg. Correlations: pregestational body mass index vs systolic blood pressure was *r*=0.049 and diastolic blood pressure was *r*=0.134. Correlation of Intensive Care Unit admission body mass index vs systolic blood pressure was *r*=0.038 and vs diastolic blood pressure *r*=0.071.

Conclusion: No significant correlation of pregestational body mass index and body mass index upon admission to the Intensive Care Unit with systolic and diastolic blood pressure was found in the patients participating in the study.

Keywords: *Body mass index; Obesity and pregnancy; High blood pressure and pregnancy; Severe preeclampsia; High risk pregnancy.*

1. INTRODUCTION

Obesity has been steadily increasing around the world. Since 1975, the prevalence of obesity has increased 2% per decade and has not decreased even though more renewed and stricter guidelines have been generated by the World Health Organization (WHO) and other international public health organizations [1]. Countries with lower economic income face rapid increases that are already exceeding their health resources for the prevention and control of the problem [2,3].

Maternal obesity has also increased worldwide in recent years proportionally across all racial groups. The prevalence of obesity before pregnancy has been reported to increase by an average of 0.5 percentage points per year, from 17.6% in 2003 to 20.5% in 2009. Obesity increased among women ages 20 to 24, 30 to 34 years, and 35 years or older, also among non-Hispanic white women, non-Hispanic blacks, hispanics, and women of other races [4].

Obesity during pregnancy has been directly linked to serious complications including gestational diabetes, high blood pressure, bleeding, preeclampsia and birth defects. In the particular case of preeclampsia, the average incidence rate in all countries is 2.16%, but the disease represents 30% of maternal deaths. A large amount of research supports the evidence that there is a very close relationship between obesity and preeclampsia [5]. Excessive weight gain during pregnancy or a state of obesity and overweight prior to pregnancy have been associated with maternal hyperinsulinism, insulin resistance, and systemic inflammation. Endothelial dysfunction, arterial hypertension, pathological proteinuria, thrombotic response, multi-organ damage and high maternal mortality and morbidity in preeclampsia have been proposed as the shared mechanisms that lead to a pro-inflammatory state [6].

Weight gain during pregnancy increases the risk of preeclampsia in nulliparous women with a stronger association with late-onset preeclampsia than with early-onset preeclampsia [7]. In 2023, Sudjai [8] reported the results of a retrospective study that included a cohort of pregnant patients with SP versus pregnant women without preeclampsia as control group. The research was conducted at the Department of Gynecology and Obstetrics, Rajavithi Hospital, Thailand to determine the association of maternal pre-pregnancy Body Mass Index (BMI) with early- or late-onset severe preeclampsia (SP). Data analysis showed that class I and II obesity were significantly associated with SP. Class I obesity was closely related to late-onset SP while class II obesity was associated with early- and late-onset SP.

The existence of a directly proportional association of the increase in BMI from the pregestational stage or of weight gain during pregnancy specifically with SP blood pressure has not been established. The objective of the present investigation was to determine the correlation of pregestational BMI and ICU admission BMI with blood pressure in pregnant patients with SP.

2. MATERIAL AND METHODS

A retrospective cross-sectional study was carried out on pregnant patients with SP admitted to the ICU of the High Specialty Medical Unit Gynecology and Obstetrics Hospital No. 3 of “La Raza” National Medical Center belonging to the Mexican Institute of Social Security, Mexico City in the period from January 01 to December 30, 2023. Patients with pregnancy ≥ 20 weeks and an established diagnosis of SP were studied according to the recommendations issued in 2020 by the American College of Obstetricians and Gynecologists (ACOG) and the Clinical Practice Guideline (CPG) for the prevention, diagnosis and treatment of preeclampsia at the second and third level of care in Mexico updated in 2017 [9,10].

The inclusion criteria were: age ≥ 18 years, with any parity, all types of morbidities and with an available clinical record. Patients with any gastrointestinal or endocrine diseases that are causes of obesity were excluded. There were no cases of elimination because we had access to the information contained in the clinical records of all patients.

A cohort of 100 patients met the selection criteria. The records were consulted to know their general data, weight and height to calculate the pregestational BMI and the BMI of their admission to the ICU with the Quetelet formula (BMI = weight in K / (height in m)^2). BMI was considered normal when it was 18.5 to 24.9, overweight BMI was 25 to 29.9, and obesity BMI > 30. In turn, three categories of obesity were taken into account according to the criteria accepted by ACOG in 2024: grade I with BMI from 30 to 34.9, grade II with BMI from 35 to 39.9 and grade III with BMI ≥ 40 [11]. Additionally, systolic and diastolic blood pressure values upon admission to the ICU were recorded.

2.1 Statistic analysis

For the statistical analysis of the data, descriptive (mean, median, standard deviation, range) and inferential statistics (Student's t test, Pearson correlation coefficient (*r*)) were used. The value $P < 0.05$ was taken as significant. The Pearson correlation coefficient (*r*) of the pregestational BMI and the BMI of their admission to the ICU versus the general mean of the systolic and diastolic blood pressure of their admission to the ICU of all patients and by groups (normal BMI, BMI with overweight and BMI with obesity) was calculated. The SPSS® statistical package version 24.0 was used.

3. RESULTS

3.1 General data

The mean age was 29.84±6.60 years (limits 14 to 43) and the median parity was 2 (limits 1 to 5). The mean gestational age was 33.93±4.03 weeks (limits 24 to 40) with the following distribution: < 34 weeks 47 %, 34 to 37 weeks 23 %, > 37 weeks 30 %. Morbidities were found in 37 % of the cases, the distribution was as follows: controlled primary hypothyroidism 9 %, gestational diabetes 8 %, gestational hypertension 5 %, type 2 diabetes mellitus 4 %, bronchial asthma 2 %, fatty liver as an ultrasonographic finding 1 %, epilepsy 1 %, controlled primary hyperthyroidism 1 %, heart disease 1 %, cocaine addiction with recent use 1 %, type 1 diabetes mellitus 1 %, rheumatoid arthritis with Sjogren's syndrome 1 %, chronic inactive hemolytic anemia 1 %, and aplastic anemia in remission 1 %.

The mean time from admission to the ICU until the end of pregnancy was 16.40±2.22 hours (limits 1 to 118), stay in the ICU 1.79±1.15 days (limits 0.125 to 7) and SP complications 22 % with following distribution: HELLP syndrome 12 %, eclampsia 5 %, hypertensive encephalopathy 2 %, acute pulmonary edema 2 % and acute kidney injury 1 %. Maternal mortality was 0 %.

To terminate the pregnancy, cesarean section was performed in 96 % and vaginal delivery in 4 %. The mean estimated bleeding was 494.1±345.31 ml (limits 200 to 2,750), obstetric hemorrhage (loss ≥ 1,000 ml) 6 % and transient uterine atony 5 %. There were no surgical reinterventions. 105 newborns were cared for (95 single products and 10 products from 5 patients with twin pregnancies). The mean weight of the newborns was 2,085.33±876.84 g (limits 520 to 4,300) and the median Apgar score at the first and five minutes after birth was 7 and 9, respectively. Prematurity (< 37 weeks of pregnancy) was found in 70 %, fetal mortality in 32 % and admission to the neonatal ICU in live newborns in 23 %.

3.2 BMI

Regarding pregestational values, the general mean weight was 69.83±15.86 K (limits 41 to 96) and height 1.57±0.19 m (limits 1.47 to 1.72). With these data, the pregestational BMI was calculated, the general mean was 28.17±5.96 (limits 16.21 to 42.96), the distribution was as follows: normal BMI 29 % (mean 22.07±1.84, limits 16.21 to 24.97), overweight BMI 43 % (mean 27.27±1.41, limits 25.29 to 29.96) and BMI with obesity 28 % (mean 35.85±4.63, limits 30.22 to 42.96). **Figure 1**

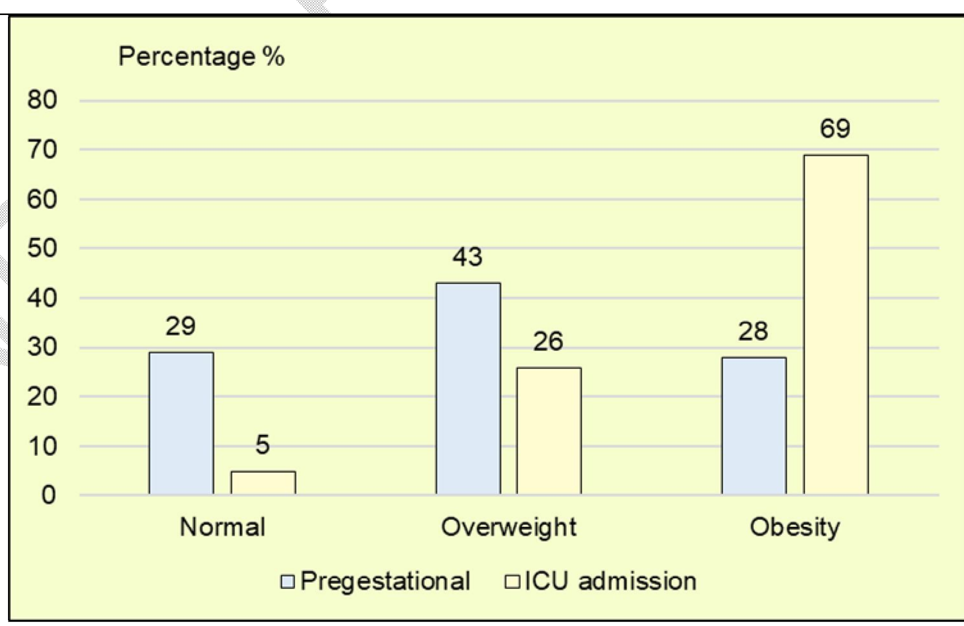

Figure 1. Distribution of 100 pregnant patients with severe preeclampsia by categories according to the pregestational Body Mass Index (BMI) and the BMI of

their admission to the Intensive Care Unit (ICU).

Regarding the values of their admission to the ICU, the general mean of weight was 82.01±15.81 K (limits 55 to 133) and height 1.57±0.19 m (limits 1.47 to 1.72). With these data, the BMI upon admission to the ICU was calculated. The overall mean was 32.90±5.95 (limits 21.95 to 40.7), the distribution was as follows: normal BMI 5 % (mean 24.46±0.36, limits 24.03 to 24.97), BMI with overweight 26 % (mean 27.97±1.28, limits 25.06 to 29.76) and BMI with obesity 69 % (mean 35.44±4.36, limits 30.4 to 40.7). **Figure 1**

When the pregestational values and those from admission to the ICU were compared, although the height was the same, the weight showed a change consisting of an increase of 12.18±0.05 K, which represented a percentage increase of 14.85 % with statistical significance (*P* = .02). As expected, BMI increased by 4.73 points, which represented an increase of 14.37 %; the change was significant (*P* = .04). **Table 1**

Table 1. Pregestational and ICU admission BMI

Parameters	Measurements		Change		*P* value
	pregestational	ICU admission			
weight K	69.83±15.86	82.01±15.81	increase K 12.18±0.05	increase % 14.85	0.02
height m	1.57±0.19	1.57±0.19	0	0	-----
BMI	28.17±5.96	32.90±5.95	increase 4.73 points	increase 14.37 %	0.04

BMI = Body Mass Index
ICU = Intensive Care Unit

The percentage of pregestational obesity increased from 28% to 69% in the ICU admission measurement, the distribution by category is shown in **Table 2**. As can be seen, the increase occurred at the expense of class II followed by class I, class III was practically unchanged.

Table 2. Distribution of obesity by categories

Obesity categories (BMI)	Measurements	
	Pregestational n= 28	ICU admission n=69
Class I (30 to 34.9)	14	21
Class II (35 to 39.9)	6	39
Class III (≥ 40)	8	9

BMI = Body Mass Index

3.3 ICU admission blood pressure

The overall mean blood pressure on admission to the ICU was as follows: systolic blood pressure 161.92±16.82 mmHg (limits 130 to 210) and diastolic blood pressure 101.11±9.75 mmHg (limits 85 to 140).

3.4 BMI and blood pressure

The distribution of pregestational BMI and ICU admission BMI with blood pressure values is shown in **Table 3**.

Table 3. Body Mass Index and blood pressure measurements

BMI	Blood pressure mmHg	
	systolic	diastolic
Pregestational values		
normal 29%	157.65±16.01	101.58±8.37
overweight 43%	163.79±17.56	103.09±11.31
obesity 28%	163.46±16.27	98.64±8.04
ICU admission values		
normal 5%	158±10.95	102±8.36
overweight 26%	158.57±15.90	103.30±9.27
obesity 69%	163.17±17.50	100.79±10.10

BMI = Body Mass Index
ICU = Intensive Care Unit

As can be seen, the highest systolic pressure values corresponded to patients with pregestational overweight and obesity compared to those of patients with normal BMI. However, when the systolic blood pressure data were analyzed by category, no significant differences were found (normal BMI vs overweight BMI P = .13, normal BMI vs obesity BMI P = .17, overweight BMI vs obesity BMI P = .93). The same was found when the diastolic blood pressure were compared (normal BMI vs overweight BMI P = .54, normal BMI vs obesity BMI P = .18 and overweight BMI vs obesity BMI P = .07).

The distribution of blood pressure measurements according to the BMI of admission to the ICU by categories is also shown in **Table 3**. The statistical comparison of the systolic blood pressure did not show significant differences for the different BMI categories (normal BMI vs overweight BMI P = .93, normal BMI vs obesity BMI P = .51, overweight BMI vs obesity BMI P = .24). The same occurred when diastolic blood pressure data were compared by BMI categories (normal BMI vs overweight BMI P = .77, normal BMI vs obesity BMI P = .79, overweight BMI vs obesity BMI P = .27).

3.5 Correlation of BMI with blood pressure

The correlation of the general mean of pregestational BMI with the general mean of systolic blood pressure was r = .04 and with diastolic blood pressure r = .13. The correlation of the mean BMI upon admission to the ICU with the mean systolic blood pressure was r = .03 and with diastolic blood pressure r = .07. All data are shown in **Table 4**. As can be seen, no significant correlation was found between the BMI categories of the pregestational measurement and the BMI at admission to the ICU with their own systolic and diastolic blood pressure.

Table 4. Correlations of Body Mass Index categories with blood pressure

BMI	Blood pressure mmHg systolic	Blood pressure mmHg diastolic
Pregestational values		
Categories	*r*	
normal 29%	0.188	0.113
overweight 43%	0.042	0.047
obesity 28%	0.200	0.004
all patients n=100	0.049	0.134
ICU admission values		
normal 5%	0.596	0.564
overweight 26%	0.001	0.020
obesity 69%	0.042	0.029
all patients n=100	0.038	0.071

r = Pearson correlation coefficient
ICU = Intensive Care Unit
BMI = Body Mass Index

4. DISCUSSION

Obesity is a worldwide disease whose frequency is increasing rapidly [1,2,4]. Mexico occupies first place for obesity in subjects of all ages, that is, from childhood to old age [12]. This increases the chances of women of childbearing age becoming obese before conception. Adding to the problem is the increase in weight and therefore BMI during pregnancy, which is already a reality. The above described is important because numerous studies have found that pregestational weight gain and during pregnancy increase the risk of developing preeclampsia and its short- and long-term complications [13,14].

The connection between both diseases can be explained because they share various pathophysiological mechanisms and biochemical mediators of oxidative stress, pro-inflammation, dyslipidemia and alteration of immune cells [5,6,15]. In clinical practice, a pregnant and obese patient is immediately identified as being at greater risk of suffering from preeclampsia and other pathologies associated with metabolic syndrome. Obesity and preeclampsia are diagnosed clinically, so their prevention and management are necessarily complementary from their detection.

In the present investigation, 100 pregnant patients with SP were studied to determine the correlation of pregestational BMI and BMI at admission to the ICU with systolic and diastolic blood pressure. These parameters (systolic and diastolic blood pressure) were chosen because they constitute the most important data on the severity of preeclampsia. It was found that 28 % of the patients in the study had pregestational obesity. **Figure 1** The incidence was lower than that of obesity in the adult population of our country, which has been reported at 36.9 % [12]. The data showed obesity in 69 % of the patients when they were admitted to the ICU, which represented a significant increase (P = .04). **Table 1** The increase occurred in class II and class I of obesity and not in class III. **Table 2** The percentage of metabolic and cardiovascular morbidities that are directly associated with obesity and metabolic syndrome was 18 % (gestational diabetes 8 %, gestational hypertension 5 %, type 2 diabetes mellitus 4 %, type 1 diabetes mellitus 1 %), the percentage is considered very low and can be justified because the age of the patients did not place them in the range of highest risk of chronic degenerative diseases due to advanced age.

The correlation of pregestational BMI with systolic and diastolic blood pressure values was not significant despite the fact that the group of obese patients had the highest blood pressure values. **Table 3** Similarly, no significant correlation was found between the BMI at admission to the ICU with systolic and diastolic blood pressure values despite the fact that the patients developed serious hypertensive complications of preeclampsia (HELLP syndrome 12 %, eclampsia 5 %, hypertensive encephalopathy 2 %, acute pulmonary edema 2 %, acute kidney injury 1 %). Thus, the data showed a significant increase in BMI and the percentage of obesity, but no correlation was found between pregestational BMI and ICU admission BMI with systolic and diastolic blood pressure. **Table 4**

There are some explanations for interpreting the findings. First, it is possible that the methodology for documenting obesity has had a significant influence. Unlike previous research, in patients the calculation of BMI with the Quetelet formula was adopted to document obesity rather than the measurement of arm bend or waist circumference. The choice was due to the fact that the two techniques mentioned have a greater margin of error when their value is compared with the fat content of the body during pregnancy [16]. Second, the study included 100 pregnant patients with SP with only 28 % in the pregestational obesity category. It is possible that the sample was not sufficient to document a positive correlation, which is why it is necessary to perform similar studies with a different design than of selected cases. Third, the number of patients with extreme obesity or in the range that current literature calls severe obesity (BMI ≥ 40), super obesity (BMI ≥ 50) and super-super obesity (BMI ≥ 60) [17] was scarce which could have influenced the results. A study with a larger number of women with severe obesity, super obesity, and super-super obesity may show different results. Fourth, all the patients studied had received periodic prenatal consultations in their primary care centers and came from second-level hospitals, so the diagnosis of hypertension due to preeclampsia was carried out early, in addition to the timely referral for specialized care in the ICU. Fifth, the research site is a tertiary care center where the patients come from first and second level centers. For this reason, none of the patients studied were virgin to antihypertensive management, which possibly limited a significant correlation. An alternative could have been to choose the highest blood pressure values recorded in their place of origin and not the measurement from their admission to the ICU. Sixth, the small number of patients with uncontrolled hypertension could have had an effect on the findings. Seventh, the morbidities related to the obesity of the patients represented a low percentage, possibly because they had a very short evolution and because they were under pharmacological compensation as part of prenatal control, so a clear effect of obesity-morbidities was not found. Eighth, the data on obesity and the severity of preeclampsia may vary according to the geographical area of each study based on racial factors, the economic condition of the nations and the health resources available to the population, these situations have been previously documented [18].

Among the findings, it was highlighted that delivery care with cesarean section or vaginal delivery was not accompanied by technical complications or anesthetic problems. Furthermore, none of the patients underwent surgery again and mortality was 0 %. Thus, patients with obesity were not identified as having a high surgical risk for medical complications such as bleeding episodes, thromboembolism, ventilation disorders or infections. The presence of hypertensive crises did not represent a problem although it was observed that patients who had excessive weight gain during pregnancy had higher blood pressure. Thus, patients with obesity did not experience the perioperative complications of medical, surgical technique or anesthesia that have been reported in previous research [17,18].

The findings of the present investigation contrast with the data of Sebire et al. [13] who in 2001 studied maternal obesity and the evolution of pregnancy in 287,213 women residing in the United Kingdom. They found that maternal obesity increased the risk for maternal and fetal complications such as gestational diabetes, preeclampsia, induction of labor, emergency cesarean section, postpartum hemorrhage, genital tract infection, urinary tract infections, low birth weight, and fetal death in utero.

In developing countries, it has also been documented that obesity increases the risk of a complicated pregnancy. In 2009, Ahmed et al. [18] studied 122 pregnant women treated at a hospital in Egypt and found that patients with pregestational obesity developed a greater number of gestational diabetes, preeclampsia, induction of labor, emergency cesarean section due to fetal stress, and wound infections.

Although in the present investigation a clear association of increased weight and BMI with blood pressure was not found, the findings continue to leave the door open for clinical research in the population of pregnant patients with obesity and preeclampsia. As it is a disease susceptible to modifications, for obesity, efforts must be directed towards prevention, detection and timely management before, during and after pregnancy with adequate control of caloric intake and its quality, exercise, lifestyle changes, stabilization of morbidities and the possibility of a bariatric surgical procedure in selected cases [19,20].

In the case of preeclampsia, maternal surveillance does not end with the termination of pregnancy because it has been documented that hypertensive states that complicate pregnancy are not only the main causes of maternal morbidity and mortality, but there is evidence that supports an association of high risk for developing coronary heart disease, chronic kidney disease and stroke in the following years. For this reason, it has been proposed that hypertensive states of pregnancy, like obesity, should be classified as risk factors for cardiovascular disease [21].

5. CONCLUSION

No significant correlation was found between pregestational BMI and ICU admission BMI with systolic and diastolic blood pressure in the patients participating in the study. The findings of the present investigation represent the experience of a single tertiary care center. Local data represent a limitation of the study. They do not invalidate the pathophysiological interaction that has been widely demonstrated between obesity and preeclampsia in recent decades nor contradict the preventive measures and management of obesity and preeclampsia recommended by international guidelines and the opinion of expert groups. Multi-centric study is required to further validate the findings.

ETHICAL APPROVAL

Prior to carrying out the study, the authorization opinion was obtained from the Local Health Research Committee and the Local Health Research Ethics Committee of the host hospital (Registration: R-2023-3504-20).

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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