

Relationship between maternal pre-pregnancy weight and fetomaternal outcomes in twin pregnancies: an original research

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November 3, 2022

Abstract

Objectives: To examine the influence of maternal pre-pregnancy body weight on fetomaternal outcomes in twin pregnancies. **Study design:** Retrospective study. **Setting:** Department of Obstetrics and Gynecology, Buergerhospital Frankfurt **Population:** 2,449 women delivering twins between 2005 and 2020 at the Buergerhospital Frankfurt. **Methods:** The mothers were categorized according to their pre-gravid body mass index into underweight, normal weight, overweight, obese, and obesity classes I – III. **Main outcome measures:** Gestational diabetes mellitus (GDM), preeclampsia/HELLP syndrome, intrauterine death (IUD), cesarean section or vaginal delivery, wound healing disorders, postpartum hemorrhage (PPH), uterine atony, preterm birth, birth weight discordance, admission to the neonatal intensive care unit (NICU), pH of the umbilical artery, and a 5'-APGAR score <7. **Results:** Obese mothers had a significantly higher risk for GDM (OR = 0.36; 95% CI 0.19 – 0.7 compared to underweight; OR = 0.32; 95% CI 0.23 – 0.43 compared to normal weight; OR = 0.47; 95% CI 0.33 – 0.69 compared to overweight), and wound healing disorders (OR = 0.19; 95% CI 0.09 – 0.4 compared to normal weight). Neonates of obese mothers showed significant results for umbilical artery pH of 7.01 – 7.1 (OR = 0.45; 95% CI 0.24 – 0.86 compared to overweight). Neonates of obesity class III mothers had a significantly higher risk for NICU admission (OR = 0.38; 95% CI 0.17 – 0.83 compared to obesity class I). No significant results for the remaining main outcome measures. **Conclusions:** Obesity, and overweight represent risk factors for adverse fetomaternal outcome in twin pregnancies.

Title page:

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Short title: Maternal pre-gravid BMI and fetomaternal outcomes in twin pregnancies.

Abstract:

Objectives: To examine the influence of maternal pre-pregnancy body weight on fetomaternal outcomes in twin pregnancies.

Study design: Retrospective study.

Setting: Department of Obstetrics and Gynecology, Buergerhospital Frankfurt am Main, Hessen, Germany

Population: 2,449 women delivering twins between 2005 and 2020 at the Buergerhospital Frankfurt, Germany.

Methods: The mothers were categorized according to their pre-gravid body mass index into underweight, normal weight, overweight, obese, and obesity classes I – III.

Main outcome measures: Gestational diabetes mellitus (GDM), preeclampsia/HELLP syndrome, intrauterine death (IUD), cesarean section or vaginal delivery, wound healing disorders, postpartum hemorrhage (PPH), uterine atony, preterm birth, birth weight discordance, admission to the neonatal intensive care unit (NICU), pH of the umbilical artery, and a 5'-APGAR score <7.

Results: Obese mothers had a significantly higher risk for GDM (OR = 0.36; 95% CI 0.19 – 0.7 compared to underweight; OR = 0.32; 95% CI 0.23 – 0.43 compared to normal weight; OR = 0.47; 95% CI 0.33 – 0.69 compared to overweight), and wound healing disorders (OR = 0.19; 95% CI 0.09 – 0.4 compared to normal weight). Neonates of obese mothers showed significant results for umbilical artery pH of 7.01 – 7.1 (OR = 0.45; 95% CI 0.24 – 0.86 compared to overweight). Neonates of obesity class III mothers had a significantly higher risk for NICU admission (OR = 0.38; 95% CI 0.17 – 0.83 compared to obesity class I). No significant results were observed for the remaining main outcome measures.

Conclusions: Obesity, and overweight represent risk factors for adverse fetomaternal outcomes in twin pregnancies.

Keywords: twin pregnancies; maternal obesity; pre-pregnancy weight; fetomaternal outcome; gestational diabetes mellitus; neonatal intensive care unit; umbilical artery pH; wound healing disorders

Main text:

Introduction:

Twinning rates were subject to many changes in the past few decades, almost doubling between 1980 – 1985 and 2010 – 2015. This is mainly due to increasing rates of assisted reproductive technology (ART) and increasing maternal age, the latter being accompanied by a higher likelihood for multiple pregnancies. In addition, a body mass index (BMI) ≥ 30 kg/m² is associated with a higher risk for twin pregnancies. With the prevalence of obese people worldwide almost tripling in the last three decades, it is no surprise that twinning rates rise in the context with increasing overweight and obesity incidences.

Although the relationship between maternal weight and the likelihood for twins has been investigated, the risks of overweight and obesity on fetomaternal outcomes have been subject to only few studies, especially regarding the impact of the three obesity classes as defined by the WHO. In singleton pregnancies, overweight and obesity lead to a 18 – 47% higher risk for obstetric complications.

The incidence of overweight and obese women of child-bearing age in Germany is at a distressing level. Thus, this study aims to examine the impact of maternal weight and especially obesity on fetomaternal complications and outcomes in twin pregnancies, hypothesizing that an increasing BMI and an increasing obesity class lead to a higher likelihood for adverse fetomaternal outcomes.

Methods:

Study design

This retrospective study included 2,586 pregnant women delivering twins between 2005 and 2020 at the Buergerhospital in Frankfurt, Germany. Thereof, 2,449 women fulfilled the two primary inclusion criteria, diamnionicity and an available pre-pregnancy BMI (calculated as weight [kg] divided by the square of height [m²]) and were analyzed for maternal outcomes.

For the neonatal analysis, 246 twin pairs of mothers being analyzed were excluded because of gestational age less than 24 weeks, stillbirth, congenital malformation, twin-to-twin transfusion syndrome, twin anemia polycythemia sequence, medically indicated abortions and hospitalization for less than 72 hours after birth.

The mothers were subdivided according to their pre-pregnancy BMI based on WHO standards (underweight <18.5 kg/m², normal weight $18.5 - 24.9$ kg/m², overweight $25 - 29.9$ kg/m², obese ≥ 30 kg/m², obesity class I $30 - 34.9$ kg/m², obesity class II $35 - 39.9$ kg/m² and obesity class III ≥ 40 kg/m²). The obese group consisted of 265 women, whereof 171 were in obesity class I, 58 in obesity class II and 36 in obesity class III.

Outcomes

Maternal and pregnancy outcomes examined included gestational diabetes mellitus (GDM), preeclampsia or HELLP syndrome (hemolysis, elevated liver enzymes and low platelets syndrome), intrauterine death (IUD) of at least one twin, cesarean or vaginal delivery, wound healing disorders, postpartum hemorrhage (PPH), including those in need of blood transfusions, uterine atony with the necessity of Sulprostone or a tamponade, and preterm birth.

GDM was diagnosed according to the guidelines of the American Diabetes Association. Every gravida underwent a 75 g oral glucose tolerance test between 24 and 28 weeks of gestation. GDM was diagnosed when at least one limiting value was exceeded (fasting: 92 mg/dL, 1 hour: 180 mg/dL, 2 hours: 153 mg/dL). Preeclampsia was defined according to the Practice Bulletin of the American College of Obstetricians and Gynecologists (ACOG) as a blood pressure of $\geq 140/90$ mmHg and proteinuria or at least one sign of organ damage. IUD was defined according to the Royal College of Obstetricians & Gynaecologists as missing signs of life in utero after 24 completed weeks of gestation. PPH was defined as bleeding $>1,000$ ml or blood loss with signs of hypovolemia within 24 hours after birth. Gestational age was calculated through measurement of the fetal crown-rump length using ultrasound and categorized into groups of $\geq 27+6$, $28 - 31+6$ and $32 - 36+6$ weeks of gestation.

Neonatal outcomes analyzed were birth weight discordance between twins, admission to the neonatal intensive care unit (NICU), pH of the umbilical artery and an APGAR score value below seven after five minutes.

Birth weight discordance was defined according to Practice Bulletin of the ACOG, estimated for every neonate, and classified into three groups of <20%, 20 – 24,9% and ≥25%. Fetuses with a birth weight discordance above 20% were monitored more intensively. Admission to NICU was defined as admission of at least one twin. The arterial umbilical pH was subdivided into categories of ≥7.0, 7.01 – 7.1 and 7.11 – 7.2.

Statistical analysis

Shapiro-Wilk-Test was used to determine whether continuous variables were normally distributed. Obese women were compared for categorical variables with underweight, normal weight and overweight women using Pearson's χ^2 test or Craddock's Flood χ^2 test. The same tests were used for the analysis of the obesity groups. A mixed effects Cox regression model was used to determine the impact of maternal BMI on the length of stay in the NICU between the weight categories.

All analyses were completed using BiAS. (Version 11.12, epsilon Verlag, Frankfurt, Germany) and RStudio (Version 4.1.1, RStudio Team (2020). RStudio: Integrated Development for R. RStudio, PBC, Boston, MA, USA). A Bonferroni correction was used to adjust p values. Therefore, ap value <0.003 was considered significant for maternal outcomes and <0.005 for neonatal outcomes. Odds ratios and relative risks were calculated with a 95% confidence interval.

Results:

Maternal characteristics

A total of 2,449 mothers were analyzed. The median age of the population was 34 years (IQR 30.01 – 37) and the median BMI was 22.96 kg/m² (IQR 20.76 – 25.95). Baseline characteristics of the mothers are shown in Table 1. Pregnancies resulting from ART were most common in the underweight group and lowest in the obese group. While rates of primiparas were similar in underweight and normal weight mothers, they decreased in overweight and obese mothers. Within the obese group, the highest rate was among obesity class I mothers. Rates of history of cesarean sections increased parallel to weight classes. Rates of underlying hypertension and diabetes mellitus were the highest among obesity class II mothers.

Maternal and obstetric outcomes

Maternal and obstetric outcomes were compared between underweight, normal weight, overweight and obese women and between obesity classes (Tables 2 and 3). GDM was significantly associated with maternal weight in the comparison of all four weight groups ($p < 0.001$; Pearson's coefficient $C = 0.15$). Obese mothers had a significantly higher risk for GDM when compared to underweight ($p = 0.003$; OR = 0.36; 95% CI 0.19 – 0.7), normal weight ($p < 0.001$; OR = 0.32; 95% CI 0.23 – 0.43) and overweight ($p < 0.001$; OR = 0.47; 95% CI 0.33 – 0.69) mothers. Among obese mothers, there was a significantly higher rate for GDM in obesity class III when compared to obesity class I ($p = 0.037$; OR = 0.45; 95% CI 0.21 – 0.95). Wound healing disorders were significantly associated with both maternal weight in general ($p < 0.001$; Pearson's coefficient $C = 0.09$) and obesity ($p < 0.001$; Pearson's coefficient $C = 0.26$). Obese women had a significantly increased risk for wound healing disorders compared to women of normal weight ($p < 0.001$; OR = 0.19; 95% CI 0.09 – 0.4), as well as mothers with obesity class III when compared to class I ($p < 0.001$; OR = 0.05; 95% CI 0.01 – 0.23). Preterm delivery was not associated with maternal weight or obesity. Nonetheless, mothers with obesity class III had the highest rate of delivery between 32 and 36+6 weeks of gestation (56%, compared to 40% in class I) in the obesity comparison. Interestingly, in the overall analysis, underweight mothers had the highest rate of delivery between 32 and 36+6 weeks of gestation (49%, compared to 42% in obese mothers). There was no significant association between maternal weight and preeclampsia or HELLP syndrome, IUD, and uterine atony with the necessity of Sulprostone or a Bakri balloon. Despite not being statistically significant, rates of PPH increased with rising BMI, albeit the highest rate occurring in obesity class I within the obese group. The normal weight and overweight groups had the highest rates of blood transfusions. There was no significant difference in rates of cesarean section or vaginal delivery between the weight groups or in the obesity analysis.

Neonatal outcomes

Neonatal outcomes were analyzed equally (Tables 2 and 3). There was no significant association between maternal weight and birth weight discordance of any severity, a pH of the umbilical artery of 7.11 – 7.2 or ≥ 7.0 and a five-minute APGAR score below seven. There was, however, a significantly increased risk for a pH of the umbilical artery of 7.01 – 7.1 in neonates of obese women when compared to overweight women ($p = 0.016$; OR = 0.45; 95% CI 0.24 – 0.86). Albeit not being associated with maternal weight or obesity classes, there was a significantly higher risk for neonate admission to NICU for obesity class III in comparison to obesity class I ($p = 0.015$; OR = 0.38; 95% CI 0.17 – 0.83) and a significantly increased rate of admission to the NICU of the firstborn of mothers with obesity class III when compared to mothers with obesity class I ($p = 0.02$; OR = 0.4; 95% CI 0.18 – 0.89). Maternal BMI did not significantly influence the length of stay in the NICU.

Discussion:

Main findings

The study population consisted of 2,449 mothers, whereof 11% were obese. Both maternal weight and obesity were significantly associated with GDM and wound healing disorders, obese mothers having a significantly higher risk for GDM and post-cesarean wound healing disorders. Preterm birth, preeclampsia or HELLP syndrome, IUD, uterine atony, PPH and rates of cesarean sections or vaginal delivery showed no significant results. In the analysis of the neonatal outcomes, neonates of obese mothers had a significantly higher risk for an umbilical artery pH of 7.01 – 7.1. Furthermore, neonates of mothers with obesity class III had a significantly higher risk for NICU admission, especially for the firstborn. Birth weight discordance of any severity, umbilical artery pH of ≥ 7.0 or 7.11 – 7.2 and a five-minute APGAR < 7 was not significantly associated with maternal weight or obesity.

Strengths and limitations

This study contributes to the still small range of studies on the effects of obesity and overweight on fetomaternal outcomes in twin pregnancies. By analyzing the outcomes wound healing disorders, uterine atony, postpartum hemorrhage, and asphyxia, four topics were included, which have not yet been addressed frequently or at all in studies on the impact of maternal weight on twin pregnancies. Many studies are conducted analyzing the impact of obesity in general. In this study, obesity has been analyzed further by subdividing this weight group into the three obesity classes as defined by the WHO, allowing a more detailed view on their impacts on fetomaternal outcomes in twin pregnancies. Furthermore, underweight mothers and their offspring were analyzed as well, their risk in twin pregnancies also only being topic to few studies.

The limitations include the retrospective nature of the study. The study population is comparatively small, which might explain why some of the results were not significant in contrast to findings of other similar studies. Furthermore, no statistical analyses to adjust for confounding variables have been performed. The Buergerhospital Frankfurt being a tertiary referral center with the second highest birth rate in Germany and a specialization on multiple pregnancies and their complications, might bias the rates of pregnancy and postpartum complications.

Interpretation

Twin pregnancies are at a higher risk for gestational diabetes than singleton pregnancies, every additional fetus in multiple pregnancies increasing the risk for GDM by 1.8 times. Consistent with these studies, data of this analysis also showed a significant association between obesity and GDM, with significantly increasing rates within obesity classes. With GDM increasing the risks for cesarean sections, preeclampsia, and preterm birth, and considering the increasing rates of GDM worldwide, prevention and information on the risks of gestational diabetes should be extended.

Obesity has been established as an important risk factor for surgical site infections after cesarean sections. Almost a third of severely obese patients were described to suffer from wound complications after a cesarean section. This study confirms these findings, showing an association between maternal weight in general and especially obesity and wound complications. Furthermore, Olsen et al. and Wall et al. showed that missing

antibiotic prophylaxis is an independent risk factor for wound infections and that patients with vertical skin incisions have a significantly increased incidence of wound complications. At the Buergerhospital Frankfurt, all cesarean sections are performed under antibiotic prophylaxis with a transverse skin incision, possibly explaining the low rates of wound healing disorders in our study.

PPH is the most important reason for pregnancy-related morbidity, 70% of all PPH being caused by uterine atony or inadequate uterine contraction. Maternal obesity and multiple pregnancies are considered being important risk factors for PPH, multifetal gestations possibly leading into uterine overdistension, and consequently into uterine atony with the risk of PPH. To our knowledge, this study was the first to assess the direct influence of maternal weight on uterine atony both with the necessity of Sulprostone and intervention with a Bakri Balloon in twin pregnancies. In contrast to the studies mentioned afore, rates of PPH did not reach significance in this study, however, women with obesity class I had a threefold risk for PPH compared to obesity class II and a twofold risk for PPH compared to obesity class III.

Paidas Teefey et al. investigated rates of cesarean deliveries especially for obesity class III women in singleton pregnancies, finding rates of nearly 50% for obesity class III women and 66% for women with a BMI of at least 30 kg/m². Albeit not statistically significant, this study confirmed these findings, showing that cesarean sections were more common with rising BMI, especially in the obese group.

Despite being a study conducted in singleton pregnancies and thus only partially applicable to twins, Bicocca et al. observed a higher risk for hypertensive pregnancy disorders, including preeclampsia, with increasing obesity classes. In twin pregnancies, findings on preeclampsia are inconsistent. On one hand, a BMI ≥ 30 kg/m² is considered as a significant risk factor for preeclampsia, on the other hand, the risk for preeclampsia might only be significantly increased in obesity class III. Potentially due to low rates of preeclampsia in this study population, findings of this study contrast the studies mentioned afore, showing no significant risks.

In singleton pregnancies, obesity was shown to be the second biggest risk factor for stillbirth. Similarly, Salihu et al. described a 60% higher risk for fetal death of both twins in obese women. Both these findings contrast the results of this study, possibly because of low rates of IUD in this study in general and similar rates in all weight groups.

Neonatal outcomes in twin pregnancies have only been investigated in a few studies, while having been analyzed thoroughly in singleton pregnancies. Obesity or increasing BMI were shown to be associated with higher rates of fetomaternal complications as well as admission to NICU in singleton pregnancies. Confirming these findings, a significantly higher risk for admission to NICU in neonates of obesity class III mothers and especially for their firstborn was observed. Maternal weight did not have an impact on the mean length of stay in the NICU.

Only a few studies have been conducted in twins investigating the topic of asphyxia and low umbilical artery pH, concluding that the second twin is at a significantly higher risk for asphyxia, low umbilical artery pH values or low APGAR scores. To our knowledge, this study is the first one to assess the impact of maternal weight and obesity on the umbilical artery pH and asphyxia in twins. Significantly higher rates of pH values of 7.01 – 7.1 in neonates of obese mothers were observed in this study. Considering the sparse number of studies on this topic, the impact of obesity on the risk for asphyxia in twins should be analyzed in further investigations. Regarding the five-minute APGAR score, our findings confirmed those of Bautista et al., showing no association between maternal BMI and a low five-minute APGAR score.

Conclusion:

With twin pregnancies already being at high risk for adverse outcomes regardless of the maternal pre-pregnancy weight, this study supports findings of other studies on the additional impact of overweight and obesity on both mother and twins. However, this study also shows a lower rate of complications in contrast to some studies mentioned afore, most likely due to the health care system in Germany and the Buergerhospital Frankfurt being a tertiary referral center with a joined NICU. This results in better and

continuous monitoring from the very start of the pregnancy and thus complications being diagnosed earlier with the option to intervene sooner. Furthermore, an antibiotic prophylaxis before cesarean sections is standard in Germany and therefore also leading to lower post-cesarean maternal complications.

With increasing incidences of overweight and obesity worldwide, the associated risks for twin pregnancies need to be addressed more to create a foundation for better understanding and enhanced prevention of overweight and obesity both in general and especially in regard to pregnancies. However, underweight has also shown to have a great impact on adverse fetomaternal outcomes in twin pregnancies, implicating the need for information in this area as well.

Acknowledgments:

This study was supported by the Dr. Senckenbergische Stiftung.

Disclosure of interests:

The authors report no conflict of interest.

Contribution to Authorship:

LN, MW and FB designed and conducted the study. LN and MW collected data, the statistical analysis was conducted by LN and AAN. Data interpretation and drafting of the manuscript were by LN, with support by MW. The literary research was conducted by CE. All authors revised the manuscript critically for important intellectual content. FB supervised the study and revised the final draft. All authors approved of the final manuscript and are accountable for all aspects of the work.

Ethics Approval:

This study has been approved by the ethics committee of the Medical Association of Hesse (January 3rd, 2022, reference number: 2021-2675-evBO).

Funding:

This study was conducted without sources of financial support or funding.

Tables:

Table 1. Maternal characteristics

Characteristics	Underweight (n=101, 4.1%)	Normal weight (n=1577, 64.4%)	Overweight (n=506, 20.7%)	Obese (n=265, 10.8%)	Obese (n=265, 10.8%)	Obese (n=265, 10.8%)	Obese (n=265, 10.8%)
	n (%)	n (%)	n (%)	Total n (%)	Class I n (%)	Class II n (%)	Class III n (%)
Age (years)	32.25 ^a	34 ^b	33.56 ^a	32.5 ^a	32.81 ^a	31.85 ^a	32.08 ^a
BMI [kg/m ²]	17.99 ^b	21.78 ^b	26.7 ^b	33.56 ^b	32 ^b	36.98 ^b	43.45 ^a
ART	38 (38%)	589 (37%)	177 (35%)	76 (29%)	50 (29%)	14 (24%)	12 (33%)
Primipara	65 (64%)	1038 (66%)	286 (57%)	137 (52%)	92 (54%)	31 (53%)	14 (39%)
MCDA twins	28 (28%)	353 (22%)	121 (24%)	59 (22%)	36 (21%)	16 (28%)	7 (19%)
DCDA twins	73 (72%)	1224 (78%)	386 (76%)	206 (78%)	135 (79%)	42 (72%)	29 (81%)

Characteristics	Underweight (n=101, 4.1%)	Normal weight (n=1577, 64.4%)	Overweight (n=506, 20.7%)	Obese (n=265, 10.8%)	Obese (n=265, 10.8%)	Obese (n=265, 10.8%)	Obese (n=265, 10.8%)
History of abortion ^c	10 (10%)	142 (9%)	57 (11%)	37 (14%)	23 (13%)	10 (17%)	4 (11%)
History of C-section	6 (6%)	149 (9%)	77 (15%)	53 (20%)	31 (18%)	10 (17%)	12 (33%)
Smoker	1 (1%)	21 (1%)	8 (2%)	7 (3%)	3 (2%)	3 (5%)	1 (3%)
Pre- existing HTN	0 (0%)	12 (1%)	6 (1%)	12 (5%)	4 (2%)	6 (10%)	2 (6%)
Pre- existing DM ^d	0 (0%)	13 (1%)	5 (1%)	9 (3%)	4 (2%)	4 (7%)	1 (3%)

Abbreviations: ART, assisted reproductive technology; BMI, body mass index; C-section, cesarean section; DCDA twins, dichorionic diamniotic twins; DM, diabetes mellitus; HTN, hypertension; MCDA twins, monochorionic diamniotic twins^aMean result^bMedian result^cAt least two abortions

^d*Diabetes mellitus type 1 and 2*

Table 2. Obstetric and neonatal outcome in underweight, normal weight, overweight and obese mothers

Outcome	Underweight n (%)	Normal weight n (%)	Overweight n (%)	Obese n (%)	p Value
Obstetric outcome	(n=101)	(n=1577)	(n=506)	(n=265)	
GDM	11 (11%)	152 (10%)	70 (14%)	67 (25%)	< 0.001 ^a
PE/HELLP syndrome	6 (6%)	106 (7%)	42 (8%)	22 (8%)	0.54
IUD ^b	3 (3%)	49 (3%)	23 (5%)	12 (5%)	0.36
C-Section	70 (69%)	1099 (70%)	368 (73%)	201 (76%)	0.16
Vaginal delivery	27 (27%)	340 (22%)	102 (20%)	50 (19%)	0.37
Wound healing disorders	2 (2%)	13 (1%)	10 (2%)	11 (4%)	< 0.001 ^a
PPH	6 (6%)	133 (8%)	43 (8%)	23 (9%)	0.84
Uterine atony + Sulprostone	3 (3%)	23 (1%)	7 (1%)	3 (1%)	0.61
Uterine atony + BBT	1 (1%)	9 (1%)	3 (1%)	4 (2%)	0.38
Delivery [?]27+6 weeks	2 (2%)	55 (3%)	25 (5%)	12 (5%)	0.32
Delivery 28 – 31+6 weeks	8 (8%)	98 (6%)	29 (6%)	20 (8%)	0.7
Delivery 32 – 36+6 weeks	49 (49%)	721 (46%)	228 (45%)	112 (42%)	0.68
Neonatal outcome	(n=94)	(n=1432)	(n=443)	(n=234)	
WD <20%	77 (82%)	1162 (81%)	360 (81%)	195 (83%)	0.88

Outcome	Underweight n (%)	Normal weight n (%)	Overweight n (%)	Obese n (%)	p Value
WD 20 – 24.9%	7 (7%)	109 (8%)	40 (9%)	17 (7%)	0.78
WD [?]25%	10 (11%)	161 (11%)	43 (10%)	22 (9%)	0.7
Admission to NICU ^c	32 (17%)	576 (20%)	169 (19%)	101 (22%)	0.52
pH 7.11 – 7.2 ^d	15 (8%)	271 (9%)	89 (10%)	52 (11%)	0.57
pH 7.01 – 7.1 ^d	9 (5%)	80 (3%)	18 (2%)	20 (4%)	0.05
pH [?]7.0 ^d	2 (1%)	26 (1%)	6 (1%)	3 (1%)	0.86
5'-APGAR <7	4 (2%)	45 (2%)	10 (1%)	9 (2%)	0.6

Abbreviations: BBT, Bakri balloon tamponade; HELLP syndrome, hemolysis, elevated liver enzymes and low platelets syndrome; IUD, intrauterine death; GDM, gestational diabetes mellitus; PE, preeclampsia; PPH, postpartum hemorrhage; NICU, neonatal intensive care unit; WD, weight discordance

^aSignificant after Bonferroni correction

^bIUD of at least one twin^cAdmission to NICU of at least one twin

^dpH of the umbilical artery

Table 3. Obstetric and neonatal outcome in obese mothers

Outcome	Obesity class I n (%)	Obesity class II n (%)	Obesity class III n (%)	p Value
Obstetric outcome	(n=171)	(n=58)	(n=36)	
GDM	38 (22%)	15 (26%)	14 (39%)	0.11
PE/HELLP syndrome	15 (9%)	4 (7%)	3 (8%)	0.9
IUD ^b	7 (4%)	3 (5%)	2 (6%)	0.9
C-Section	125 (73%)	47 (81%)	29 (81%)	0.37
Vaginal delivery	36 (21%)	7 (12%)	7 (19%)	0.32
Wound healing disorders	1 (1%)	8 (14%)	4 (11%)	< 0.001 ^a
PPH	19 (11%)	2 (3%)	2 (6%)	0.16
Uterine atony + Sulprostone	3 (2%)	0 (0%)	0 (0%)	0.43
Uterine atony + BBT	4 (2%)	0 (0%)	0 (0%)	0.33
Delivery [?]27+6 weeks	6 (4%)	4 (7%)	2 (6%)	0.53
Delivery 28 – 31+6 weeks	13 (8%)	6 (10%)	1 (3%)	0.4
Delivery 32 – 36+6 weeks	68 (40%)	24 (41%)	20 (56%)	0.22
Neonatal outcome	(n=155)	(n=48)	(n=31)	
WD <20%	132 (85%)	39 (81%)	24 (77%)	0.52
WD 20 – 24.9%	11 (7%)	3 (6%)	3 (10%)	0.84
WD [?]25%	12 (8%)	6 (13%)	4 (13%)	0.48

Outcome	Obesity class I n (%)	Obesity class II n (%)	Obesity class III n (%)	<i>p</i> Value
Admission to NICU ^c	58 (19%)	21 (22%)	22 (35%)	0.01
pH 7.11 – 7.2 ^d	33 (11%)	11 (11%)	8 (13%)	0.87
pH 7.01 – 7.1 ^d	13 (4%)	4 (4%)	3 (5%)	0.37
pH [?]7.0 ^d	2 (1%)	1 (1%)	0 (0%)	0.73
5'-APGAR <7	7 (2%)	2 (2%)	0 (0%)	0.49

Abbreviations: BBT, Bakri balloon tamponade; HELLP syndrome, hemolysis, elevated liver enzymes and low platelets syndrome; IUD, intrauterine death; GDM, gestational diabetes mellitus; PE, preeclampsia; PPH, postpartum hemorrhage; NICU, neonatal intensive care unit; WD, weight discordance

^aSignificant after Bonferroni correction

^b*IUD of at least one twin*^c*Admission to NICU of at least one twin*

^d*pH of the umbilical artery*