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Body Mass Index and Operative Times at Cesarean Delivery

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Abstract

OBJECTIVE—To examine the relationship between body mass index (BMI, kg/m²) and incision-to-delivery interval and total operative time at cesarean delivery.

METHODS—Women with singleton gestations undergoing uncomplicated primary and repeat cesarean deliveries were identified from the Maternal-Fetal Medicine Units Network Cesarean Registry. Women were classified by BMI category at time of delivery (normal 18.5–24.9, overweight 25.0–29.9, obese 30.0–39.9, and morbidly obese 40 or greater). Incision-to-delivery interval and total operative times during cesarean delivery were compared among the three groups. Primary outcome was prolonged incision-to-delivery interval as defined by 90th percentile or greater of the study population or 18 minutes or longer.

RESULTS—Of the 21,372 women included in the analysis, 9,928 were obese (46.5%) and 2,988 (14.0%) were morbidly obese. Longer operative times were found among women with overweight (median [interquartile range] incision-to-delivery: 9.0 [6.0] and total operative time: 45.0 [21.0] minutes), obese (10.0 [7.0]; 48.0 [22.0] minutes), and morbidly obese BMIs (12.0 [8.0]; 55.0 [26.0] minutes) compared with women with normal BMI at delivery (9.0 [5.0]; 43.0 [20.0] minutes) ($P<.001$). Morbidly obese women had a more frequent incision-to-delivery interval that was 18 minutes or longer ($n = 602$ [20%] compared with 127 [6%] in normal BMI). After adjustments including number of prior cesarean deliveries, incision-to-delivery interval 18 minutes or longer was significantly related to obese (odds ratio [OR] 1.62, 95% confidence interval [CI] 1.31–2.03) and morbidly obese (OR 2.81, 95% CI 2.24–3.56) BMI at delivery.

CONCLUSION—Increasing BMI is related to increased incision-to-delivery interval and total operative time at cesarean delivery with morbidly obese BMI exposing women to the highest risk of prolonged incision-to-delivery interval.

Maternal obesity is a major obstetric concern in the United States with an estimated 32% of women of reproductive age having a prepregnancy body mass index (BMI, calculated as

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weight (kg)/[height (m)]² 30 or higher.¹ Prepregnancy obesity, excessive weight gain, and delivery obesity are all related to adverse pregnancy outcomes, including an almost twofold increase in the cesarean delivery rate.^{2–4} Difficult anesthetic management of cesarean delivery,⁵ increased risk of gestational hypertension, preeclampsia, gestational diabetes, macrosomia and wound complications,^{2,6} and more frequent use of vertical skin incision in morbidly obese (BMI 40 or greater) patients⁷ have been documented.

Few studies have addressed specific effects of maternal obesity on operative times at cesarean delivery. The prior studies have been relatively small- or medium-sized and limited to one center. A cohort of 1,656 women from Mississippi identified multiple factors associated with increased operative times including maternal BMI 30 or higher.⁸ In addition, Butwick et al⁵ showed in a small cohort of 100 patients that the total cesarean operative time is lengthened in morbidly obese patients. Most recently, Conner et al⁹ demonstrated that incision-to-delivery interval in cesarean delivery is increased with increasing BMI in a cohort of 2,244 pregnant women.

In this study, we investigated the effect of increased maternal BMI on cesarean delivery operative times using a large, multicenter cohort of more than 21,000 pregnancies. We hypothesized that the incision-to-delivery interval and total operative time increase with increasing BMI.

MATERIALS AND METHODS

This study is a secondary analysis of the Maternal-Fetal Medicine Units Network Cesarean Registry, a previously reported prospective cohort observational study that was conducted by the *Eunice Kennedy Shriver* National Institute of Child Health and Development Maternal-Fetal Medicine Units Network from 1999 to 2002 at 19 participating centers.¹⁰ Briefly, data were collected in women who underwent delivery by primary cesarean delivery, repeat cesarean delivery, or trial of labor after cesarean delivery to determine the risk of uterine rupture among women undergoing a trial of labor. For the final 2 years of the study, only women who underwent repeat cesarean delivery or vaginal birth after cesarean delivery who delivered neonates greater than 20 weeks of gestation or greater than 500 g were enrolled. Data were collected through detailed chart review at delivery, and information regarding perioperative morbidity was collected from discharge summaries. Data regarding patient and hospital were deidentified by the Maternal-Fetal Medicine Unit.^{10,11} The data released from the Maternal-Fetal Medicine Unit included maternal BMI at delivery but not height and weight. Ethics committees in each participating center approved the study protocol and study participants gave their written informed consent before participating. Because of the deidentified data from the Maternal-Fetal Medicine Unit, this secondary analysis received a waiver of exemption by the Stanford University institutional review board.

The analysis included women with BMI of 18.5 or more at the time of delivery with a singleton gestation undergoing either primary or repeat cesarean delivery. Exclusion criteria were emergency cesarean delivery, uterine rupture, placenta accreta, hysterectomy in the current pregnancy, and history of prior myomectomy. Study groups were based on four BMI

categories according to the World Health Organization guidelines¹²: normal 18.5–24.9, overweight 25.0–29.9, obese 30.0–39.9, and morbidly obese 40 or greater. Only cases with available data on each variable were analyzed. For neonatal adverse outcomes (pH less than 7.1; Apgar less than 7 at 5 minutes, and neonatal intensive care unit [NICU] admission), missing data were considered the same as an absence of the finding. Both arterial and venous cord blood values were included in the analysis.

Operative times assessed included the interval from the skin incision to the delivery (incision-to-delivery interval) and the interval from the skin incision to the completion of the surgery (total operative time), both measured in minutes. The time variables were rounded to the closest 10th decimal. The incision-to-delivery interval and the total operative time during cesarean delivery were compared among four BMI groups. Our primary outcome was prolonged incision-to-delivery interval, 18 minutes, defined by 90th percentile or greater of all incision-to-delivery intervals in this cohort. As an additional subgroup analysis, neonatal adverse outcomes were studied among women with general compared with regional (epidural and spinal) anesthesia.

Statistical analysis was performed using the R 2.15.0. Comparisons of continuous variables between two groups were performed using *t* test or Wilcoxon test. Categorical variables were compared with χ^2 test. After univariable analysis, significant ($P < .1$) covariates were included into the multivariable logistic regression analyses. The final model was built using stepwise backwards exclusion. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for prolonged incision-to-delivery interval and for neonatal adverse outcomes. $P < .05$ was considered statistically significant.

RESULTS

Twenty one thousand three hundred seventy-two women were included in the analysis, of whom 12,832 (60.0%) underwent primary and 8,540 (40.0%) underwent repeat cesarean delivery. A total of 9,928 (46.5%) women were obese and 2,988 (14.0%) were morbidly obese at delivery. Morbidly obese women were significantly less likely to be Caucasian and more likely to receive public insurance and have more prior deliveries and cesarean deliveries (Table 1). Obese and morbidly obese women were more likely to develop preeclampsia or gestational hypertension compared with women with normal BMI, whereas no significant differences were found in the rates of gestational diabetes (Table 1).

Both incision-to-delivery interval and total operative times were significantly longer among overweight (median [interquartile range] incision-to-delivery interval: 9.0 [6.0] and total operative time: 45.0 [21.0] minutes), obese (10.0 [7.0] and 48.0 [22.0] minutes), and morbidly obese women (12.0 [8.0] and 55.0 [26.0] minutes) compared with women with normal BMI at delivery (9.0 [5.0] and 43.0 [20.0] minutes, $P < .001$) (Table 2). Compared with women with a normal BMI, morbid obesity was associated with a prolonged incision-to-delivery interval ($n = 602$ [20%] compared with 127 [6%], $P < .001$) (Table 2).

Obese and morbidly obese women were more likely to undergo vertical skin incisions compared with the normal BMI group (Table 2). Neonates of overweight, obese, and

morbidly obese women were born later and with higher birth weight than the neonates of women with normal BMI (Table 2). In addition, overweight, obese, and morbidly obese women were more likely to have an epidural anesthesia compared with normal-weight women (Table 2).

A statistically significant tendency of a lower umbilical cord pH was found in groups with increased BMI (Table 3). The normal BMI group, however, demonstrated a higher rate of low Apgar scores at 5 minutes and an increased rate of NICU admission compared with other groups (Table 3).

Multivariate analysis for prolonged incision-to-delivery interval (18 minutes or longer) was performed adjusting for number of prior cesarean deliveries, maternal race, type of insurance, skin incision type, and neonatal birth weight in the final model. After the adjustments, the odds for prolonged incision-to-delivery interval were significantly associated with obese BMI (OR 1.62, 95% CI 1.31–2.03) and morbidly obese BMI (OR 2.81, 95% CI 2.24–3.56) at delivery, whereas there was no statistically greater odds of prolonged incision-to-delivery interval for the overweight group (Table 4).

After adjusting for maternal BMI category at delivery, maternal race, number of prior cesarean deliveries, and type of skin incision in the final model, umbilical cord pH less than 7.1 was significantly related to prolonged incision-to-delivery interval (OR 1.40, 95% CI 1.05–1.85). No significant associations were found between prolonged incision-to-delivery interval and neonatal NICU admission (adjusted OR 1.11, 95% CI 0.97–1.27) or Apgar scores less than 7 at 5 minutes (adjusted OR 1.31, 95% CI 0.95–1.77), respectively.

In subanalysis between women with general compared with regional anesthesia, the neonates of women with general anesthesia had more frequently less than 7 Apgar points at 5 minutes ($n = 99$ [13.8%] compared with 491 [2.3%] in regional anesthesia, $P < .001$) and were more frequently admitted to the NICU ($n = 320$ [44.4%] compared with 5,141 [24.5%] in regional anesthesia, $P < .001$). No significant difference was seen in absolute neonatal cord pH values between women who received general compared with regional anesthesia (mean [standard deviation] cord pH: 7.25 [0.09] compared with 7.24 [0.08] among women with regional anesthesia) or in cord pH less than 7.1 categories ($n = 18$ [2.5%] compared with 437 [2.1%] in regional anesthesia).

DISCUSSION

With a significant portion of cesarean deliveries performed for obese women in the United States every year, it is important to understand the influence of BMI on operative times. Prolonged operative times have been also related to higher surgery costs resulting from greater anesthesia requirements.⁵ Our study demonstrated an association between increased maternal BMI and incision-to-delivery interval in a large multicenter cohort of women undergoing primary and repeat cesarean delivery. The association between increased BMI and incision-to-delivery interval was independent of the number of prior cesarean deliveries, type of skin incision, and neonatal birth weight, which are known risk factors for increased operative time. In addition, increased BMI was related to longer total operative time at

cesarean delivery. Our findings in this large cohort are consistent with previous smaller studies reporting an association between obesity and increased operative time.^{5,8,9,13}

Previous studies have demonstrated an association between increasing BMI and perioperative maternal morbidity, including anesthetic complications,^{14,15} increased estimated blood loss, and increased postoperative wound complications.¹⁶ Maternal factors that affect incision-to-delivery interval are particularly relevant in that they may affect neonatal outcomes. Our study demonstrated a 1-minute increase in median incision-to-delivery interval and a 5-minute increase in median total operative time among women with obese BMI compared with women with normal BMI. For morbidly obese women, the median incision-to-delivery interval was increased 3 minutes and total operative time 12 minutes compared with women with normal BMI. Although the absolute increase in incision-to-delivery interval may not be clinically relevant for most women, the increase in prolonged incision-to-delivery interval is clinically relevant, as suggested by the association with umbilical cord blood pH less than 7.1 among this group independent of maternal BMI at delivery, maternal race, number of prior cesarean deliveries, and type of skin incision. In a smaller subcohort from the Maternal-Fetal Medicine Unit Cesarean Registry, maternal obesity at the time of cesarean delivery was also associated with low neonatal cord blood pH values and increased base deficit values.¹⁷ Edwards et al¹⁷ examined 5,742 women and included those who delivered a live, term, nonanomalous singleton neonate by prelabor cesarean delivery under spinal anesthesia. Our results support the findings of Edwards et al and suggest that prolonged operative time may have an effect on neonatal outcomes at cesarean delivery.

Our data demonstrated an increase in both incision-to-delivery interval as well as in total operative time among obese and morbidly obese women as compared with nonobese women. Our study in a multicenter cohort of more than 21,000 women is consistent with results of Doherty et al and Conner et al who showed in cohorts of 1,656 and 2,244 women that total cesarean operative time was lengthened with maternal BMI greater than 30.^{8,9} Butwick et al⁵ also demonstrated longer cesarean intraoperative times among women with BMI 40 or greater. However, possibly as a result of the small size of each BMI group (n = 25), Butwick et al⁵ did not identify differences in incision-to-delivery times between groups. In our study, obese and morbidly obese women also had a somewhat higher incidence of vertical skin incisions compared with women with normal BMI. In a regression model, however, vertical skin incision was related to shorter incision-to-delivery interval, thus making the finding of lengthened operative times among morbidly obese women more powerful.

There are number of potential limitations in this retrospective analysis of prospectively obtained data. The study participants' heights and weights were not available for this secondary analysis. In addition, although the majority of the data was well coded, there was a large amount of missing values in neonatal cord pH variable. We attempted to control for most potential confounders, although some factors like the experience of the surgeon, accompanying sterilization procedure, or anesthetic complications were not accounted for. Other comorbidities related to obesity may have also played a role in operative and neonatal morbidity in these pregnancies.

The strengths of this study include the multicenter prospective data collection, large sample size, and ability to adjust for multiple potential confounding variables. With 47% being obese and 14% morbidly obese, our study population is reflective of what others have found among women undergoing a cesarean delivery.^{8,13} In addition, we accounted for the effect of major operative complications by excluding cases with emergency cesarean delivery, uterine rupture, placenta accreta, hysterectomy, and history of prior myomectomy.

In conclusion, increasing BMI is associated with both increased incision-to-delivery time and total operative time. As obesity rates increase among women of reproductive age, so it increases our need to understand potential maternal and neonatal morbidities from the operating room to the NICU.

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Table 1

Demographics and Clinical Characteristics of the Study Groups

BMI at Delivery	Normal (n = 2,013)	Overweight (n = 6,443)	Obese (n = 9,928)	Morbidly Obese (n = 2,988)
Maternal age (y)				
Younger than 18	113 (6)	244 (4)*	293 (3)*	57 (2)*
18–35	1,680 (83)	5,318 (82)	8,293 (83)	2,560 (86)
Older than 35	220 (11)	881 (14)	1,342 (14)	371 (12)
Race				
Caucasian	1,076 (54)	3,423 (53)*	4,656 (47)*	1,286 (43)*
African American	413 (21)	1,079 (17)	2,271 (23)	1,166 (39)
Hispanic	390 (19)	1,517 (24)	2,520 (25)	451 (15)
Asian	62 (3)	195 (3)	121 (1)	19 (1)
Native American	2 (<1)	8 (<1)	29 (1)	8 (<1)
Other or unknown	70 (3)	221 (3)	332 (3)	58 (2)
Public insurance	726 (36)	1,973 (31)*	3,520 (36)	1,321 (44)*
Missing	116 (6)	289 (5)	430 (4)	128 (4)
Parity				
0	949 (47)	2,992 (46)	4,370 (44)	1,232 (41)*
1–2	716 (36)	2,304 (36)	3,514 (35)	1,072 (36)
3 or more	186 (9)	542 (8)	994 (10)	352 (12)
Missing	162 (8)	605 (10)	1,050 (11)	332 (11)
Prior cesarean deliveries				
0	1,322 (66)	3,967 (62) [†]	5,759 (58)*	1,682 (56)*
1–2	442 (22)	1,593 (25)	2,589 (26)	785 (26)
3 or more	57 (2)	183 (3)	363 (4)	134 (5)
Missing	192 (10)	700 (10)	1,217 (12)	487 (13)
Diabetes				
Gestational	54 (3)	244 (4)	745 (7)	435 (15)
Other	14 (1)	94 (1)	254 (3)	158 (5)
Missing	1,945 (96)	6,105 (95)	8,929 (90)	2,395 (80)
Preeclampsia or gestational hypertension	196 (10)	633 (10)	1,543 (16)*	734 (25)*
Missing	0 (0)	0 (0)	0 (0)	0 (0)

BMI, body mass index.

Data are n (%).

Comparisons made with χ^2 test.* $P < .001$ compared with normal BMI.[†] $P < .05$ compared with normal BMI.

Table 2

Characteristics of Cesarean Delivery in the Study Groups

BMI at Delivery	Normal	Overweight	Obese	Morbidly Obese
n	2,013	6,443	9,928	2,988
Skin incision				
Vertical	232 (12)	861 (13)*	1,744 (18) [†]	536 (18) [†]
Pfannenstiel	1,769 (88)	5,553 (87)	8,110 (82)	2,436 (82)
Missing	12 (<1)	29 (<1)	74 (<1)	16 (<1)
Uterine incision [‡]				
Transverse	1,906 (95)	6,201 (96)*	9,576 (97) [§]	2,815 (94)
Low segment vertical	22 (1)	40 (1)	91 (1)	29 (1)
Classical	67 (3)	172 (3)	210 (2)	123 (4)
Missing	0 (0)	1 (<0.1)	1 (<0.1)	2 (0.1)
Anesthesia mode				
Epidural	1,027 (51)	3,555 (55) [§]	5,571 (56) [†]	1,731 (58) [†]
Spinal	1,170 (58)	3,612 (56)	5,669 (57)	1,678 (56)
General	97 (5)	198 (3) [†]	320 (3) [†]	105 (4)*
Local	2 (0.1)	9 (0.1)	8 (0.1)	4 (0.1)
Missing	0 (0)	0 (0)	0 (0)	0 (0)
Incision-to-delivery interval (min)	9.0 (5.0)	9.0 (6.0) [§]	10.0 (7.0) [†]	12.00 (8.0) [†]
Missing	0 (0)	0 (0)	0 (0)	0 (0)
Total operative time (min)	43.0 (20.0)	45.0 (21.0) [§]	48.0 (22.0) [†]	55.0 (26.0) [†]
Missing	0 (0)	0 (0)	0 (0)	0 (0)
Incision-to-delivery interval 18 min or greater	127 (6)	548 (9) [§]	1,145 (12) [†]	602 (20) [†]
Gestational age at delivery (wk)	37.2±3.7	38.4±2.9 [†]	38.7±2.6 [†]	38.6±2.6 [†]
Missing	1 (<0.1)	3 (<0.1)	5 (<0.1)	1 (<0.1)
Birth weight (g)	2,783±825	3,188±752 [†]	3,368±750 [†]	3,448±800 [†]
Missing	0 (0)	3 (<0.1)	1 (<0.1)	2 (<0.1)

BMI, body mass index.

Data are n, n (%), mean±standard deviation, or interquartile range ("Incision-to-delivery interval" and "Total operative time").

Comparisons made with Student's *t* test or Wilcoxon test for continuous variables and with χ^2 test for categorical.* $P<.05$ compared with normal BMI.[†] $P<.001$ compared with normal BMI.[‡] Excluding T or J incisions and cases with unknown incisions.[§] $P<.01$ compared with normal BMI.

Table 3

Neonatal Outcomes

BMI at Delivery	Normal	Overweight	Obese	Morbidly Obese
n	2,013	6,443	9,928	2,988
Umbilical cord pH at delivery	7.26±0.08	7.25±0.08*	7.24±0.08*	7.22±0.09*
Missing	1,283 (64)	4,274 (66)	6,105 (61)	1,754 (59)
Source of umbilical blood				
Arterial	584 (29)	1,853 (29)	3,361 (34)	1,044 (35)
Venous	76 (4)	171 (3)	247 (2)	97 (3)
Unknown	73 (4)	154 (2)	228 (2)	95 (3)
Missing	1,280 (64)	4,265 (66)	6,092 (61)	1,752 (59)
Umbilical cord pH less than 7.1 at delivery	21 (1)	108 (2) [†]	216 (2) [‡]	100 (3)*
Missing	1,283 (64)	4,274 (66)	6,105 (61)	1,754 (59)
Apgar score less than 7 at 5 min	79 (4)	177 (3) [‡]	222 (2)*	82 (3) [†]
Missing	2 (0.1)	7 (0.1)	10 (0.1)	0 (0)
NICU admission	642 (32)	1,543 (24)*	2,331 (24)*	833 (28) [‡]
Missing	0 (0)	0 (0)	0 (0)	0 (0)

BMI, body mass index; NICU, neonatal intensive care unit.

Data are n, mean±standard deviation, or n (%).

Comparisons made with Student's and with χ^2 test.

* $P<.001$ compared with normal BMI.

[†] $P<.05$ compared with normal BMI.

[‡] $P<.01$ compared with normal BMI.

Table 4

Odds for Prolonged (18 Minutes or More) Incision-to-Delivery Interval at Cesarean Delivery

Characteristic	Adjusted OR (95% CI) for Prolonged Incision-to-Delivery Interval (18 min or More)
BMI at delivery	
Normal	Reference
Overweight	1.22 (0.98–1.54)
Obese	1.62 (1.31–2.03)
Morbidly obese	2.81 (2.24–3.56)
Insurance	
Private insurance	Reference
Public insurance	1.18 (1.06–1.32)
Race	
Caucasian	Reference
African American	1.97 (1.74–2.24)
Hispanic	1.14 (0.98–1.34)
Asian	1.04 (0.67–1.54)
Native American	0.51 (0.08–1.70)
Prior cesarean deliveries	
0	Reference
1–2	2.33 (2.10–2.59)
3 or more	4.19 (3.45–5.06)
Skin incision at delivery	
Transverse	Reference
Vertical	0.55 (0.46–0.65)
Birth weight (kg)*	1.09 (1.02–1.17)

OR, odds ratio; CI, confidence interval; BMI, body mass index.

Covariates included in the final model as adjustors: maternal race, type of prenatal insurance, number of prior cesarean deliveries, type of skin incision, and neonatal birth weight.

* Odds ratio calculated for one unit increase in the variable.