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Impact of obesity on incision to delivery interval and neonatal outcomes at cesarean

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Abstract

OBJECTIVE—To test the hypothesis that increasing body mass index (BMI) is associated with increased time from skin incision to infant delivery and increased neonatal morbidity at cesarean.

STUDY DESIGN—We performed a retrospective cohort study of all cesarean deliveries occurring at one institution from 2004-2008. Four comparison groups were defined by body mass index (BMI) <30 kg/cm² (n=668), 30-39.9 (n=1002), 40-49.9 (n=403), or ≥50 (n=193). The primary outcome was time from skin incision to infant delivery. Secondary outcomes were a composite measure of neonatal morbidity and its individual components: 5-minute Apgar score less than 7, umbilical cord arterial pH <7.10 and <7.20, umbilical cord arterial base excess <-8 (mmol/L), Special Care Nursery (SCN) admission, and NICU admission.

RESULTS—Increasing BMI was associated with significantly increased time from skin incision to infant delivery, demonstrating a dose response pattern. Minutes from skin incision to delivery of the infant by BMI strata were; 9.4 ± 5.9 for BMI <30, 11.0 ± 6.8 for BMI 30-39.9, 13.0 ± 8.0 for BMI 40-49.9, and 16.0 ± 11.3 for BMI ≥50 (p < 0.01). Composite neonatal morbidity was significantly higher with increasing BMI; 23.0% for BMI <30, 25% for BMI 30-39.9, 29.8% for BMI 40-49.9, and 32.1% for BMI ≥50 (p=0.02).

CONCLUSION—Increasing BMI is associated with a significantly increased time from skin incision to infant delivery and neonatal morbidity. Cesarean technique remains to be optimized for obese women.

Keywords

Cesarean; Incision; Interval; Neonatal outcomes; Obesity

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Introduction

Rates of obesity and morbid obesity among obstetric patients in the United States are steadily increasing, creating an urgent need for evidence based practices focused on this developing population.¹ Prior studies have demonstrated that obese women are at high risk for overall obstetric maternal morbidity including higher rates of cesarean delivery.²⁻³ In addition, obese women are at remarkably increased risk for surgical related morbidity after cesarean; obese women have a higher rate of wound infection, wound separation, dehiscence, anesthetic complication, thrombosis, and surgical tissue injury associated with cesarean deliveries.⁴⁻⁷ Surprisingly, there is little published data on the impact of obesity on cesarean surgical characteristics and neonatal outcomes.

In this study, we sought to evaluate the relationship between the length of time from cesarean skin incision to infant delivery and increasing body mass index (BMI). Secondly, we aimed to establish if there is a concomitant increase in neonatal morbidity with increasing BMI. Previous studies have investigated cesarean decision to incision timing and the effect on neonatal outcome, and have found conflicting results.⁸⁻¹⁰ However, the impact of incision to delivery timing on neonatal morbidity as it relates to obesity remains unknown. We hypothesized that as degree of obesity increases, time interval from skin incision to delivery is prolonged, with an associated increase rate of neonatal morbidity.

Materials and Methods

We performed a retrospective cohort study of all consecutive cesarean deliveries performed at one tertiary care facility over a 4 year study period from 2004-2008. Approval was obtained prior to initiation of the study from the Washington University Human Research Protection Board. Inclusion criteria consisted of women with a non-anomalous, singleton gestation undergoing a cesarean delivery within the study period without regard to gestational age, indication for delivery, prior cesarean delivery, or labor prior to cesarean. Exclusion criteria were met for women with multiple gestations or known fetal congenital anomalies.

Detailed demographic information on each patient was extracted from the medical record by dedicated obstetric research nurses. Data obtained included patient medical and surgical history, obstetrics and gynecology history, prenatal history, antepartum records, delivery records, and post-partum records. BMI (kg/cm²) was calculated from the patient's height and weight recorded in the medical record at time of delivery, and obesity was defined by the WHO criteria as BMI ≥ 30 .¹¹ Four study groups were defined by BMI, with non-obese women (BMI <30) serving as the reference group, and obese women stratified into three comparison groups: BMI 30-39.9, 40-49.9, and ≥ 50 .

The primary outcome measure was time from skin incision to infant delivery. This interval was defined as the minutes elapsed from initial skin incision to complete delivery of the infant. Time was routinely recorded in the medical chart by the nurse in the operating room and was available for all patients in the cohort.

Secondary outcomes were composite neonatal morbidity and its individual components. Measures of neonatal morbidity included 5-minute Apgar score less than 7, umbilical cord arterial pH <7.10 and <7.20, umbilical cord arterial base excess <-8 (mmol/L), Special Care Nursery (SCN) admission, or NICU admission. Infants with one or more marker of morbidity were considered positive for neonatal composite morbidity, and infants with more than one criterion for neonatal morbidity were only counted once in the composite. Apgar scores were assigned clinically by the attending physician or nurse practitioner attending the delivery.¹² Umbilical arterial blood gases were universally obtained immediately after

delivery from an umbilical cord segment. The individual components of the composite outcome were chosen for their clinical relevance. For analysis of the secondary outcomes, women who received general endotracheal anesthesia were excluded from analysis to decrease bias given the a priori increase in risk for the measures of adverse outcomes among women undergoing general anesthesia.

Baseline characteristics were compared between the study groups using one way ANOVA for continuous variables and chi-square test for categorical variables. Normal distribution of continuous variables was tested by examination of the histogram as well as the Kolmogorov-Smirnov test. The primary outcome, incision to delivery interval, was compared between groups using one way ANOVA with Tukey post-hoc analysis, as well as with test of trend. Bivariate analyses were then performed to identify potentially confounding variables. Because the primary outcome measure is a continuous variable, we used multiple linear regression analysis to model its independent relationship with increasing BMI while controlling for confounders. Candidate variables were obtained from results of our bivariate analyses, biological plausibility and variables identified in prior studies to be predictors of surgical duration. Backward step-wise selection was used to reduce the number of variables in the model. Only variables that were statistically significant were included in the final models. Multivariable logistic regression analysis was used for the categorical secondary outcome measures. All statistical analyses were completed using STATA software package, version 10, Special Edition (College Station, TX). Tests with $p < 0.05$ were considered significant.

Results

During the study period, 2266 women met inclusion criteria. Of these women, 70% (1598) were obese with BMI ≥ 30 , and 30% (668) were non-obese with BMI < 30 . When obese women were divided into the study categories, 44.2% (1002) had BMI 30-39.9, 17.8% (403) had BMI 40-49.9, and 8.5% (193) had BMI ≥ 50 .

At baseline, increasing BMI was associated with increasing maternal age, multiparity, African American race, and diabetes (Table 1). Increasing obesity was also associated with a higher rate of prior cesarean, and higher estimated fetal weight. In addition, a higher BMI was associated with a higher rate of having labor prior to cesarean delivery. Degree of obesity was not associated with tobacco or drug use, pre-eclampsia, or gestational age at delivery. The groups were also similar with respect to non-reassuring fetal status (NRFS) as the indication for cesarean, and the use of general anesthesia.

The time interval from skin incision to delivery of the infant was significantly longer as BMI increased. Non-obese women had the shortest time interval of 9.4 ± 5.9 minutes. A dose-response was seen with increasing BMI and longer time interval: 11.0 ± 6.8 minutes for BMI 30-39.9, 13.0 ± 8.0 minutes for BMI 40-49.9, and 16.0 ± 11.3 minutes for BMI ≥ 50 (p value test of trend < 0.01). (Figure 1) The beta coefficients generated by the linear regression equation are listed in Table 2, which indicate the minutes added or subtracted from the incision to delivery interval baseline of 9.55 minutes for each variable. After adjusting for prior cesarean delivery, non-reassuring fetal status as the indication for cesarean, and administration of general anesthesia, BMI 30-39.9 added 1.28 minutes, BMI 40-39.9 added 3.17 minutes, and BMI ≥ 50 added 5.71 minutes to the time interval from skin incision to delivery compared to the reference group (BMI < 30). Prior cesarean delivery was associated with increased time interval, whereas cesarean indication of non-reassuring fetal status and general anesthesia were associated with decreased time interval. (Table 2) Variables that were entered in the initial linear regression model that did not remain significant in the final model include type of skin incision and cesarean after labor.

Markers of neonatal morbidity, were analyzed for a cohort of 2160 women after exclusion of 106 women who received general anesthesia. We found an increasing incidence for composite neonatal morbidity as BMI increased. In the adjusted analysis, only cesarean indication for non-reassuring fetal status was found to be significant in the final model; labor prior to cesarean and gestational age were not significant and therefore did not remain in the final model. Adjusted risks of the neonatal composite morbidity were significantly increased for women with BMI 40-49.9 and BMI ≥ 50 compared to non-obese women. However, women with BMI 30-39.9 did not have a significantly increased risk for neonatal composite morbidity when compared to women with BMI <30 . When individual measures of neonatal morbidity were considered, increasing BMI was associated with a statistically significant increase in arterial cord blood pH <7.20 and base excess <-8 . Other individual measures of neonatal morbidity, including 5 minute Apgar <7 , umbilical cord arterial pH <7.10 , and NICU and SCN admission were not significantly different across BMI strata. (Table 3)

When we restrict the composite outcome to only the more conservative measures of neonatal morbidity (excluding the criteria of pH <7.2 and SCN admission), the results for the higher BMI strata remain significant. (BMI 30-39.9 aOR= 1.0, 95% CI 0.68-1.5, p=0.941; BMI 40-49.9 aOR=1.7, 95% CI 1.1-2.6, p=0.03; BMI ≥ 50 aOR= 1.8, 95% CI 1.1-3.2, p= 0.03).

Comment

We found longer time intervals from skin incision to infant delivery as BMI increased, and a concomitant increase in composite neonatal morbidity for women undergoing cesarean. Specifically, the time from skin incision to delivery for BMI ≥ 50 was 1.6 times longer than for non-obese women. We also found a significantly increased incidence of composite neonatal morbidity as BMI increased in women undergoing cesarean. However, other than umbilical arterial cord blood base excess <-8 and pH < 7.20 , the individual measures of neonatal well-being did not meet statistical significance.

The measures of neonatal morbidity chosen for the composite reflect relevant markers or surrogates for clinical morbidity. An Apgar score less than 7 at 5 minutes has been associated with an increased risk for development of cerebral palsy (aOR 24.7-130.8 compared to Apgar score of 10 at 5 minutes).¹³ Umbilical cord arterial blood pH and base excess values are markers of neonatal acidosis. We also considered SCN admission as a measure of neonatal morbidity because these neonates often have prolonged hospital stays and require separation from the family unit for more intensive monitoring. Even when limiting the composite outcome to more conservative measures of morbidity (excluding pH <7.2 and SCN admission), the results are unchanged.

Prior studies have illustrated that increasing BMI is associated with longer total operative time and other measures of maternal surgical morbidity.⁶ However, it remains unknown whether the same operative influences of obesity may affect neonatal morbidity. Previous investigations have largely focused on women in labor, and the time interval from decision to perform cesarean to skin incision, or the interval from uterine incision to delivery, and the relationship to neonatal morbidity.^{8, 10, 14} Few studies have examined the role of the time interval from skin incision to delivery on neonatal outcomes, and no prior studies have examined the effect of BMI on this interval.^{9, 10} In addition, results of all studies evaluating incision to delivery interval on neonatal outcomes are confounded by indication; surgery tends to be appropriately performed faster in fetuses suspected to be at risk, likely improving outcomes to levels comparable to fetuses considered to be at low risk in whom surgery is slower. The aim of this study was to estimate the impact of increasing BMI in incision to delivery time and associated markers of neonatal morbidity. While this may represent a potentially modifiable contributor to neonatal morbidity in this patient population, it is important to note that this deserves further investigation and that there are many other

obstetric and fetal factors in which intervention may not help to alleviate all neonatal morbidity.

Andersen et al performed a retrospective cohort study of 180 term, singleton, patients who underwent cesarean delivery at one institution over a 6 month period.¹⁰ The primary goal was to investigate if there was an association between the intervals of skin incision to delivery time, and uterine incision to delivery time on infant Apgar scores and umbilical cord blood values. Andersen did not find a relationship between time intervals and measures of neonatal morbidity. However, the study's negative findings could be attributed to small sample size (only 79 patients had umbilical cord blood gas data) and inadequate power. In addition, maternal weight or BMI was not recorded or adjusted for in the analysis.

In a more recent study, Maayan-Metzger et al investigated the impact of three different time intervals, including skin incision to delivery interval, on measures of neonatal outcome.⁹ This retrospective cohort study involved 933 term, singleton patients who were undergoing elective cesarean delivery with regional anesthesia. Maayan-Metzger found that in 15.1% of cases, the skin incision to delivery interval was greater than 10 minutes, but did not find a significant association between time interval and neonatal complications. Although this study was able to adjust for many important maternal factors, information on BMI was not collected. Importantly, this study's negative findings may also be due to insufficient power, especially because their selected population included only women undergoing elective cesarean at term in which neonatal morbidity is rare.

Compared to previous studies on the subject, our study offers several strengths. Our study population was comprised of a large proportion of obese and morbidly obese patients, which allowed us to examine multiple BMI strata and evaluate for a dose response. In addition, the detailed and systematic data extraction performed by experienced research nurses enabled us to account for many confounding factors. The universal policy of collection of umbilical cord blood in our study decreased bias inherent in testing only selected samples. By allowing complete evaluation of the cohort for laboratory measures of neonatal wellbeing, generalizability was improved. Another strength of our study was our exclusion of women who had cesarean deliveries performed under general anesthesia in the secondary analyses. Neonates born to women under general anesthesia have been shown to have worse Apgar scores and umbilical blood gas values, likely due to the emergent nature of many cesareans requiring general anesthesia and the anesthetic agents themselves.⁷

The potential limitations of our study must be considered as well. One limitation is the retrospective nature of our study design. Although we were able to adjust for many confounding factors, there may be potential unknown factors that were not adjusted for in the analysis. Additionally, despite our large sample size of over 2000 women, rates of neonatal morbidity were low. The small numbers of neonates with morbidity did not give adequate power to our secondary analysis of individual neonatal outcomes. However, the small numbers of neonates with morbidity attests to the likelihood that cesareans were performed in appropriate clinical situations, before neonatal wellbeing was compromised. In addition, our study illustrates a strong association between increasing BMI and increased incision to delivery interval, as well as an association between increasing BMI and neonatal composite morbidity. Therefore, we infer that it is the increase in time interval which contributed to the neonatal morbidity. However, because we did not directly investigate the relationship between incision to delivery interval and the effect on neonatal morbidity, we cannot conclude causation. Lastly, maternal BMI at delivery was used rather than pre-pregnancy BMI, because maternal BMI at the time of delivery is most relevant to patient counseling and clinician decision-making regarding delivery and operative approach.

We found that the skin incision to delivery time interval in cesarean deliveries increases as BMI increases, with associated increase in neonatal morbidity. This finding demonstrates another way obesity can impact surgical duration and neonatal outcome, and illustrates the need to optimize surgical techniques for obese women. Further research is needed to help determine a causal relationship between skin incision to delivery interval and neonatal morbidity with a larger sample size to provide adequate power for rare neonatal outcomes. However, our findings highlight a population of women and neonates for whom a longer time interval from skin incision to delivery should be anticipated, and who may benefit from the availability of a skilled neonatal care team. Finally, results of this study further characterize a challenging patient population at cesarean delivery that deserves future research aimed at improvement of treatment and outcomes.

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Condensation

Increasing body mass index is associated with a significantly increased time from skin incision to infant delivery and neonatal morbidity at cesarean.

Figure 1. Skin incision to delivery interval by BMI strata

A dose-response was seen with respect to increasing BMI and longer incision to delivery time interval.

Error bars: 95% Confidence Interval

* Indicates $p < 0.05$ when compared to reference category BMI <30

Table 1

Baseline characteristics for women in the cohort compared by BMI

	BMI<30 (n=668)	BMI 30-39.9 (n=1002)	BMI 40-49.9 (n=403)	BMI 50 (n=193)	P value
Age	25.4 ± 6.5	26.0 ± 6.1	26.6 ± 6.3	27.9 ± 5.5	<0.01
Nulliparity (n=885)	44.6%	39.2%	35.0%	27.5%	<0.01
African American race (n=1566)	58.1%	71.8%	78.2%	74.6%	<0.01
Tobacco use (n=378)	16.3%	17.0%	16.9%	16.1%	0.98
Drug use (n=185)	8.4%	8.8%	7.4%	5.7%	0.49
Diabetes (n=203)	3.9%	8.3%	16.4%	19.7%	<0.01
Pre-Eclampsia (n=117)	4.0%	5.3%	5.5%	7.8%	0.21
Prior cesarean (n=973)	38.0%	42.7%	45.4%	56.0%	<0.01
Gestational Age at Delivery (weeks)	38.7 ± 1.5	38.8 ± 1.4	38.7 ± 1.4	38.5 ± 1.3	0.06
Birth Weight (grams)	3130 ± 579	3299 ± 591	3356 ± 593	3339 ± 672	<0.01
Indication for Delivery NRFS (n=658)	30.1%	29.4%	30.0%	21.2%	0.10
Labor prior to cesarean (n=1054)	48.4%	48.6%	48.9%	35.4%	<0.01
General Anesthesia (n=106)	6.1%	3.9%	4.2%	4.7%	0.19
Vertical Skin Incision (n=83)	2.3%	1.8%	5.0%	15.5%	<0.01

Table 2

Multiple linear regression model estimating the effect of increasing BMI on incision to delivery interval

Variable	Beta Coefficient	P value
Constant	9.55	-
BMI <30	Reference	-
BMI 30-39.9	1.28	<0.01
BMI 40-49.9	3.17	<0.01
BMI 50	5.71	<0.01
Prior Cesarean Delivery	3.35	<0.01
Indication for Cesarean-Non-reassuring fetal status	-3.30	<0.01
General Anesthesia	-6.57	<0.01

Table 3

Measures of Neonatal Morbidity stratified by BMI

	BMI<30 (n=627)	BMI 30-39.9 (n=963)	BMI 40-49.9 (n=386)	BMI 50 (n=184)	P value
5 minute Apgar < 7 (n=41)	2.6%	1.5%	2.1%	1.6%	0.46
pH <7.10 (n=78)	2.6%	3.5%	4.4%	6.6%	0.06
pH <7.20 (n=354)	11.7%	16.0%	21.4%	25.1%	<0.01
Base excess < -8 mmol/L (n=114)	3.1%	5.2%	8.2%	8.2%	<0.01
NICU admission (n=23)	1.6%	1.0%	0.5%	0.5%	0.35
Special care nursery admission (n=224)	11.0%	10.3%	9.8%	9.8%	0.92
Composite (n=558)	23.0%	25.0%	29.8%	32.1%	0.02
Adjusted Odds Ratio* (95% CI)	Reference	1.1 (0.9-1.4)	1.4 (1.1-1.9)	1.7 (1.2-2.4)	-

* Adjusted for cesarean indication NRFS. Variables that did not remain significant in the final model include cesarean after labor, and gestational age.