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Inter-delivery weight gain and risk of cesarean delivery following a prior vaginal delivery

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Structured Abstract

Background—Approximately 1/3 of all deliveries in the United States are via cesarean. Previous research indicates weight gain during pregnancy is associated with an increased risk of cesarean delivery. It remains unclear, however, whether and to what degree weight gain between deliveries (i.e., inter-delivery weight gain) is associated with cesarean delivery in a subsequent pregnancy following a vaginal delivery.

Objectives—To determine whether inter-delivery weight gain is associated with an increased risk of intrapartum cesarean delivery following a vaginal delivery.

Study design—This is a case-control study of women who had two consecutive singleton births of at least 36 weeks' gestation between 2005 and 2016, with a vaginal delivery in the index pregnancy. Women were excluded if they had a contraindication to a trial of labor (e.g., fetal malpresentation or placenta previa) in the subsequent pregnancy. Maternal characteristics and delivery outcomes for both pregnancies were abstracted from the medical record. Maternal weight gain between deliveries was measured as the change in body mass index (BMI) at delivery. Women who underwent a subsequent cesarean delivery were compared to those who had a repeat vaginal delivery using chi square statistics for categorical variables and t tests or ANOVA for continuous variables. Multivariable logistic regression was used to determine whether inter-delivery weight gain remained independently associated with intrapartum cesarean delivery after adjusting for potential confounders.

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Condensation of paper: Among women with a prior vaginal delivery, inter-delivery weight gain was independently associated with an increased risk of cesarean delivery in a subsequent pregnancy.

Results—Of 10,396 women who met eligibility criteria and had complete data, 218 (2.1%) had a cesarean delivery in the subsequent pregnancy. Inter-delivery weight gain was significantly associated with cesarean delivery, and remained significant in multivariable analysis for women with a BMI increase of at least 2 kg/m^2 (adjusted odds ratio [aOR] = 1.53, 95% confidence interval [95% CI] = 1.03–2.27 for BMI increase of 2 kg/m^2 to < 4 kg/m^2; aOR = 1.99, 95% CI = 1.19–3.34 for BMI increase of 4 kg/m^2 or more). Furthermore, women who gained 2 kg/m^2 or more were significantly more likely to undergo cesarean delivery specifically for the indications of arrest of dilation or arrest of descent (aOR = 2.01, 95% CI = 1.21–3.33 for BMI increase of 2 to < 4 kg/m^2; aOR = 2.34, 95% CI = 1.15–4.76 for BMI increase of 4 kg/m^2 or more). Contrarily, women who lost 2 kg/m^2 or more were less likely to undergo any cesarean delivery (aOR = 0.41, 95% CI = 0.21–0.78) as well as less likely to undergo cesarean delivery for an arrest disorder (aOR = 0.29, 95% CI = 0.10–0.82). Weight gain or loss was not significantly associated with a cesarean delivery for fetal indications.

Conclusion—Among women with a prior vaginal delivery, inter-delivery weight gain was independently associated with an increased risk of intrapartum cesarean delivery in a subsequent pregnancy.

Keywords

cesarean delivery; weight gain

Introduction

Cesarean deliveries accounted for 32.2% of all deliveries in the United States in 2014.[1] In low-risk pregnancies, a cesarean delivery is more likely than a vaginal delivery to result in maternal morbidity and mortality.[2,3] Furthermore, women who have had prior cesarean deliveries are more likely to have a subsequent cesarean (versus vaginal) delivery,[4] whereas those who have had a vaginal delivery are much more likely to have a subsequent vaginal delivery.[5]

Approximately two-thirds of adults in the US are overweight or obese (body mass index [BMI] ≥ 25 kg/m^2).[6,7] The association of excess body weight with adverse pregnancy outcomes, including cesarean delivery, has been demonstrated repeatedly.[8] Excessive gestational weight gain (weight gain that exceeds Institute of Medicine recommendations) also has been associated with higher odds of cesarean delivery.[9,10]

Yet, whether a change in weight between deliveries (i.e., inter-delivery weight gain) is associated with mode of delivery following a vaginal birth is unclear. In one previous study among women who were diagnosed with gestational diabetes mellitus in the first pregnancy, a weight gain of ten pounds or more between deliveries was associated with an increased risk of cesarean delivery, while weight loss was associated with a decreased risk of cesarean delivery.[11] This question has not been explored in a more general population.

The purpose of this study was to determine whether inter-delivery weight gain is associated with the odds of intrapartum cesarean delivery following a vaginal delivery. We hypothesized that women who increased their weight between births would have higher odds of subsequent cesarean delivery.

Materials and methods

This is a case-control study of women at least 18 of age who delivered two consecutive singleton births of at least 36 weeks' gestation at Northwestern Memorial Hospital in Chicago, IL or Lake Forest Hospital in Lake Forest, IL between January 2005 and December 2015. Women were identified through a query of the hospital's electronic data warehouse, in which all medical record data from a variety of electronic record sources (e.g., inpatient and outpatient records, billing, and pharmacy) are compiled. Women were included if they had a vaginal delivery (either spontaneous or operative) in the index pregnancy, no prior cesarean, and a subsequent delivery at the same set of institutions (i.e., either Northwestern Memorial Hospital or Lake Forest Hospital). Patients were excluded if they had a contraindication to a trial of labor in the subsequent pregnancy, including fetal malpresentation, presumed macrosomia, placenta previa, an interval surgery that precluded a trial of labor (such as a cavity-entering myomectomy or a cornual ectopic resection), or an active herpes simplex virus outbreak. Women who had a planned cesarean in the subsequent pregnancy due to complications from the previous delivery (including a history of a shoulder dystocia or complications from an obstetric laceration) were also excluded. Approval for this study was obtained from the Northwestern Institutional Review Board with a waiver of informed consent.

Demographic, maternal, and obstetric data, including mode of delivery in the subsequent delivery and indication for cesarean delivery, if applicable, were abstracted from the electronic medical record. Weight change was defined as the difference in body mass index (BMI) at the time of the second delivery from BMI at the time of the index delivery. In order to assist with clinical translation of the results, BMI change was categorized as loss of 2 kg/m^2 or greater, loss of 2 kg/m^2 or less to gain of 2 kg/m^2, gain more than 2 kg/m^2 and less than 4 kg/m^2, and gain of 4 kg/m^2 or more. This classification scheme was adapted from Jain et. al., who chose a BMI gain or loss of 2 kg/m^2 as a clinically meaningful amount of change (about 12 pounds for a 5 foot 4 inch woman).[12]

Other variables included in multivariable models were: BMI at the index delivery, maternal age in years at the time of the subsequent delivery, any diabetes (pre-existing or gestational) in the subsequent pregnancy, parity (defined as one, two, or three or more previous deliveries of at least 20 weeks' gestational age at the time of the subsequent delivery), operative vaginal delivery (forceps or vacuum) in the index delivery, and the time (years) elapsed between deliveries. Race and ethnicity were defined as white non-Hispanic, black non-Hispanic, Hispanic, Asian, or other. Variables were retained in multivariable models if they were significantly different between groups at the $p \leq 0.10$ level in bivariable comparisons. Infant birthweight in the second pregnancy was deliberately excluded, as this variable likely lies on the causal pathway mediating the association between maternal weight gain and cesarean delivery.

Bivariable comparisons were performed using the student t test or one-way ANOVA for continuous variables and chi square tests for categorical variables. Multivariable logistic regression was used to adjust for potential confounders. Analyses were performed to assess the association of BMI change with any cesarean delivery, as well as with a cesarean delivery for the specific indications of an arrest disorder (arrest of dilation, arrest of descent, or failed induction of labor) or for nonreassuring fetal status. Specific indication for cesarean delivery was determined by examining the operative report for the surgery, with nonreassuring fetal status taking priority over an arrest disorder as the primary indication if both were listed as indications for cesarean delivery. Finally, we examined factors associated with weight change between deliveries. All hypothesis tests were two-tailed, and a probability value of 0.05 was used to determine statistical significance. All analyses were carried out in STATA (version 14.2, StataCorp, College Station, TX).

Results

Of 11,506 women identified in the electronic medical record who delivered two consecutive pregnancies, 50 underwent a planned primary cesarean due to complications during a prior delivery, including shoulder dystocia (n=19), obstetric lacerations/persistent pelvic floor dysfunction (n=28), neonatal alloimmune thrombocytopenia (n=1), and a sacral fracture (n=2). Another eight underwent planned cesareans for indications that arose in the interval since their prior delivery: bladder augmentation due to spinal cord dysfunction (n = 1), development of a large obstructing fibroid in the anterior lower uterine segment (n = 1), and history of a cavity-entering myomectomy or cornual ectopic wedge resection (n = 6). Thirty women had a cesarean in the subsequent pregnancy for indications that arose within the subsequent pregnancy (nine for malpresentation, one for placenta previa, nineteen for presumed macrosomia, and one for an active herpes outbreak in labor). Three women underwent a cesarean delivery without any accepted medical indication. Of the remaining 11,415 women, 1,019 women had missing information on race and ethnicity and were excluded from the study population. Women did not differ either in their likelihood of undergoing cesarean delivery ($p = 0.62$ for any cesarean delivery, $p = 0.82$ for an arrest disorder, $p = 0.60$ for nonreassuring fetal status) or in terms of weight gain ($p = 0.14$) based on whether they were missing information on race and ethnicity. Data were complete for all other variables, including weight change and other potential confounding factors.

Of the 10,396 women remaining in the study population, 2.1% (n=218) had a cesarean delivery following a vaginal delivery. Of these, 51.8% (n=113) were performed for an arrest disorder (50 for arrest of dilation and 63 for arrest of descent) and 48.2% (n=105) were performed for nonreassuring fetal heart tracings. The average BMI at delivery in the index pregnancy was 29.1 kg/m^2 (standard deviation [SD] = 4.7) and in the subsequent pregnancy was 29.4 kg/m^2 (SD = 4.9). In this population, 8.9% (n=926) lost more than 2 kg/m^2 between deliveries, 9.7% (n=1,008) gained between 2 and 4 kg/m^2, and 4.2% (n=437) gained 4 or more kg/m^2. The remainder (77.2%, n=8,025) neither gained nor lost more than 2 kg/m^2 between deliveries.

Gain of 2 kg/m^2 or more between deliveries was associated with an increased risk of cesarean delivery in an unadjusted analysis ($p < 0.001$; Table 1). This finding persisted in multivariable analysis: gains of 2–4 kg/m^2 (adjusted odds ratio [aOR] = 1.53, 95% confidence interval [CI] = 1.03–2.27) and 4 kg/m^2 or more (aOR = 1.99, 95% CI = 1.19–3.34) were associated with an increased risk of cesarean delivery (Table 2). Contrarily, weight loss was associated with a decreased risk of any cesarean delivery (aOR = 0.41, 95% CI = 0.21–0.78).

When examining the specific indication for cesarean, gain of 2 kg/m^2 or greater was associated with an increased risk of cesarean for an arrest disorder in multivariable models (aOR = 2.01, 95% CI 1.21–3.33 for BMI increase of 2 – 4 kg/m^2; aOR = 2.34; 95% CI = 1.15–4.76 for BMI increase of > 4 kg/m^2). Similarly, loss of 2 kg/m^2 or greater was associated with a decreased risk of cesarean for an arrest disorder (aOR = 0.29, 95% CI = 0.10–0.82). Conversely, there was no association between weight change and a cesarean delivery for fetal indications (Table 2).

Finally, we examined factors associated with BMI change between pregnancies. BMI change between deliveries was significantly associated with all factors examined, including BMI at the time of initial delivery, race, ethnicity, maternal age, parity, time between pregnancies, operative vaginal delivery in the index pregnancy, and diabetes in the subsequent delivery (Table 3). Weight loss was associated with white non-Hispanic race and lower parity. Although BMI at the time of initial delivery was significantly associated with weight gain, the group of women that lost weight between deliveries had the highest initial BMI.

Comment

The main finding of this study is that weight gain between births is associated with increased odds of intrapartum cesarean delivery and, specifically, increased odds of cesarean delivery for an arrest disorder following a vaginal delivery in the prior pregnancy, while weight loss between deliveries is associated with decreased odds of intrapartum cesarean delivery. Conversely, weight change was not associated with cesarean delivery for fetal indications. These findings are in agreement with existing literature regarding the association of weight control with delivery outcomes.[10,11] We have shown that even a relatively modest weight gain or weight loss was associated with these effects.

In our study, weight gain between deliveries may have been due to postpartum weight retention, weight gain in the interval between pregnancies, increased gestational weight gain in the second pregnancy, or some combination of these factors. Postpartum weight retention has been shown to occur in women with normal pre-pregnancy BMI, as well as in women who were overweight or obese prior to pregnancy.[13,14] Excessive gestational weight gain is associated with greater likelihood of cesarean birth, independent from maternal diabetes.[9] Our data show an increased risk of cesarean delivery due to weight gain even when controlling for BMI in the initial pregnancy, indicating that increased weight gain is associated with cesarean delivery for women of all weight categories. Further, as Table 3 shows, women who lost weight between deliveries were actually more likely to have a higher BMI in the initial pregnancy, thus indicating that weight loss between deliveries is both possible and is associated with a decreased risk of subsequent cesarean delivery even for obese women. These data underscore the importance of managing weight gain between births, both between pregnancies and during the subsequent pregnancy.

Finally, this study confirms that weight gain and diabetes mellitus are independent risk factors for cesarean delivery. Importantly, both diet and exercise, alone and in combination, have been shown to combat postpartum weight retention and excessive gestational weight gain.[15] These lifestyle-based methods for weight control are attractive during child-bearing years as they are non-pharmacologic, inexpensive, and low-risk. If patients could interrupt the trajectory of weight retention in the postpartum period, weight gain between pregnancies, and excess gestational weight gain, this may reduce their risk of future cesarean birth.[12]

This study has limitations as well. Firstly, measuring change as BMI difference at the time of delivery does not allow us to distinguish between postpartum weight retention following the initial pregnancy, weight gain that occurred in the interval between pregnancies, and gestational weight gain in the subsequent pregnancy, which does not allow us to distinguish if any of these are more associated with cesarean delivery than the others. Secondly, as this is an observational study, we cannot infer causality. There is a risk of residual confounding, as in any large, observational study. Thirdly, these data come from a single large, tertiary care institution and a single community hospital, and may lack external validity in other practice settings. In particular, the rate of operative vaginal delivery is higher and the rate of cesarean is lower at Northwestern Memorial Hospital than at many other tertiary care hospitals, which would decrease the number of cesarean deliveries compared to other practice settings, perhaps differentially so with respect to maternal weight gain. Finally, it should be noted that while statistically significant, the absolute difference in risk of cesarean based on weight change category is also small. Nevertheless, weight change represents a modifiable risk factor for cesarean delivery.

The strengths of the study include a large, racially/ethnically diverse sample. We were also able to obtain granular information from the institutional data warehouse regarding an operative vaginal delivery in the previous birth and maternal diabetes status, as well as the indication for cesarean section, which may not be available in administrative datasets.

We conclude that gain of ≥ 2 kg/m^2 is associated with higher odds of a cesarean birth following a vaginal delivery, and weight loss of 2 kg/m^2 or more is associated with decreased odds of a cesarean birth. This association is independent of maternal age, race, diabetes, inter-pregnancy time interval, and parity. The association between weight change and cesarean delivery is true only for cesareans performed for arrest of dilation or descent, rather than for fetal indications. These data emphasize that weight management in the postpartum period, during the interval between pregnancies, and during the subsequent pregnancy may help to reduce the risk of future cesarean deliveries.

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Table 1

Factors associated with cesarean delivery following vaginal delivery

Variable	Vaginal delivery (N=10,178)	Cesarean delivery (N=218)	P value[a]	Adjusted odds ratio[b]	95% confidence interval
BMI at delivery (kg/m^2)[c]	29.1 ± 4.6[d]	31.0 ± 5.6	< 0.001	1.08	1.06 – 1.11
Change in BMI:			< 0.001		
lost more than 2 kg/m^2	9.0	4.6		0.41	0.21 – 0.78
lost < 2 kg/m^2 to gained < 2 kg/m^2	77.3	72.1		(ref)	
gained 2 kg/m^2 to < 4 kg/m^2	9.6	14.7		1.53	1.03 – 2.27
gained 4 kg/m^2 or more	4.1	8.7		1.99	1.19 – 3.34
Race/ethnicity:			0.002		
non – Hispanic white	69.9	61.0		(ref)	
non – Hispanic black	5.9	11.9		1.91	1.08 – 2.72
Hispanic	1.6	2.8		1.87	0.85 – 4.23
Asian	6.3	6.4		1.23	0.68 – 2.01
other race	16.3	17.9		1.19	0.70 – 1.53
Operative vaginal delivery[c]	13.6	22.5	< 0.001	1.91	1.40 – 2.64

[a]P values are from a chi square test for categorical variables, student t test for continuous variables.

[b]In addition to the other factors listed here, odds ratios are also adjusted for parity, maternal age, and diabetes at subsequent delivery and time between deliveries, factors which were not significant in multivariable models.

[c]Measured at the time of index delivery.

[d]Dichotomous variables are presented as percent of corresponding column, and continuous variables are presented as mean ± standard deviation.

[e]Measured at the time of subsequent delivery.

Table 2

Association of weight change with cesarean delivery for an arrest disorder versus fetal indications

	No cesarean for arrest disorder (N=10,178)	Cesarean delivery for arrest disorder (N = 113)	P value[a]	Adjusted odds ratio[b]	95% confidence interval	No cesarean for fetal indications (N=10,178)	Cesarean delivery for fetal indications (N = 105)	P value[a]	Adjusted odds ratio[b]	95% confidence interval
Change in BMI:			< 0.001					0.08		
lost more than 2 kg/m^2	9.0[c]	3.5		0.29	0.10 – 0.82	9.0	5.7		0.53	0.23 – 1.24
lost < 2 kg/m^2 to gained < 2 kg/m^2	77.3	69.9		(ref)		77.3	74.3		(ref)	
gained 2 kg/m^2 to < 4 kg/m^2	9.6	17.7		2.01	1.21 – 3.33	9.6	11.4		1.09	0.58 – 2.02
gained 4 kg/m^2 or more	4.1	8.9		2.34	1.15 – 4.76	4.2	8.6		1.70	0.81 – 3.56

[a] P values presented are from a chi square test.

[b] Odds ratios are adjusted for maternal race/ethnicity; maternal BMI and operative vaginal delivery at index delivery; maternal age, parity, and diabetes at subsequent delivery; and time between deliveries.

[c] Presented as percent of corresponding column.

Table 3

Correlates of weight change between deliveries

Variable	Lost more than 2 kg/m^2 (N=926)	Lost 2 kg/m^2 to gained < 2 kg/m^2 (N=8,025)	Gained 2 kg/m^2 to < 4 kg/m^2 (N=1,008)	Gained 4 kg/m^2 or more (N=437)	P value[a]
BMI:					
index delivery	32.3 ± 5.5[b]	28.6 ± 4.3	29.7 ± 4.8	30.2 ± 6.1	< 0.001
subsequent delivery	28.4 ± 4.8	28.7 ± 4.4	32.5 ± 4.8	36.9 ± 6.3	< 0.001
Race/ethnicity:					< 0.001
white non – Hispanic	71.2	73.1	54.1	41.6	
black non – Hispanic	6.3	4.8	10.8	16.9	
Hispanic	1.0	1.4	3.0	3.2	
Asian	5.6	6.5	6.2	2.8	
other race	16.0	14.2	26.0	35.5	
Maternal age at delivery (years)[c]	33.1 ± 4.4	33.7 ± 4.2	32.4 ± 5.2	31.3 ± 5.3	< 0.001
Parity:[c]					< 0.001
one	86.7	87.2	78.8	74.6	
two	9.8	9.4	14.6	15.6	
three or more	3.5	3.4	6.7	9.8	
Time between deliveries (years)	2.4 ± 1.0	2.4 ± 1.0	2.9 ± 1.3	3.2 ± 1.6	< 0.001
Operative vaginal delivery[d]	13.2	14.3	12.4	8.2	0.002
Diabetes[c]	4.0	2.6	3.7	3.0	0.03

[a]P values are from a chi square test for categorical variables, one way ANOVA for continuous variables.

[b]Dichotomous variables are presented as percent of corresponding column, and continuous variables are presented as mean ± standard deviation.

[c]Measured at the time of subsequent delivery.

[d]Measured at the time of index delivery.