



Sonographic Estimated Fetal Weight and Cesarean Delivery among Nulliparous Women with Obesity

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Abstract

Objective This study was aimed to examine the association between having an ultrasound estimate of fetal weight (US-EFW) and mode of delivery among obese women.

Study Design A retrospective cohort study of nulliparous women with a body mass index of ≥ 35 kg/m² who delivered term singleton gestations. We examined whether having had an US-EFW within 35 days of delivery, or an US-EFW ≥ 90 th percentile for gestational age, was associated with intrapartum cesarean delivery.

Results Of 2,826 women, 22.5% ($n = 636$) had an US-EFW within 35 days of delivery. Having an US-EFW was associated with increased frequency of cesarean (43.1% for those with an US-EFW versus 30.0% for those without, $p < 0.001$); this finding persisted when controlling for confounders (adjusted odds ratio [aOR] 1.48, 95% confidence interval [CI] 1.21–1.81). Of the 636 women with an US-EFW, 22.5% ($n = 143$) had an US-EFW ≥ 90 th percentile for gestational age, which was associated with increased frequency of an intrapartum cesarean (60.8% for those with an US-EFW ≥ 90 th percentile vs. 37.9% for those with an US-EFW of < 90 th percentile, $p < 0.001$), even when accounting for confounders (aOR = 1.78, 95% CI: 1.10–2.87).

Conclusion The presence of an US-EFW among nulliparous obese women was associated with undergoing intrapartum cesarean delivery.

Keywords

- obesity
- pregnancy
- ultrasound
- cesarean section
- large for gestational age

Obstetricians use ultrasound to predict fetal weight near delivery.¹ Obese women are more likely than nonobese women to undergo ultrasound in the third trimester because following fundal height is less feasible in this patient population.² Obesity is increasingly common in reproductive aged women³; thus, the use of ultrasound in obese pregnant women will likely only increase.

Recent evidence indicates that obstetric providers may be influenced by ultrasound data when making decisions regarding mode of delivery. While some studies of low-risk populations show that an ultrasound-estimated fetal weight (US-EFW) is not associated with increased risk of cesarean delivery,⁴ most others indicate that an US-EFW is associated with increased frequency of cesarean delivery,

regardless of actual birth weight.^{5–7} The association between an US-EFW and cesarean is even stronger for fetuses estimated to be ≥ 90 th percentile for gestational age, even though the sensitivity of ultrasound for an EFW ≥ 90 th percentile is low.^{8–10} This body of literature suggests the performance of an US-EFW may influence provider cognitive processes independent of actual birth weight in ways that affect management of women during labor.

Understanding the potential influence of an US-EFW on mode of delivery is especially pertinent in light of the American College of Obstetricians and Gynecologists' (ACOGs') stated goal of reducing the rate of primary cesarean delivery,¹¹ which is currently at an all-time high.¹² Obese women are already at higher risk of cesarean delivery than

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their nonobese counterparts,¹³ and when undergoing cesarean delivery experience complications, such as wound infections, at higher rates than nonobese women.¹⁴ The extent to which the presence of an US-EFW and ultrasonographic diagnosis of estimated fetal weight \geq 90th percentile when an ultrasound is performed are associated with risk of cesarean delivery in this already high-risk population remains unknown, as most previous studies have focused on low risk women.

We hypothesize that there is an increased risk of cesarean delivery, as well as a cesarean delivery for an arrest disorder, associated with the presence of an US-EFW or of the ultrasonographic diagnosis of an EFW \geq 90th percentile.

Materials and Methods

This is a retrospective cohort study of nulliparous women with a body mass index (BMI) at the time of delivery of 35 kg/m² or greater who delivered term (37^{0/7} weeks of gestation or greater), singleton gestations and received sonographic examinations at Northwestern Memorial Hospital in Chicago, IL, between January 1, 2010 and December 31, 2015. We chose women with a BMI of 35 kg/m² or greater at delivery as this represents the group of women who were most likely to have had a BMI of 30 kg/m² or more at the start of pregnancy, not just at delivery. Using this cut-off also allows us to focus on the group of women most likely to have undergone an ultrasound given inability to follow serial fundal heights. All women in this study underwent a trial of labor. We included women who presented in spontaneous labor as well as women who were induced. While women at our institution are often induced for medical comorbidities, such as chronic hypertension and diabetes, we do not routinely induce women for obesity alone. We excluded women who underwent primary cesarean delivery for presumed macrosomia, as this study was designed to assess how knowledge of estimated fetal weight might affect intrapartum management. We also excluded women who had a contraindication to a vaginal trial of labor, such as malpresentation, or who elected for a primary cesarean in the absence of labor. Finally, we excluded women with fetuses with major anomalies. Per standard clinical practice, pregnancies were initially dated by last menstrual period (LMP); pregnancies were dated or redated using ultrasound either when the LMP was unknown or when the dating by LMP conflicted with dating by ultrasound using standard ACOG guidelines.¹⁵

Clinical and demographic data were abstracted from the electronic medical record and ultrasound records used for clinical care. These data included whether a woman had any US-EFW in the last 5 weeks (up to 35 days) prior to delivery. We chose a cut-off of 5 weeks prior to delivery as previous studies have indicated that an ultrasound done at 34 to 36 weeks is reasonably predictive of birth weight at term in the population of pregnant women with obesity,^{16,17} and thus ultrasounds even 5 weeks prior to delivery are likely to be considered in physician decision making. Additionally, this time frame is felt to be pragmatic as clinicians do not always have a more recent ultrasound available. Ultrasounds performed in the eligible time period solely for fetal biophy-

sical profile, position confirmation, or other reasons without performance of a growth estimate were not considered to have been an US-EFW.

Among women having an US-EFW, we defined women as having an EFW \geq 90th percentile if the US-EFW was at or above the 90th percentile for gestational age at the time of ultrasound, based on the Hadlock's formula.¹⁸ We defined women as having a large-for-gestational age (LGA) neonate if the birth weight met or exceeded the 90th percentile for birth weight at a specific week of gestational age, using a standardized table of U.S. birth weights generated by Oken et al.¹⁹

Our primary outcome was mode of delivery, categorized as vaginal delivery (including operative vaginal delivery) or cesarean delivery. Women were further classified as having undergone a cesarean for an arrest disorder if the primary indication for cesarean delivery was arrest of dilation, arrest of descent, or failed induction of labor.

Demographic and clinical variables potentially correlated with either obesity or cesarean delivery were abstracted from the medical record. These include class of obesity (class II, corresponding to a BMI of 35–39.9 kg/m², vs. class III, corresponding to a BMI of \geq 40 kg/m²), any maternal diabetes (gestational or pregestational), any hypertensive disorder of pregnancy (including chronic hypertension), maternal race/ethnicity (white non-Hispanic, black non-Hispanic, Hispanic, Asian, or other), birth weight (measured in kilograms), maternal age at delivery (years), and induction of labor. Variables were retained in multivariable models if they were significantly associated with either cesarean delivery or having an US-EFW at the $p \leq 0.10$ level in bivariable comparisons.

The Student *t*-test or Chi-square analyses were used for continuous and categorical variables, respectively, in bivariable analyses. Multivariable logistic regression was used to control for potential confounders. Odds ratios (ORs) and 95% confidence intervals (CIs) were estimated. All hypothesis tests were two-tailed, and a probability value of 0.05 was used to determine statistical significance. All analyses were performed in STATA (version 15.0, StataCorp, College Station, TX).

This protocol was approved by the Northwestern University Institutional Review Board (Protocol # STU00202227) on 12/18/15 with a waiver of informed consent.

Results

For this study, 3,001 women who met initial inclusion criteria were identified. Of these, 31 were excluded as they underwent a primary cesarean without labor for presumed macrosomia, 10 were excluded as they had a complete placenta previa, 111 were excluded for malpresentation, and 39 were excluded for other contraindications to vaginal delivery (including a previous cavity-entering myomectomy, active herpes simplex virus [HSV], and elevated human immunodeficiency virus [HIV] viral load). Five women underwent a nonmedically indicated primary cesarean delivery. Thirteen women were missing data on race/ethnicity and were also excluded; all other women had complete data on all potential confounders. Of the remaining 2,792 women with complete data who

comprised the analyzable cohort, 22.6% ($n = 630$) had an US-EFW within 5 weeks of delivery. Of those who had an ultrasound, 22.2% ($n = 140$) had an antenatal diagnosis of US-EFW ≥ 90 th percentile for gestational age. Women were more likely to have had an US-EFW if they had any diabetes, hypertensive disorder, or a higher BMI. Additionally, women who underwent induction of labor were more likely to have an US-EFW (►Table 1).

In this cohort, 33.0% ($n = 922$) underwent an intrapartum cesarean delivery. Having an US-EFW was associated with increased frequency of cesarean delivery: 42.9% ($n = 270$) of the 630 women who had an US-EFW underwent cesarean versus 30.2% ($n = 652$) of 2,162 women who had no US-EFW ($p < 0.001$). This finding persisted even when controlling for actual birthweight and other confounding factors (adjusted OR [aOR] = 1.36, 95% CI: 1.12–1.67; ►Table 2). Birthweight, induction of labor, any diabetes, black non-Hispanic race/ethnicity, and maternal age were the other main demographic and clinical factors associated with increased odds of cesarean delivery (►Table 2). Notably, maternal BMI itself

was not associated with cesarean delivery once these other factors were accounted for.

An antenatal diagnosis of an US-EFW ≥ 90 th percentile for gestational age was also associated with an increased frequency of cesarean delivery, with 60.7% ($n = 85$) of the 140 women with an US-EFW ≥ 90 th percentile for gestational age undergoing a cesarean, compared with 37.8% ($n = 185$) of the 490 women with an US-EFW < 90 th percentile ($p < 0.001$; ►Table 3). In multivariable models, an US-EFW ≥ 90 th percentile for gestational age remained associated with increased odds of a cesarean delivery (aOR = 1.82, 95% CI: 1.11–2.99) compared with having an US-EFW < 90 th percentile. As ►Table 1 shows, however, the diagnostic accuracy of ultrasound for LGA birth weight is not high; of 143 women with an US-EFW ≥ 90 th percentile, only 43.6% ($n = 61$) ultimately delivered a neonate that was large for gestational age. Birth weight, induction of labor, diabetes, and maternal age remained significantly associated with cesarean delivery.

Of the 922 women who underwent intrapartum cesarean delivery, 74.8% ($n = 690$) had a cesarean delivery for an

Table 1 Cohort characteristics

Variable	US-EFW ($n = 630$)	No US-EFW ($n = 2,162$)	<i>p</i> -Value	US diagnosis of ≥ 90 th percentile ^a ($n = 140$)	US diagnosis of < 90 th percentile ^b ($n = 490$)	<i>p</i> -Value
Maternal age at delivery (y)	28.7 \pm 6.2 ^c	29.1 \pm 6.2	0.16	29.5 \pm 6.0	28.5 \pm 6.3	0.12
Maternal race:			< 0.001			0.001
White non-Hispanic	169 (26.8)	789 (36.5)		57 (40.7)	112 (22.9)	
Black non-Hispanic	192 (30.5)	377 (17.4)		34 (24.3)	158 (32.2)	
Asian	22 (3.5)	58 (2.7)		5 (3.6)	17 (3.5)	
Hispanic	152 (24.1)	591 (27.3)		29 (20.7)	123 (25.1)	
Other	95 (15.1)	347 (16.1)		15 (10.7)	80 (16.3)	
Maternal BMI at delivery (kg/m ²)	41.0 \pm 5.5	39.5 \pm 4.8	< 0.001	41.2 \pm 6.0	40.9 \pm 5.3	0.54
Class of obesity:			< 0.001			0.62
Class II (BMI = 35–39.9 kg/m ²)	331 (52.5)	1,464 (67.7)		71 (50.7)	260 (53.1)	
Class III (BMI ≥ 40 kg/m ²)	299 (47.5)	698 (32.3)		69 (49.3)	230 (46.9)	
Any maternal diabetes	111 (17.6)	109 (5.0)	< 0.001	27 (19.3)	84 (17.1)	0.56
Any maternal hypertensive disorder	151 (24.0)	338 (15.6)	< 0.001	34 (24.3)	117 (23.9)	0.92
Gestational age at delivery (wk)	39.4 \pm 1.2	39.7 \pm 1.1	< 0.001	39.7 \pm 1.2	39.4 \pm 1.2	0.01
Induction of labor	329 (52.2)	750 (34.7)	< 0.001	76 (54.3)	253 (51.6)	0.58
Birth weight (kg)	3.470 \pm 0.52	3.466 \pm 0.46	0.88	4.002 \pm 0.39	3.318 \pm 0.45	< 0.001
Birth weight category:			0.05			< 0.001
SGA	16 (2.5)	44 (2.0)		0 (0.0)	16 (3.3)	
AGA	529 (84.0)	1897 (87.7)		79 (56.4)	450 (91.8)	
LGA	85 (13.5)	221 (10.2)		61 (43.6)	24 (4.9)	

Abbreviations: AGA, appropriate gestational age; BMI, body mass index; LGA, large gestational age birth weight at delivery; SGA, small gestational age; US-EFW, ultrasonographic estimated fetal weight.

^aDefined as US-EFW ≥ 90 th percentile for gestational age at the time of ultrasound.

^bDefined as US-EFW < 90 th percentile for gestational age at the time of ultrasound.

^cData presented are mean \pm standard deviation for continuous variables, n (%) for categorical variables.

Table 2 A sonographic estimate of fetal weight is associated with cesarean delivery

Variable	Cesarean delivery (n = 922)	Vaginal delivery (n = 1,870)	p-Value	Adjusted odds ratio ^a	95% confidence interval
Presence of an US-EFW ^b	270 (29.3) ^c	360 (19.3)	< 0.001	1.36	1.12–1.67
Birth weight (kg)	3.600 ± 0.50	3.401 ± 0.45	< 0.001	2.63	2.18–3.17
Induction of labor	496 (53.8)	583 (31.2)	< 0.001	2.18	1.82–2.61
Class of obesity:	–	–	< 0.001	–	–
Class II (BMI ^b = 35–39.9 kg/m ²)	538 (58.4)	1,257 (67.2)		reference	–
Class III (BMI ≥ 40 kg/m ²)	384 (41.7)	613 (32.8)		1.20	0.92–1.55
Any maternal diabetes	112 (12.2)	108 (5.8)	< 0.001	1.49	1.10–2.03
Any maternal hypertensive disorder	191 (20.7)	298 (15.9)	0.002	1.12	–
Maternal age at delivery (y)	30.2 ± 5.9	28.5 ± 6.2	< 0.001	1.05	0.89–1.41
Maternal race:			< 0.001		1.03–1.07
White non-Hispanic	319 (34.6)	639 (34.2)		(ref)	–
Black non-Hispanic	221 (24.0)	348 (18.6)		1.84	1.42–2.38
Asian	28 (3.0)	52 (2.8)		1.15	0.69–1.91
Hispanic	202 (21.9)	541 (28.9)		1.12	0.87–1.43
Other	152 (16.5)	290 (15.5)		1.19	0.92–1.54
Maternal BMI at delivery (kg/m ²)	40.4 ± 5.2	39.6 ± 4.9	< 0.001	1.00	0.98–1.03

^aAdjusted for ultrasound for estimated fetal weight, birthweight, induction of labor, class of obesity, any maternal diabetes, any maternal hypertensive disorder, maternal age, maternal race, maternal BMI.

^bUS-EFW, ultrasonographic estimated fetal weight; BMI, body mass index.

^cData presented are mean ± standard deviation for continuous variables, n (%) for categorical variables.

Table 3 Association between ultrasound diagnosis of estimated fetal weight ≥ 90th percentile and cesarean delivery

Variable	Cesarean delivery (n = 270)	Vaginal delivery (n = 360)	p-Value	Adjusted odds ratio ^a	95% confidence interval
US diagnosis of ≥ 90th percentile ^b	85 (31.5) ^c	55 (15.3)	< 0.001	1.82	1.11–2.99
Birth weight (kg)	3.584 ± 0.50	3.384 ± 0.52	< 0.001	1.87	1.23–2.84
Induction of labor	174 (64.4)	155 (43.1)	< 0.001	2.11	1.47–3.03
Class of obesity:			0.002		
Class II (BMI = 35–39.9 kg/m ²)	123 (45.6)	208 (57.8)		(ref)	
Class III (BMI ≥ 40 kg/m ²)	147 (54.4)	152 (42.2)		1.19	0.70–2.01
Any maternal diabetes	69 (25.6)	42 (11.7)	< 0.001	2.14	1.34–3.43
Any maternal hypertensive disorder	72 (26.7)	79 (21.9)	0.17	1.13	0.74–1.74
Maternal age at delivery (y)	29.8 ± 6.1	27.9 ± 6.1	0.001	1.06	1.02–1.09
Maternal race:			0.33		
White non-Hispanic	77 (28.5)	92 (25.6)		(ref)	
Black non-Hispanic	89 (33.0)	103 (28.6)		1.65	0.99–2.76
Asian	8 (3.0)	14 (3.9)		0.71	0.26–1.99
Hispanic	55 (20.4)	97 (26.9)		0.93	0.54–1.61
Other	41 (15.2)	54 (15.0)		1.11	0.63–1.93
Maternal BMI at delivery (kg/m ²)	41.8 ± 5.8	40.4 ± 5.2	0.002	1.03	0.98–1.08

Abbreviation: BMI, body mass index.

^aAdjusted for ultrasound estimated fetal weight ≥ 90th percentile, birth weight, induction of labor, class of obesity, any maternal diabetes, any maternal hypertensive disorder, maternal age, maternal race, maternal BMI.

^bDefined as ultrasonographic estimated fetal weight ≥ 90th percentile for gestational age at the time of ultrasound.

^cData presented are mean ± standard deviation for continuous variables, n (%) for categorical variables.

arrest disorder and 25.2% ($n = 232$) had a cesarean delivery for fetal indications. Eliminating the 232 women who underwent cesarean for fetal indications, 30.4% ($n = 210$) of the remaining 690 women who had a cesarean for an arrest disorder had an US-EFW, whereas only 19.3% ($n = 360$) of the 1,870 women who underwent vaginal delivery had an US-EFW ($p < 0.001$). When controlling for confounding factors, women who had an US-EFW were 1.46 times as likely to undergo a cesarean for arrest of dilation or descent (as opposed to a vaginal delivery) than women with no US-EFW (95% CI: 1.17–1.82). Women with an US-EFW ≥ 90 th percentile for gestational age were also more likely to undergo a cesarean for an arrest disorder; of the 210 women who underwent cesarean for an arrest disorder and had an US-EFW, 34.8% ($n = 73$) had an US-EFW ≥ 90 th percentile, whereas only 15.3% ($n = 55$) of women who underwent vaginal delivery had an US-EFW ≥ 90 th percentile ($p < 0.001$). This result did not, however, remain significant in multivariable models (aOR = 1.47 for women who had an US-EFW ≥ 90 th percentile, 95% CI: 0.90–2.41).

Discussion

Many factors likely influence a practitioner's decisions regarding labor management and mode of delivery, including fetal status, maternal medical conditions, labor progress, and estimated fetal weight. In this study, among women with obesity undergoing a trial of labor, we found an association between the presence of an US-EFW within 5 weeks of delivery and cesarean delivery, even when accounting for actual birth weight. These findings are consistent with those of Froehlich et al who studied a more general population regarding the association between documentation of an estimated fetal weight (clinical or ultrasonographic) and cesarean delivery.²⁰ Our findings are also consistent with other studies among lower-risk women,^{5,9} confirming that the presence of an ultrasound is associated with an increased intrapartum cesarean rate among this group of women already at higher risk for cesarean delivery. Although ACOG recommends consideration of cesarean delivery for women who have an US-EFW above 5,000 g,²¹ the women in this study did not meet this criterion and underwent cesarean delivery following a trial of labor.

Rather than US-EFW serving as a reason for a prelabor cesarean delivery, in this cohort of women who labored, we hypothesize the relationship between having an US-EFW and the performance of cesarean delivery is less straightforward. Previous work by our group indicated that obstetricians' cognitive traits are associated with their patients' mode of delivery.²² In this same manner, perhaps the presence of an US-EFW subtly affects physicians' cognitive processes resulting in, for example, a lower threshold for cesarean delivery than in a comparable patient for whom US-EFW data were unavailable, for instance by giving the perception that the fetus was larger and may not fit in a woman's pelvis, even though the ultimate birth weight of all fetuses was similar. Such findings highlight the need to further understand the role of provider cognition and decision making in the context of having ultrasonographic data.

Our study suggested an US-EFW is associated specifically with a cesarean for an arrest disorder, as opposed to increased risk of cesarean delivery for nonreassuring fetal heart tracings, further bolstering the possibility that perceived knowledge of fetal weight may affect decisions providers make regarding how likely they feel their patients are to deliver vaginally. However, it was notable that the US-EFW had a poor ability to predict LGA status. Previous work on the accuracy of ultrasound to detect LGA fetuses has shown high specificity but low positive predictive value.^{9,23} In our study population, over half of the women identified as having an fetus with an EFW ≥ 90 th percentile on ultrasound ultimately delivered an infant that was not LGA, demonstrating that ultrasound has a poor positive predictive value for fetal overgrowth; providers should keep this inherent inaccuracy in mind when making decisions regarding labor dystocia with regard to the US-EFW. As for all patients, one way to counteract a potentially misleading effect of an US-EFW on the cesarean rate is to adhere to standard definitions of labor dystocia.¹¹

This paper has several strengths, including study of a large cohort of women with a BMI ≥ 35 kg/m² undergoing a trial of labor that included detailed information on the indication for cesarean delivery and offered the ability to determine the timing of an ultrasound relative to delivery. This diverse population was also cared for by a large number of clinicians, thus enhancing generalizability. Our work also has several limitations. First, performing an ultrasound to estimate fetal size was not universal, and there is no formal protocol at our institution regarding which women should be referred for a growth ultrasound. Rather, ultrasounds are ordered at the discretion of the main obstetric provider. Women who had an US-EFW were more likely to have a higher BMI, and thus selection bias in who received an US-EFW based on maternal BMI or another characteristic related to their baseline risk of a cesarean delivery may have confounded the association between provider knowledge of US-EFW and cesarean delivery. Similarly, we are able to control for some medical comorbidities, such as diabetes, which may influence which women received an ultrasound but not all medical comorbidities. Second, we used a 5-week cut-off for ultrasound prior to delivery given that, practically speaking, it is not possible to obtain an US-EFW for every patient within 1 to 2 weeks of delivery; however ultrasounds performed more distal to a patient's delivery may influence a practitioner's decision to perform a cesarean delivery in different ways than an US-EFW obtained closer to delivery might. Third, all patients at this institution are managed by both attending and trainee physicians, and thus it is not possible to distinguish whether there is a differential effect of provider experience. Providers are likely heterogeneous in their propensity to perform a cesarean delivery based on experience and other factors that are not possible to measure. Finally, this is an observational study, and all associations are correlational.

While the results of this and other studies indicate that the use of ultrasound to estimate fetal weight is associated with an increase in odds of cesarean delivery, there remains a role for ultrasound in delivery planning.²¹ Ultrasound is also an important tool for diagnosing fetal growth disorders, such

as intrauterine growth restriction, especially in populations where following fundal heights to screen for growth disorders is not likely to be accurate, such as in morbidly obese women.¹⁵ Further research could explore how providers use ultrasound information when counseling patients and managing patients in labor.

Presentations

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Conflicts of Interest

None of the authors have any conflicts of interest to report.

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