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Association between Sonographic Estimated Fetal Weight and the Risk of Cesarean Delivery among Nulliparous Women with Diabetes in Pregnancy

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Abstract

Objective—The objective of this study was to examine the association between an ultrasound-estimated fetal weight (US-EFW) and mode of delivery among nulliparous diabetic women.

Study Design—This is a retrospective cohort study of nulliparous women with medication-requiring gestational or pregestational diabetes who delivered term, singleton gestations following a trial of labor. We determined whether having had an US-EFW within 35 days of delivery was associated with cesarean delivery.

Results—Of 304 women who met the eligibility criteria, 231 (76.0%) had an US-EFW within 35 days of delivery. An US-EFW was associated with increased likelihood of intrapartum cesarean (51.5% for those with an ultrasound vs. 27.4% for those without, $p < 0.001$); this finding persisted even when controlling for birth weight and other confounding factors (adjusted odds ratio: 2.23, 95% confidence interval: 1.16–4.28). Among women with a recent US-EFW, a diagnosis of a large-for-gestational-age (LGA) fetus was associated with overall intrapartum cesarean frequency (65.2% for women with an LGA fetus vs. 46.1% for those without, $p = 0.009$), but this association did not remain significant in multivariable models.

Conclusion—An US-EFW within 35 days of delivery among nulliparous women with medication-requiring diabetes was positively associated with intrapartum cesarean delivery.

Keywords

cesarean delivery; diabetes mellitus; estimated fetal weight; ultrasound

The use of obstetric ultrasound to predict fetal weight near delivery is increasingly common.[1] Estimated fetal weight via ultrasound is an important tool used to guide the timing and mode of delivery, especially in pregnancies complicated by medical conditions such as

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Conflict of Interest
None.

diabetes mellitus and maternal obesity. The performance of ultrasound may influence provider intrapartum decision making. In some studies of low-risk populations, having an ultrasound-estimated fetal weight (US-EFW) has not been shown to be associated with mode of delivery,[2] while in others, an US-EFW has been associated with increased risk of cesarean delivery.[3–5] The association between an US-EFW and cesarean is even stronger for fetuses estimated to be large for gestational age (>90% for gestational age; LGA), even though the accuracy of ultrasound for LGA birth weight is low.[6–8] This growing body of literature suggests the performance of an US-EFW may influence provider cognitive processes independent of actual birth weight.

Understanding the role of ultrasound in estimating birth weight, diagnosing LGA status, and influencing mode of delivery is especially pertinent in light of the American College of Obstetricians and Gynecologists (ACOG) and the Society for Maternal-Fetal Medicine stated goal of reducing the rate of primary cesarean section,[9] which is currently at an all-time high.[10] Yet most studies associating an US-EFW with risk of cesarean delivery specifically exclude all women with diabetes[3,8] or women with pregestational, as opposed to gestational, diabetes.[7] Importantly, women with diabetes during pregnancy are known to have higher rates of LGA fetuses.[11] Women with diabetes during pregnancy commonly undergo routine sonographic fetal growth surveillance in the third trimester due to this association with abnormal fetal growth. However, the extent to which the presence of an US-EFW, and of an ultrasonographic diagnosis of LGA, is associated with risk of cesarean delivery in this already high-risk population remains unknown.

Based on previous studies, we hypothesize 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 LGA, in a cohort of nulliparous women with both gestational and pregestational diabetes undergoing a trial of labor.

Materials and Methods

This is a retrospective cohort study of nulliparous women with medication-requiring gestational diabetes or pregestational diabetes who delivered term (37.0 weeks' gestation or more), singleton gestations and received sonographic examinations at the Northwestern Memorial Hospital in Chicago, IL, between January 1, 2010, and December 31, 2015. Approval for this study was obtained from the Northwestern Institutional Review Board with a waiver of informed consent. All women in this study underwent a trial of labor; 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. 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 for redating by ultrasound.[12]

Diabetes was defined in this cohort as either pre-existing (type 1 or type 2) or White class A2 (medication-requiring gestational diabetes). At our institution, gestational diabetes is diagnosed using either a glucose value of 200 mg/dL or more following a 1-hour 50-g oral glucose challenge test, or using a diagnostic 3-hour 100-g oral glucose tolerance test performed after obtaining a value between 135 and 199 mg/dL on the 1-hour 50-g test.[13] For the 3-hour diagnostic test, our institution uses the Carpenter–Coustan diagnostic criteria.[14] Any two of four abnormal values are diagnostic for gestational diabetes, and patients are referred to a nutritionist to initiate medical nutrition therapy. We monitor fasting and 1 hour postprandial serum blood glucose values in clinic once per week. While the decision to start medical therapy is individualized, we typically initiate medical therapy when either the fasting blood sugar exceeds 95 mg/dL or the 1-hour postprandial value exceeds 140 mg/dL on two consecutive weekly visits. Type 1 or 2 diabetes mellitus are commonly diagnoses made prior to pregnancy; however, our institution follows recommended guidelines for early screening and diagnosis of type 2 diabetes during pregnancy.[15]

Clinical and demographic data were abstracted from the electronic medical record and ultrasound database, including whether a woman had any US-EFW in the last 5 weeks (up to 35 days) prior to delivery. We chose a cutoff of 5 weeks prior to delivery as previous studies have indicated that ultrasound done in earlier in the third trimester is reasonably predictive of birth weight at term in the diabetic population,[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 but solely for fetal biophysical profile, position confirmation, or other reasons without performance of a growth estimate were not considered to have been an US-EFW.

We defined women has an LGA fetus if the US-EFW was at or above the 90th percentile for gestational age at the time of ultrasound, based on the Hadlock formula.[18] We defined women as having an 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] Mode of delivery was 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 diabetes or cesarean delivery were abstracted from the medical record. These include self-reported maternal race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), type of diabetes (gestational White class A2, type 2, or type 1), birth weight (measured in kilograms), maternal age at delivery (years), maternal body mass index (BMI) at delivery (kg/m^2), 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* ::: 0.10 level in bivariable comparisons. We also noted the occurrence of a shoulder dystocia or perineal laceration (categorized as none, first degree, second degree, third degree, or fourth degree) at the time of delivery.

The Student's *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 14.2, StataCorp, College Station, TX).

Results

For this study, of 316 women with diabetes, 12 were excluded as they underwent a primary cesarean without labor for presumed macrosomia. Of the remaining 304 women, 76.0% (*N* = 231) had an US-EFW meeting criteria. Of those who had an ultrasound, 28.6% (*N* = 66) had a diagnosis of LGA (an US-EFW >90th percentile for gestational age at the time of ultrasound). Ultrasound as a means of detecting an LGA birth weight was highly sensitive but with high false-positive rate: of the 66 women identified as having an LGA fetus on ultrasound, only 34.9% (*N* = 23) delivered an infant who was LGA at birth, whereas of the 165 women identified as having an appropriately sized (appropriate for gestational age; AGA) or small for gestational age (SGA) fetus on ultrasound, 3.6% (*N* = 6) were LGA at delivery (Table 1). Women were more likely to have had an US-EFW if they had pregestational diabetes or had a higher BMI. Additionally, women who were younger and who underwent induction of labor were more likely to have an US-EFW.

In this cohort, 45.7% (*N* = 139) underwent an intrapartum cesarean delivery. Having an US-EFW was associated with increased frequency of cesarean delivery: 51.5% (*N* = 119) of the 231 women who had a US-EFW underwent cesarean versus 27.4% (*N* = 20) of 73 women who had no US-EFW ($p < 0.001$). This finding persisted even when controlling for birth weight and other confounding factors (adjusted OR: 2.23, 95% CI: 1.16–4.28; Table 2). Birth weight and maternal BMI were the other main predictors of cesarean delivery (Table 2). Restricting the sample to the 269 women who did not have an antenatal diagnosis of an LGA fetus did not materially change these results, in terms of magnitude, direction, or significance of these odds ratios.

An antenatal diagnosis of LGA was also associated with an increased frequency of cesarean delivery, with 65.2% (*N* = 43) of the 66 women with an US-EFW >90% for gestational age undergoing a cesarean, compared with 46.1% (*N* = 76) of the 165 women predicted to have an AGA or SGA infant ($p = 0.01$; Table 3). In multivariable models, however, an LGA US-EFW was no longer predictive of a cesarean delivery, whereas birth weight and maternal BMI remained significantly associated with cesarean delivery (Table 3).

Of the 139 women who underwent intrapartum cesarean delivery, 69.1% (*N* = 96) had a cesarean delivery for an arrest disorder and 30.9% (*N* = 43) had a cesarean delivery for other indications. Excluding women who underwent cesarean for another indication (such as fetal indications), women with an US-EFW were more likely to undergo a cesarean for an arrest disorder (42.6% [*N* = 83] of those with an US-EFW vs. 19.7% [*N* = 13] of those without an US-EFW, $p = 0.001$). Women predicted to have an LGA infant were also more likely to undergo a cesarean for an arrest disorder with 61.7% (*N* = 37) of the 60 women with an US-EFW diagnosis of LGA vs. 34.1% (*N* = 46) of the 135 women without an US-EFW diagnosis of LGA ($p < 0.001$). However, in multivariable models, controlling for potential confounders including type of diabetes, neither a recent US-EFW nor an LGA US-EFW remained associated with a cesarean for an arrest disorder versus a vaginal delivery. Again, restricting the sample to only women without a diagnosis of an LGA fetus did not materially change these results.

Of the 66 women with an US-EFW of LGA status, 23 delivered vaginally. These 23 women were no more likely to experience either shoulder dystocia or a third degree perineal laceration than women who delivered vaginally who had an US-EFW that was AGA or SGA ($p = 0.40$ for shoulder dystocia, $p = 0.13$ for third degree laceration). There were no fourth degree perineal lacerations among the women in this study.

Discussion

Ultrasound to assess fetal weight is commonly performed in the diabetic pregnant population, often with the goals of optimizing antepartum glycemic control and assessing fetal size prior to the onset of labor.[16] 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 gestational or pregestational diabetes mellitus undergoing a trial of labor, we found an association between the presence of an US-EFW within 5 weeks of delivery and cesarean delivery. 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,[3,7] confirming that the presence of an ultrasound is associated with an increased intrapartum cesarean rate, even after accounting for birth weight. While ACOG recommends consideration of cesarean delivery for women with diabetes who have an US-EFW more than 4,500 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, we hypothesize that the relationship between an US-EFW and the performance of cesarean delivery is perhaps 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. Such findings highlight the need to further understand the role of provider cognition and decision making in the context of having ultrasonographic data.

Although our study suggested an US-EFW diagnosis of LGA is associated specifically with a cesarean for an arrest disorder, this association did not persist once we account for actual birth weight. However, it was notable that the US-EFW had a poor ability to predict LGA status. Previous work on the accuracy of ultrasound in the diabetic population to detect LGA fetuses has shown high specificity but low positive predictive value.[7,23] In our study population, over half of the women identified as having an LGA fetus ultimately delivered an infant who 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.[9]

While the results of this and other studies indicate that the use of ultrasound to estimate fetal weight is associated with an increase in the likelihood of cesarean delivery, there remains a role for ultrasound in delivery planning. As noted earlier, when an ultrasound exam establishes an US-EFW above a certain threshold, ACOG recommends offering a cesarean delivery in part to avoid the risks of shoulder dystocia and its associated adverse outcomes.[21] Other studies have suggested that failing to detect a fetus with a birth weight of 4,000 g or more is associated with increased risk of shoulder dystocia and perineal injury from lacerations.[5] Our study did not show this but was underpowered to detect these rare events. Future work may seek to understand factors that influence the accuracy and utility of US-EFW in this population.

This article has several strengths, including a well-characterized cohort of women with both pregestational and medication-requiring gestational diabetes that included detailed information on the indication for cesarean delivery and offered the ability to determine the timing of an ultrasound relative to delivery. Our work also has several limitations. First, while performing an ultrasound to estimate fetal size was common, it was not universal. Women who had an US-EFW may have differed in terms of glycemic control or in other ways related to their baseline risk of a cesarean delivery; such differences may have confounded the association between provider knowledge of US-EFW and cesarean delivery. Second, as noted, the study was underpowered to detect differences in less common adverse outcomes such as shoulder dystocia. Third, we used a 5-week cutoff 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. Fourthly, 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 heterogenous 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 there remains the potential for unmeasured confounding, as well as noncausal associations.

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Table 1

Characteristics of a cohort of insulin—using diabetic pregnant women

Variable	US-EFW (*N* = 231)	No US-EFW (*N* = 73)	*p*-Value	US diagnosis of LGA[a] (*N* = 66)	US diagnosis of AGA/SGA[b] (*N* = 165)	*p*-Value
Maternal age at delivery (y)	31.3 ± 5.4[c]	32.9 ± 4.7	0.02	32.0 ± 5.1	31.0 ± 5.5	0.22
Maternal BMI at delivery (kg/m^2)	36.0 ± 7.8	32.3 ± 6.0	< 0.001	35.1 ± 7.6	36.4 ± 7.8	0.27
Type of diabetes						
A2	131 (56.7)	59 (80.8)	0.001	32 (48.5)	99 (60.0)	0.004
Type 2	52 (22.5)	6 (8.2)		11 (16.7)	41 (24.9)	
Type 1	48 (20.8)	8 (11.0)		23 (34.9)	25 (15.2)	
Gestational age at delivery (wk)	38.5 ± 0.9	38.5 ± 1.0	0.82	38.7 ± 0.8	38.5 ± 0.9	0.16
Induction of labor	168 (72.7)	30 (41.1)	< 0.001	49 (74.2)	119 (72.1)	0.74
Birth weight (kg)	3.426 ± 0.51	3.227 ± 0.58	0.005	3.866 ± 0.43	3.250 ± 0.42	< 0.001
Birth weight category						
SGA	19 (8.2)	15 (20.6)	0.014	0 (0.0)	19 (11.5)	< 0.001
AGA	183 (79.2)	51 (69.9)		43 (65.2)	140 (84.9)	
LGA	29 (12.6)	7 (9.6)		23 (34.9)	6 (3.6)	

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

[a]Defined as US-EFW > 90% for gestational age at the time of ultrasound.

[b]Defined as US-EFW ::: 90% for gestational age at the time of ultrasound.

[c]Data presented are mean ± 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* = 139)	Vaginal delivery (*N* = 165)	*p*-Value	Adjusted odds ratio[a]	95% confidence interval
US-EFW	119 (85.6)[b]	112 (67.9)	< 0.001	2.23	1.16–4.28
Birth weight (kg)	3.519 ± 0.58	3.260 ± 0.46	< 0.001	2.41	1.42–4.08
Induction of labor	93 (66.9)	105 (63.6)	0.55	0.72	0.41–1.24
Type of diabetes					
A2	76 (54.7)	114 (69.1)	0.03	(Ref)	
Type 2	30 (21.6)	28 (17.0)		1.05	0.55–2.02
Type 1	33 (23.7)	23 (13.9)		1.83	0.93–3.62
Maternal age at delivery (y)	31.7 ± 5.5	31.6 ± 5.2	0.87	1.04	0.99–1.09
Maternal BMI at delivery (kg/m^2)	37.2 ± 8.3	33.4 ± 6.3	< 0.001	1.08	1.04–1.12

Abbreviations: BMI, body mass index; US-EFW, ultrasound-estimated fetal weight.

[a] Adjusted for ultrasound-estimated fetal weight, birth weight, induction of labor, type of diabetes, maternal age, maternal BMI.

[b] Data presented are mean ± standard deviation for continuous variables, *N* (%) for categorical variables.

Table 3

Association between ultrasound diagnosis of LGA and cesarean delivery

Variable	Cesarean delivery (*N* = 119)	Vaginal delivery (*N* = 112)	*p*-Value	Adjusted odds ratio[a]	95% confidence interval
US diagnosis of LGA[b]	43 (36.1)[c]	23 (20.5)	0.01	1.46	0.69–3.08
Birth weight (kg)	3.537 ± 0.56	3.308 ± 0.41	< 0.001	2.25	1.10–4.63
Induction of labor	83 (69.8)	85 (75.9)	0.30	0.56	0.29–1.06
Type of diabetes					
A2	60 (50.4)	71 (63.4)	0.11	(Ref)	
Type 2	29 (24.4)	23 (20.5)		1.22	0.60–2.47
Type 1	30 (25.2)	18 (16.1)		1.90	0.89–4.06
Maternal age at delivery (y)	31.4 ± 5.6	31.2 ± 5.3	0.83	1.03	0.98–1.09
Maternal BMI at delivery (kg/m^2)	37.9 ± 8.6	34.1 ± 6.2	< 0.001	1.10	1.05–1.14

Abbreviations: BMI, body mass index; LGA, large for gestational age; US, ultrasound.

[a]Adjusted for ultrasound-estimated fetal weight, birth weight, induction of labor, type of diabetes, maternal age, maternal BMI.

[b]Defined as ultrasound-estimated fetal weight > 90% for gestational age at the time of ultrasound.

[c]Data presented are mean ± standard deviation for continuous variables, *N* (%) for categorical variables.