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The utility of midtrimester ultrasound assessment of the subcutaneous space in predicting cesarean wound complications

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Abstract

Objective—To evaluate the association between cesarean wound complications and thickness of the subcutaneous space within the anterior abdomen at the midtrimester fetal anatomical survey.

Methods—In this case-control study, cases were identified using an ICD9 code for wound complications of cesarean delivery. For each case, we identified the woman with the next consecutive midtrimester ultrasound who had a cesarean delivery without a wound complication, matched on age and race, as the control. A blinded investigator measured subcutaneous space at three distinct suprapubic levels in the midsagittal plane.

Results—Of 7228 women with a cesarean delivery, 123 (1.7%) had a wound complication. Seventy-nine cases were eligible. Midline suprapubic subcutaneous thickness did not differ between cases and controls at the superior, middle or inferior locations ($p = 0.35$). Body mass index was moderately correlated with ultrasound-derived measurements ($r = 0.63$; $p < 0.001$). The incidence of vertical skin incision, stapled skin closure and classical hysterotomy differed between groups ($p = 0.046$). There was no significant increase in wound complication risk with increasing subcutaneous space thickness, even after adjustment ($p = 0.34$).

Conclusion—Prenatal ultrasound can quantify the subcutaneous space. Vertical skin incision, stapled wound closure, and a classical hysterotomy were associated with cesarean wound complication, but midtrimester subcutaneous thickness was not.

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Declaration of interest

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Keywords

Abdominal wall thickness; cesarean wound complication; second trimester ultrasound; ultrasound prediction; wound risk factors

Introduction

The prevalence of wound complications after cesarean delivery ranges from 6 to 12% [1–3]. Risk factors include insulin-dependent diabetes mellitus, use of internal fetal monitors, prolonged rupture of membranes, chorioamnionitis, endometritis, abdominal obesity and maternal smoking [2–6].

There is little data to identify patients in the midtrimester who are at risk for cesarean wound complications. Vermillion et al. [2] measured abdominal subcutaneous thickness intraoperatively and concluded that an increased abdominal thickness at the time of cesarean section was an independent risk factor for the development of superficial wound infection. This finding has been duplicated in the gynecology literature as well [7]. In addition, abdominal subcutaneous thickness, measured by pre-operative computed tomography (CT) scan, was determined to be an independent risk factor for the development of a surgical site infection [8]. We hypothesized that women with an increased subcutaneous thickness at the time of midtrimester fetal anatomic ultrasound evaluation are at an increased risk for cesarean wound complications.

Methods

This study was conducted at Beth Israel Deaconess Medical Center, a tertiary care center in Boston, Massachusetts. The project was approved by the institutional review board. We performed a retrospective case-control study of women undergoing cesarean delivery between 1 December 2008 and 1 June 2013. Inclusion criteria included delivery occurring within the above dates, and a midtrimester fetal anatomy ultrasound performed at 15 to 24 weeks of gestation at our institution. In addition, there needed to be an available suprapubic ultrasound image, in the midsagittal plane, demonstrating the maternal bladder inferiorly and a demarcation between the rectus fascia and the underlying muscle allowing for proper *post-hoc* measurements. Cases were excluded if the ultrasound images did not allow for complete and accurate measurement of the subcutaneous space.

Cases were identified using the ICD 9 code 674.34, which codes for complications of an obstetrical wound in the postpartum state [9]. Wound complications, identified in the inpatient and/or outpatient setting, were diagnosed by an attending physician caring for the patient at the time of the complication and documented in the medical record. One of the authors (NR) confirmed each post-operative wound complication by electronic medical record review, confirming documentation by the attending physician of record. Controls were the next consecutive ultrasound performed who underwent a cesarean delivery without a wound complication, matched on maternal age at delivery (± 5 years) and race/ ethnicity. An investigator (SS), a maternal-fetal medicine fellow with training in landmark identification and blinded to case and control status, performed three *post-hoc* midline

suprapubic subcutaneous thickness measurements (cm) in the midsagittal plane on the midtrimester ultrasound (Figure 1). This investigator was not involved in the production of the original ultrasound. *Post-hoc* measurements were obtained using the caliber tool in either ViewPoint software (version 5.6.12.601, GE Healthcare, Wauwatosa, WI) or Centricity Web Enterprise Software (version 3.0, GE Healthcare, Barrington, IL).

Demographic characteristics were obtained via electronic medical record review. Indication for cesarean delivery, preoperative antibiotic regimen and type of wound complication (seroma, hematoma, wound dehiscence, wound infection or cellulitis) were also extracted from the medical record. In addition, the type of skin incision (Pfannenstiel versus vertical), hysterotomy (low transverse versus classical), and skin closure technique (staples versus suture) were obtained from the medical record.

All statistical tests were performed using SAS 9.3 (SAS Institute Inc., Cary, NC). All tests were two sided, and *p* values <0.05 were considered statistically significant. Data are presented as mean±standard deviation, median (interquartile range) or proportion. Comparisons were made using a Chi-square or Fisher's exact test for categorical variables and parametric or non-parametric tests for continuous variables, as appropriate. Odds ratios (OR) and 95% confidence intervals (95% CI) were determined using conditional logistic regression to adjust for the matching factors. Variables that were believed to influence both subcutaneous thickness and the risk of wound infection, including diabetes, type of hysterotomy, skin closure, presence or absence of labor, and prior cesarean delivery, were considered as potential confounders. Those that changed the odds ratio by more than 10% were retained in the final model. Spearman's correlation coefficients were used to evaluate associations between continuous variables.

In performing a power calculation, we assumed that cases would have a mean subcutaneous thickness of 4.1±1.8 cm and that controls would have a mean subcutaneous thickness of 2.3±1.2 cm based on a study by Vermillion et al. [2]. Specifying $\alpha=0.05$ and a 1:1 ratio of cases to controls, with 79 cases we had more than 99% power to detect a difference of the magnitude noted between the above values.

Results

A total of 7228 patients underwent cesarean delivery during the study period and 123 (1.7%) were found to have a postoperative wound complication. Forty-four were excluded because either the ultrasound imaging was not available or the imaging did not allow for midline suprapubic *post-hoc* measurements, leaving 79 cases with wound complications. Among the 56 cases with an isolated wound complication, 21.4% had a seroma, 7.1% had a hematoma, 8.9% had a wound separation, 33.9% had a wound infection and 28.6% had cellulitis; 29.1% of cases had more than one of these complications. Although none of the differences reached statistical significance, the cases were more likely to possess risk factors for the development of a wound complication; including chorioamnionitis, prior wound complication, smoking during pregnancy and diabetes (including gestational diabetes). Among the cases, 70.9% experienced labor, compared to 59.5% in the control group. There was no statistical difference in the indication for cesarean delivery between the two groups,

regardless of whether the delivery was preceded by labor (all $p > 0.14$). Baseline participant characteristics are shown in Table 1.

The midline suprapubic measurements for the cases and controls are shown in Table 2. The measurements for the two groups were not significantly different (all $p > 0.35$). Median pre-pregnancy BMI was similar between cases and controls, and was moderately associated with an increasing subcutaneous thickness at each measurement site; $r=0.63$, $p<0.001$ for the superior measurement; $r=0.66$, $p<0.0001$ for the midline measurement and $r=0.65$, $p<0.001$ for the inferior measurement. However, there was no difference in BMI between the cases and controls.

A classical hysterotomy and a vertical midline skin incision were each associated with the development of a wound complication ($p=0.01$ and 0.02 , respectively). In addition, wound complications were significantly more likely to result when the skin incision was closed with staples compared to a suture closure ($p=0.046$) (Table 2). The crude ORs demonstrated that there was no association between subcutaneous thickness and wound complication at the superior (OR: 1.2; 95% CI: 0.79–2.0), midline (OR: 1.1; 95% CI: 0.68–1.9), or inferior (OR: 0.89; 95% CI: 0.55–1.4) measurements. After adjusting for type of hysterotomy and prior cesarean delivery, the only variables shown to be confounders, the results were similar for the superior (OR: 1.1; 95% CI: 0.66–1.8), midline (OR: 0.96; 95% CI: 0.55–1.7), and inferior (OR: 0.70; 95% CI: 0.41–1.2) measurements.

Discussion

There is a paucity of data on the utility of the midtrimester obstetrical ultrasound as a means of identifying patients at risk for the development of a wound complication after cesarean delivery. Previous reports have demonstrated an association with wound complications and increasing thickness of the subcutaneous space [2,7]. Vermillion et al. [2] demonstrated subcutaneous thickness, measured intraoperatively, as the only significant risk factor for the development of wound infection after cesarean delivery. In addition, they concluded duration of ruptured membranes, number of intrapartum vaginal exams, chorioamnionitis, type of skin incision or duration of surgery, did not contribute significantly to the development of a cesarean wound infection.

Radiologic imaging has been used to measure subcutaneous space thickness pre-operatively as a means of assessing wound complication risk. Fujii et al. [10] demonstrated abdominal subcutaneous thickness, measured by pre-operative CT as the strongest predictor for surgical site infections associated with elective colorectal surgery. Lee et al. [8] made similar conclusions in a population of patients undergoing midline laparotomy, also using preoperative CT; they too reported subcutaneous thickness as an independent risk factor for the development of a surgical site infection.

In contrast to these previous studies, our study failed to demonstrate an association between midline subcutaneous thickness at time of midtrimester fetal anatomical survey ultrasound and cesarean wound complications. One explanation could be the timing of the ultrasound measurements. Previous reports demonstrating an association between subcutaneous

thickness and wound complications measured the subcutaneous space either immediately pre-operatively or intra-operatively. Our study used measurements months prior to the cesarean delivery, allowing time for fat accumulation and redistribution in the suprapubic region. In addition, our power calculation was based on a previous study, which demonstrated an almost two-fold difference in subcutaneous space measurements in cesarean deliveries affected by surgical site infections, with the infected group measuring 4.1 cm compared to 2.3 cm in the controls [2]. In this study, the thickest measurements for both groups were located at the inferior measurement location. Additionally, there could be “compressive” effect from the abdominal transducer falsely decreasing the overall measurement of the subcutaneous space. While this phenomenon might have a comparable effect in both cases and controls, it is possible that sonographers apply more force in patients destined or predisposed to have wound infections because of particular characteristics of the tissue in these patients. Lastly, the location of the subcutaneous measurements may also have contributed to the lack of association between measurements and wound complications. Measurements were made suprapubically in the midsagittal plane; however, in many patients, particularly those with a large abdominal pannus, this location may underestimate the extent of subcutaneous tissue at risk for complication.

Both Lee et al. [8] and Fuji et al. [10] limited the postoperative period to 30 days, consistent with the definition of a surgical site infection endorsed by the Center for Disease Control [11]. Vermillion et al. [2] extended the surveillance period to 6 weeks post-partum. In our study, all but two cases were diagnosed within the 6-week postpartum period. Both of these diagnoses were confirmed with medical record review; thus, they were included in our analysis. The variation in inclusion criteria could limit the comparability of our finding with other studies that limited the post-operative surveillance period.

Nonetheless, this study has strengths. Each case of wound complication was confirmed with chart review, eliminating any chance of coding error. Second, a blinded investigator was used to make each measurement for both the case and control groups, reducing the risk of bias. Lastly, given the retrospective nature of the measurements, independent validation of each measurement was available to confirm the accuracy of the measurements.

The limitations of this study include the potential miscoding of cases resulting in the inability to capture cases of cesarean wound complication and the possibility that we missed cases that presented outside of the postpartum period. In addition, this study was underpowered given that the observed differences in the subcutaneous thickness was smaller than anticipated based on the study by Vermillion et al. [2]. Lastly, we excluded 35% of potential cases due to imaging not fulfilling inclusion criteria. Eliminating these potential cases certainly could have introduced bias.

In conclusion, we did not identify an association between abdominal subcutaneous thickness measured at time of the midtrimester fetal anatomical assessment and the development of wound complications with cesarean delivery. The use of staples for skin closure, skin incision type and a classical hysterotomy incision were all associated wound complications. The study highlights the ability of ultrasound to measure the subcutaneous thickness at the time of obstetrical ultrasound, and provides background for future prospective investigations

focusing on the timing and the location of ultrasound measurements to best identify patients at risk for wound complications.

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Figure 1. Midline ultrasound image in the suprapubic plane measuring the subcutaneous space. (A) superior subcutaneous measurement; (B) midline subcutaneous measurement; (C) inferior subcutaneous measurement.

Table 1

Participant characteristics.

	Cases (<i>n</i> =79)	Controls (<i>n</i> =79)	<i>p</i> value
Maternal age at delivery (years)	32.8±6.4	32.8±5.8	0.97
Pre-pregnancy body mass index	27.1 (22.8–32.1)	26.7 (22.8–34.4)	0.96
Race or ethnicity			
Caucasian	43 (54.4)	43 (54.4)	1.0
Black/African-American	19 (24.1)	19 (24.1)	
Hispanic	5 (6.3)	5 (6.3)	
Gestational age at delivery	39.0 (38.0–40.0)	39.4 (38.9–40.4)	0.07
Risk factors			
Immunosuppressant use	3 (3.8)	0 (0.0)	0.25
Chorioamnionitis	9 (11.4)	5 (6.3)	0.26
Prior cesarean wound complication	2 (2.5)	0 (0.0)	0.50
Current smoker	4 (5.1)	2 (2.5)	0.68
Diabetes (including gestational)	12 (15.2)	11 (13.9)	0.82
Primary cesarean delivery			0.18
Yes	57 (72.2)	49 (62.0)	
No	22 (27.8)	30 (38.0)	
Indication for cesarean delivery			
Labor	56 (70.9)	47 (59.5)	0.14
Arrest of descent	9 (16.1)	3 (6.4)	
Arrest of labor	12 (21.4)	6 (12.8)	
Cord/placenta abnormality	1 (1.8)	0 (0.0)	
Failed induction	3 (5.4)	6 (12.8)	
Malpresentation	4 (7.1)	1 (2.1)	
Non-reassuring fetal status	17 (30.4)	15 (31.9)	
History of cesarean	10 (17.9)	16 (34.0)	
No labor	23 (29.1)	32 (40.5)	0.79
Elective	4 (17.4)	5 (15.6)	
Malpresentation	11 (47.8)	13 (40.6)	
Other	0 (0.0)	2 (6.3)	
History of cesarean	8 (34.8)	12 (37.5)	

Data are presented as mean±standard deviation, median (interquartile range) or *n* (%).

Table 2

Intraoperative characteristics and subcutaneous thickness.

	Cases (<i>n</i> =79)	Controls (<i>n</i> =79)	<i>p</i> value
Type of hysterotomy			
Low transverse	74 (89.9)	75 (94.9)	0.01
Classical	8 (10.1)	1 (1.3)	
Other	0 (0.0)	3 (3.8)	
Skin incision			
Vertical midline	9 (11.4)	1 (1.3)	0.02
Pfannensteil	70 (88.6)	78 (98.7)	
Skin closure			
Suture	15 (19.0)	26 (32.9)	0.046
Staples	64 (81.0)	53 (67.1)	
Subcutaneous thickness (cm)			
Superior	1.88 (1.45–2.29)	1.74 (1.42–2.27)	0.35
Middle	1.94 (1.50–2.44)	1.86 (1.48–2.35)	0.65
Inferior	2.24 (1.89–2.68)	2.42 (1.87–2.88)	0.44

Data are presented as *n* (%) or median (interquartile range).