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Unintended hysterotomy extension during caesarean delivery: risk factors and maternal morbidity

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Abstract

We conducted an observational retrospective cohort study to evaluate the risk factors and the maternal morbidity associated with unintended extensions of the hysterotomy during caesarean delivery. We evaluated 2707 women who underwent low-transverse caesarean deliveries in 2011 at an academic, tertiary-care hospital. Hysterotomy extensions were identified through operative reports. Of the 2707 caesarean deliveries, 392 (14.5%) had an unintended hysterotomy extension. On the multivariable regression modelling, neonatal weight (OR 1.42; 95%CI 1.17–1.73), the arrest of labour [first-stage arrest (2.42; 1.73–3.38); second-stage arrest (5.54; 3.88–7.90)] and a non-reassuring foetal status (1.65; 1.20–2.25) were significantly associated with hysterotomy extensions. Hysterotomy extensions were significantly associated with an increased morbidity including an estimated blood loss >1200 millilitres (2.06; 1.41–3.02), a decline in postoperative haemoglobin ≥3.7 g/dL (2.07; 1.35–3.17), an evaluation for lower urinary tract injury (5.58; 3.17–9.81), and a longer operative time (8.11; 6.33–9.88). Based on these results, we conclude that unintended hysterotomy extensions significantly increase the maternal morbidity of caesarean deliveries.

Keywords

Caesarean section; caesarean delivery; hysterotomy; extension; morbidity; retrospective

Introduction

Over 1.2 million women undergo caesarean delivery (CD) in the United States each year (Hamilton et al. 2015). In 2014, CD was the method of delivery for 32.2% of all births (Hamilton et al. 2015). The maternal morbidity associated with CD is significantly greater

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than vaginal delivery due to higher rates of blood loss, transfusion and unplanned hysterectomy (Curtin et al. 2015). Unintended extensions of the uterine incision frequently occur at the time of CD with an estimated incidence of 4–8% (Rodriguez et al. 1994; de la Torre et al. 2006; Cromi et al. 2008). These extensions can involve the broad ligament, cervix and vagina and thus, may contribute to the increased morbidity associated with CD by increasing the surgical complexity and blood loss (Sung et al. 2007).

Unintended hysterotomy extensions have often been included as secondary outcomes in studies assessing other risk factors for CD morbidity such as a prolonged second stage of labour (Sung et al. 2007; Asicioglu et al. 2014a). In an evaluation of CDs performed following labour, the hysterotomy extensions were significantly more common after a prolonged second stage of labour (Sung et al. 2007). Variations in surgical technique including blunt versus sharp creation of the hysterotomy have also been assessed (Rodriguez et al. 1994; Magann et al. 2002; Cromi et al. 2008; Sekhavat et al. 2010; Xu et al. 2013; Asicioglu et al. 2014b; Xodo et al. 2016). While there is a trend towards a reduced incidence of hysterotomy extensions after blunt creation, this has not been statistically significant in meta-analysis (RR 0.57; 95%CI 0.28–1.17) (Xu et al. 2013).

As the relationship between unintended hysterotomy extensions and CD morbidity has been largely limited to secondary outcome evaluations, the clinical sequelae and maternal morbidity associated with hysterotomy extensions have been incompletely evaluated. The purposes of this study were to assess the frequency of and identify risk factors for unintended hysterotomy extensions and to evaluate the impact of unintended extensions on maternal outcomes. We hypothesised that unintended hysterotomy extensions would be associated with clinically significant maternal morbidity including intraoperative haemorrhage, urinary tract injury and longer operative times.

Materials and methods

We conducted a retrospective cohort study of all CDs performed from 1 January 2011 to the 31 December 2011 at a large, tertiary-care academic medical centre. *International Classification of Diseases, Ninth Revision* (ICD-9) codes for CD were used to identify the sample. The data were extracted from the medical records and validated through a double entry process (Shree et al. 2016). Any discrepancies were resolved by a third review of the medical record. The University of Pittsburgh Institutional Review Board approved this study as a minimal risk and waived the need for informed consent.

The demographic variables included race, parity, insurance status, tobacco use and comorbidities. Gestational hypertension (HTN), included gestational HTN, pre-eclampsia, superimposed pre-eclampsia, or eclampsia and diabetes mellitus (DM) was dichotomised into pre-gestational or gestational. Chorioamnionitis was diagnosed by the physician based on clinical and laboratory criteria necessary for the diagnosis (Higgins et al. 2016). Private practice CDs were performed by a private practice physician with either a resident physician or a physician's assistant. The resident teaching service CDs were performed by a fourth-year resident and a first or second-year resident under the supervision of a teaching service physician. While we did not specifically assess the impact of the physician training level on

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the hysterotomy extension, the ‘resident teaching service’ variable serves as a proxy for the training level.

Labour was defined as the onset of contractions, cervical change, spontaneous or artificial rupture of membranes and/or the administration of an induction or augmentation agent. Non-laboured primary CDs were elective or performed for malpresentation, placenta previa, multifetal gestation, foetal growth restriction or anomalies, previous shoulder dystocia, fourth-degree laceration or ano-rectal disease or previous uterine surgery. Non-laboured repeat CDs were defined as elective repeat CDs. A first-stage arrest was defined after the onset of labour and with a cervical exam of fewer than 10 cm. The second-stage arrest was defined after the onset of labour and a complete cervical dilation. Due to a small sample size ($n = 56$), CDs performed following a failed trial of labour after a previous CD were included in the category corresponding to the CD indication. A non-reassuring foetal status included CDs for placental abruption, umbilical cord prolapse or a non-reassuring foetal heart tracing.

A hysterotomy extension was defined as any documentation of an extension by the surgeon in the operative note. The diagnosis of a hysterotomy extension was at the discretion of the operating physician. The estimated blood loss (EBL) in millilitres (ml) was extracted from the CD operative note. An intraoperative haemorrhage was defined as the 95th percentile for EBL (>1200 ml in our dataset). A change in the haemoglobin was the difference between the preoperative haemoglobin and the lowest postoperative haemoglobin value obtained during the hospitalisation. A clinically significant change in the postoperative haemoglobin was defined as ≥3.7 g/dL (95th percentile for this change). The need for a blood transfusion was defined as any transfusion of packed red blood cells intraoperatively or during the postoperative hospital course. The operative time was defined as the time in minutes from the skin incision to the skin closure. Because of the low frequency of cystotomy, an evaluation for lower urinary tract (LUT) injury was assessed as a composite outcome defined as the backfilling of the bladder, intraoperative cystoscopy or an actual cystotomy repair. Evaluation of the LUT was at the discretion of the surgeon.

The variables were summarised using a mean and standard deviation, a median and an interquartile range (IQR), or the frequencies and percentages as appropriate. The Chisquare, *t*-tests or Fisher’s exact test were used for the binary outcomes. Pearson’s correlation was used to examine the associations with the operative time. The predictors exhibiting $p < .2$ in the bivariate analysis were included in the initial multivariable models. To check for collinearity, the variance inflation factor (VIF) was calculated for each predictor. The variable ‘labour’ was multi-collinear and removed as a predictor from the multivariable models. To select the final models, stepwise backward elimination was used based on minimising the Akaike Information Criterion (Lawless and Singhal 1978). The prevalence of blood transfusion ($n = 12$) and cystotomy ($n = 11$) were low, not associated with the hysterotomy extension in the bivariate analysis, and were not evaluated in the multivariate analysis. The missing values (2.8%) were excluded from the final models. All of the analyses were conducted using STATA® 12 (College Station, TX) and the R Foundation for Statistical Computing 3.2 (Austria).

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Results

Between 1 January 2011 and 31 December 2011, 2876 CDs were performed at our institution. We included only term pregnancies (≥37 weeks of gestation) and excluded the non-Pfannenstiel skin incisions ($n = 34$) and the hysterotomies that were not low transverse ($n = 46$). In our dataset, there were no hysterectomies performed following an unintended zhysterotomy extension, so all of the caesarean hysterectomies ($n = 8$) were excluded from the analysis. We also excluded the CDs in which any extra procedures were performed (i.e. drain placement, oophorectomy/cystectomy). Due to one or more of the previous diagnoses, 169 (5.9%) CDs were excluded.

Our final sample consisted of 2707 low transverse CDs performed via a Pfannenstiel skin incision and 392 (14.5%) had documentation of an unintended hysterotomy extension (Table 1). The mean age of the patients in our sample was 30 years. The majority of the patients were Caucasian, had private insurance, and had their CD performed by a private attending. The mean BMI of our cohort was 33.3 kg/m^2. Approximately 17% had either chronic or gestational HTN, 11% had either pre-gestational or gestational DM and 4% of patients had a diagnosis of chorioamnionitis. The most common indication for a CD was an elective repeat CD. Over half of the CDs were performed after the onset of labour. Approximately 6% of the CDs had an EBL >1200 ml and 5% had a postoperative drop in haemoglobin of ≥3.7 g/dL. 2.4% required an intraoperative evaluation for LUT injury [a backfilling of the bladder ($n = 77$), an intraoperative cystoscopy ($n = 24$), or a cystotomy requiring repair ($n = 11$)], and less than 1% required a blood transfusion. The mean duration of a CD operative time was approximately 51 minutes.

The patient, provider and procedure characteristics for the patients with and without a hysterotomy extension were compared (Table 1). Hysterotomy extensions occurred in 22.3% of the patients who laboured prior to their CD compared to only 5.2% of patients who did not labour prior to their CD ($p < .01$). The patients with a hysterotomy extension were more likely to be younger (28.9 vs. 29.9 years; $p < .01$), at a greater gestational age (39.5 vs. 38.6 weeks; $p < .01$), have an infant with a greater neonatal weight (3446 vs. 3263 grams; $p < .01$) and be diagnosed with chorioamnionitis (8.9% vs. 3.4%; $p < .01$). The patients with a hysterotomy extension were also significantly more likely to have their CD performed for a first-stage arrest (27.3% vs. 14.1%; $p < .01$), a second-stage arrest (33.2% vs. 7.6%; $p < .01$) or a non-reassuring foetal status (23.2% vs. 17.6%; $p = .01$) and were significantly more likely to be in labour prior to their CD (83.7% vs. 49.3%; $p < .01$). The patients who did not have an unintended hysterotomy extension were more likely to be multiparous (55.6% vs. 30.1%; $p < .01$) and have a non-laboured CD (primary [15.7 vs. 3.8%; $p < .01$], repeat [32.8% vs. 11.5%; $p < .01$]). Finally, patients with an unintended hysterotomy extension were significantly more likely to have an EBL of >1200 cc (10.5% vs. 4.8%; $p < .01$), a drop in postoperative haemoglobin of 3.7 g/dL (8.5% vs. 3.9%; $p < .01$), an evaluation for an LUT injury (7.1% vs. 1.6%, $p < .01$) and a longer CD operative time (57.5 vs. 49.6 minutes; $p < .01$).

Multivariable logistic regression models were developed to identify risk factors predictive of hysterotomy extension at the time of a CD (Table 1). A greater neonatal weight (OR 1.42;

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95%CI 1.17–1.73) and the CDs performed for a first-stage arrest (2.42; 1.73–3.38), a second-stage arrest (5.54; 3.88–7.90) and a non-reassuring foetal status (1.65; 1.20–2.25) were significantly more likely to have a hysterotomy extension. Conversely, the non-laboured CDs [primary (0.34; 0.19–0.61) and repeat (0.47; 0.31–0.71)] were significantly less likely to have a hysterotomy extension.

Table 2 describes the adjusted multivariable models for four perioperative complications hypothesised to be associated with an unintended hysterotomy extension. In the multivariable analyses, a hysterotomy extension was significantly associated with an EBL >1200 ml (OR 2.06; 95%CI 1.41–3.02), a decline in the postoperative haemoglobin of ≥3.7 g/dL (2.07; 1.35–3.17), an evaluation for LUT injury (5.58; 3.17–9.81) and a longer operative time (8.11 minutes; 6.33–9.88).

Discussion

Unintended hysterotomy extensions are frequent complications of low transverse CDs, particularly after the onset of labour. Unintended hysterotomy extensions subsequently increase maternal morbidity by increasing the blood loss, the frequency of an LUT evaluation and the operative time. Our findings indicate that the rate of a hysterotomy extension in the general obstetric population is approximately 15%, which is higher than the previously reported estimates (Rodriguez et al. 1994; de la Torre et al. 2006; Cromi et al. 2008).

The CDs performed after the onset of labour had frequency of extensions four times greater than the patients who did not labour prior to their CD. The most significant independent risk factor for the hysterotomy extension was a second-stage labour arrest. This is consistent with the prior literature, demonstrating that a second-stage arrest is the most consistent risk factor for an increased maternal morbidity at the time of a CD, including hysterotomy extensions (de la Torre et al. 2006; Sung et al. 2007; Asicioglu et al. 2014a). Rodriguez et al. (1994) (n = 296) found an increase in the prevalence of unintended hysterotomy extensions with the increasing stages of labour [1.4% without labour, 15.5% after the first stage and 35.0% after the second stage ($p < .01$)]. Due to a lower uterine segment thinning that occurs with labour progression combined with the force necessary to disengage the foetal head from the pelvis, an increase in the incidence of a hysterotomy extension after labour is not unexpected.

Importantly, a hysterotomy extension was found to be an independent risk factor for an intraoperative haemorrhage and a significant drop in postoperative haemoglobin. In the analysis by de la Torre et al. (2006), the intraoperative blood loss was also greater in the CDs complicated by the extensions ($p < .01$), but they did not find a significant change between the preand postoperative haematocrit levels ($p = .376$) or the blood transfusion (0.6% vs. 0.8%; NS). Despite our low prevalence of blood transfusion, the association between hysterotomy extensions, a greater EBL and a greater postoperative haemoglobin decline has important clinical implications. Obstetric haemorrhage is the fourth most common cause of a pregnancy-related mortality in the United States and accounts for approximately 11% of maternal deaths (CDC 2016). Thus, we highlight the importance of the optimisation of haemoglobin during pregnancy to avoid the morbidity associated with an increased blood

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loss surrounding delivery. Additionally, utilising the cell salvage mechanisms in the setting of an unintended extension can be considered given the association with an increased blood loss.

Hysterotomy extensions were found to increase the risk of intraoperative evaluation for LUT injury and to have longer CD operative times. The prevalence of LUT injury in our cohort was low (0.4%), but consistent with the rates found in previous evaluations of LUT injury during CD (Oliphant et al. 2014). In contrast, an intraoperative evaluation for an LUT injury was common during the CDs complicated by a hysterotomy extension and highlights the increased surgical complexity of these cases. The procedures used to evaluate for an LUT injury such as backfilling the bladder and cystoscopy may also require an additional training to the providers and staff and an increase in resource utilisation (Oliphant et al. 2014). Relatedly, the hysterotomy extensions had the most significant impact on the operative time in the multivariable analysis. An increase in the CD duration is understandable, as the identification and repair of the extension, achieving haemostasis and evaluating the patients for an LUT injury takes time.

Upon comparing our results to those of studies over the last 10 years, the rate of hysterotomy extensions during routine CD has potentially doubled from approximately 6.6% to 14.5%, which is of significant clinical importance (de la Torre et al. 2006). Recent re-evaluations of the labour curve with a focus on extending the second stage of labour to increase vaginal delivery rates may have increased the frequency of CDs performed after a prolonged second stage (Kilpatrick and Laros 1989; Laughon et al. 2014; Gimovsky and Berghella 2016). Although we were unable to quantify the duration of labour in our cohort, 11% of patients had a CD performed after a second-stage arrest. Given the associated morbidities in this group of women, prospective studies are needed to identify the risk factors predictive of arrest to better stratify the patients who may ultimately require CD.

Our study must be interpreted in light of certain limitations. This study was performed in a university tertiary-care hospital and may not be applicable to the community settings. Our study was retrospective and based on the available medical records. The presence of a hysterotomy extension was based on the surgeon documentation and could not otherwise be confirmed, which may have underestimated the true prevalence of the extensions in our cohort. Likewise, we were unable to determine the size or location of the extension from the CD operative notes. Due to limitations associated with the electronic medical record templates which were used for the documentation, we were unable to determine how the hysterotomy was created (a blunt versus a sharp dissection). However, in a recent systematic review and meta-analysis, a blunt versus a sharp expansion of the hysterotomy was not significantly associated with the development of a hysterotomy extension (Xu et al. 2013). We were also unable to determine the length of the first stage and the second stage of labour. Lastly, the interventions to decrease the trauma to the uterus during the delivery of the impacted foetal head have been evaluated (Jeve et al. 2016; Seal et al. 2016; Waterfall et al. 2016). The reverse breech extraction through the hysterotomy (the ‘pull technique’) has been compared to assistance from a vaginal hand (the ‘push’ technique) in the CDs performed for a second-stage arrest in four randomised trials. The reverse breech extraction was significantly associated with a decrease in the risk of hysterotomy extension across all four

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trials (Waterfall et al. 2016). Unfortunately, we were unable to assess if either of these methods were used to assist the delivery of the foetal head, as this information was not uniformly recorded in the medical record. Further evaluation of methods such as these to aid the obstetrician during difficult caesarean delivery should and will likely be an area of continued research.

In conclusion, unintended hysterotomy extensions are common and are associated with an increase in maternal morbidity. A second-stage arrest is a strong independent risk factor for a hysterotomy extension and the impact of a prolonged second stage on the CD morbidity should be factored into the clinical decision-making. Once the decision for a CD is made after a second-stage arrest, surgeons should be prepared for a potentially longer procedure with an increased possibility of an unintended hysterotomy extension. Upon identifying a hysterotomy extension intraoperatively, the preparedness for a possible haemorrhage is warranted. It is also important to notify and prepare the operating room staff for the potential need to evaluate for an LUT injury. As one out of every three births result in a CD, the efforts to mitigate maternal morbidity associated with CD are of significant clinical importance.

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IMPACT STATEMENT

- **What is already known on this subject?** Maternal morbidity associated with caesarean delivery (CD) is significantly greater than that in vaginal delivery. Unintended extensions of the hysterotomy occur in approximately 4–8% of CDs and are more common after a prolonged second stage of labour. The morbidity associated with hysterotomy extensions has been incompletely evaluated.
- **What do the results of this study add?** We demonstrate a rate of hysterotomy extension in a general obstetric population of approximately 15%, which is higher than previously reported estimates, and represents a potential doubling of the rate of the unintended hysterotomy extensions in recent years. The most significant risk factor for a hysterotomy extension was a second-stage labour arrest with a fourfold increase in the frequency of extensions. A hysterotomy extension is a significant independent risk factor for an intraoperative haemorrhage, a drop in postoperative haemoglobin, an intraoperative evaluation for lower urinary tract injury, and longer CD operative times.
- **What are the implications of these findings for clinical practice and/or further research?** A second-stage arrest is a strong independent risk factor for a hysterotomy extension. Recent re-evaluations of the labour curve that extend the second stage of labour will likely increase the frequency of CDs performed after a prolonged second stage. In these scenarios, obstetricians should be prepared for an unintended hysterotomy extension and for the possibility of a longer procedure with the increased risks of blood loss and the need for evaluation of the lower urinary tract.

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J Obstet Gynaecol. Author manuscript; available in PMC 2019 November 01.

Table 1

Sample characteristics[a] (n = 2707) and specific risk factors predictive of unintended hysterotomy extension[b].

	All (N = 2707)	No extension (N = 2315)	Extension (N = 392)	p value	Unadjusted OR (95%CI)	Final adjusted ORa (95%CI)
Patient characteristics						
Age (years)	29.8 (±5.7)	29.9 (±5.7)	28.9 (±5.7)	<**.01**	0.97 (0.95–0.99)	0.99 (0.97–1.01)
Gestational age (weeks)	38.7 (±2.2)	38.6 (±2.3)	39.5 (±1.6)	<**.01**	1.30 (1.21–1.39)	1.06 (0.98–1.15)
Neonatal weight (grams)	3290 (±672)	3263 (±687)	3446 (±555)	<**.01**	1.55 (1.30–1.85)	**1.42 (1.17–1.73)**
Race						
Caucasian	2086 (77.7)	1772 (77.2)	314 (80.7)	.31	1.23 (0.91–1.67)	–
African-American	453 (16.9)	396 (17.3)	57 (14.7)		ref	–
Other	144 (5.4)	126 (5.5)	18 (4.6)		0.99 (0.56–1.75)	–
BMI (kg/m^2)	33.3 (±7.1)	33.3 (±7.2)	33.3 (±6.8)	.76	1.00 (0.98–1.01)	–
Multiparous	1405 (51.9)	1287 (55.6)	118 (30.1)	<**.01**	0.34 (0.27–0.43)	0.90 (0.65–1.24)
Tobacco use	219 (8.1)	185 (8.0)	34 (8.7)	.72	1.09 (0.75–1.60)	–
Insurance status						
Private payer	1551 (68.6)	1323 (68.6)	228 (68.5)	1.00	–	–
Medicaid	710 (31.4)	605 (31.4)	105 (31.5)		1.01 (0.78–1.29)	–
Hypertensive disorders						
Chronic HTN	56 (2.1)	47 (2.0)	9 (2.3)	.85	1.12 (0.55–2.31)	–
Gestational HTN	408 (15.1)	352 (15.2)	56 (14.3)		0.93 (0.69–1.27)	–
Diabetes mellitus						
Pre-Gestational DM	80 (3.0)	67 (2.9)	13 (3.3)	.89	1.15 (0.63–2.10)	–
Gestational DM	213 (7.9)	183 (7.9)	30 (7.7)		0.97 (0.65–1.45)	–
Chorioamnionitis	114 (4.2)	79 (3.4)	35 (8.9)	<**.01**	2.78 (1.84–4.20)	1.01 (0.65–1.56)
Provider characteristics						
Private practice	1926 (73.0)	1649 (73.2)	277 (71.9)	.66	–	–
Resident teaching service	712 (27.0)	604 (26.8)	108 (28.1)		1.064 (0.83–1.36)	–
Procedure characteristics						
Caesarean delivery indication						
Non-laboured primary CD	379 (14.0)	364 (15.7)	15 (3.8)	<**.01**	0.21 (0.13–0.36)	**0.34 (0.19–0.61)**
Non-laboured repeat CD	804 (29.7)	759 (32.8)	45 (11.5)	<**.01**	0.27 (0.19–0.37)	**0.47 (0.31–0.71)**

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	All (*N* = 2707)	No extension (*N* = 2315)	Extension (*N* = 392)	*p* value	Unadjusted OR (95%CI)	Final adjusted ORa (95%CI)
First-stage arrest	433 (16.0)	326 (14.1)	107 (27.3)	<**.01**	2.29 (1.78–2.95)	**2.42 (1.73–3.38)**
Second-stage arrest	307 (11.3)	177 (7.6)	130 (33.2)	<**.01**	5.99 (4.62–7.78)	**5.54 (3.88–7.90)**
Non-reassuring foetal status	498 (18.4)	407 (17.6)	91 (23.2)	**.01**	1.42 (1.10–1.83)	**1.65 (1.20–2.25)**
Labour prior to CD	1470 (54.3)	1142 (49.3)	328 (83.7)	<**.01**	–	–
Intraoperative and postoperative factors						
EBL >1200 cc[c]	151 (5.6)	110 (4.8)	41 (10.5)	<**.01**	na	na
Change in Hgb ≥3.7 g/Dl[c]	123 (4.6)	90 (3.9)	33 (8.5)	<**.01**	na	na
Blood transfusion	12 (0.4)	11 (0.5)	1 (0.3)	1.00	na	na
LUT injury evaluation[d]	64 (2.4)	36 (1.6)	28 (7.1)	<**.01**	na	na
Operative time (minutes)[e]	50.8 (±16.3)	49.6 (±15.4)	57.5 (±19.4)	<**.01**	na	na

BMI: body-mass index; HTN: hypertension; DM: diabetes mellitus; CD: caesarean delivery; Hgb: haemoglobin; EBL: estimated blood loss; LUT: lower urinary tract; OR: odds ratio; CI: confidence interval; na: not applicable.

[a] *n* (%) or mean (±standard deviation), bolded values are statistically significant.

[b] Final multivariable model with the lowest Akaike Information Criterion (AIC), model controlled for variables listed in table, bolded values are statistically significant value.

[c] Represents 95th percentile.

[d] Defined as backfilling the bladder or cystoscopy or cystotomy repair.

[e] Defined as time from skin incision to skin closure in minutes.

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Table 2

Maternal morbidity associated with unintended hysterotomy extension[a].

	Adjusted OR (95%CI)			
	Change in Hgb ≥3.7 g/dL[b]	**EBL >1200cc[b]**	**LUT injury evaluation[c]**	**Operative time[d]**
Primary predictor				
Hysterotomy extension	**2.07 (1.35–3.17)**	**2.06 (1.41–3.02)**	**5.58 (3.17–9.81)**	**8.11 (6.33–9.88)**
Patient characteristics				
Age (years)			1.05 (0.99–1.09)	
Gestational age (weeks)	–	–	–	–
Neonatal weight (grams)	–	–	–	–
Race				
Caucasian	–	–	–	–
African–American	–	–	–	–
Other	–	–	–	–
BMI (kg/m^2)	**0.96 (0.93–0.99)**	**1.03 (1.01–1.06)**	–	**0.40 (0.31–0.48)**
Multiparous	–	–	**3.09 (1.65–5.77)**	**3.24 (1.96–4.53)**
Tobacco Use	–	–	–	–
Medicaid	–	–	–	–
Hypertensive Disorders				
Chronic HTN	0.68 (0.09–5.05)	–	–	–
Gestational HTN	**3.65 (2.44–5.48)**	–	–	–
Diabetes mellitus				
Pre-gestational DM	–	–	–	–
Gestational DM	–	–	–	–
Chorioamnionitis	–	–	–	–
Provider characteristics				
Resident teaching service	–	–	1.62 (0.94–2.80)	**3.42 (2.06–4.78)**
Procedure characteristics				
CD indication				
Non-laboured primary CD	–	–	–	–
Non-laboured repeat CD	**0.38 (0.21–0.67)**	**0.46 (0.29–0.73)**	–	–
First-stage arrest	–	–	–	–
Second-stage arrest	–	–	**2.22 (1.09–4.54)**	2.67 (0.62–4.73)
Non-reassuring fetal status	–	–	–	**−4.43 [−6.04–(−2.83)]**

OR: odds ratio; CI: confidence interval; Hgb: haemoglobin; EBL: estimated blood loss; LUT: lower urinary tract; BMI: body-mass index; HTN: hypertension; DM: diabetes mellitus; CD: caesarean delivery.

[a] Final multivariable models with the lowest Akaike Information Criterion (AIC), models controlled for variables listed in table.

Bolded values are statistically significant. Odds ratios used for Hgb, EBL and LUT injury evaluation; mean difference used for operative time.

[b] Value represents 95th percentile.

[c] Defined as backfilling the bladder or cystoscopy or cystotomy repair.

[d] Defined as time from skin incision to skin closure in minutes.

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