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## Characteristics Associated With Severe Perineal and Cervical Lacerations During Vaginal Delivery

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### Abstract

**Objective**—To characterize potentially modifiable risk factors for third- or fourth-degree perineal lacerations and cervical lacerations in a contemporary U.S. obstetric practice.

**Methods**—The Consortium on Safe Labor collected electronic medical records from 19 hospitals within 12 institutions (228,668 deliveries from 2002 to 2008). Information on patient characteristics, prenatal complications, labor and delivery data, and maternal and neonatal outcomes were collected. Only women with successful vaginal deliveries of cephalic singletons at 34 weeks of gestation or later were included; we excluded data from sites lacking information about lacerations at delivery and deliveries complicated by shoulder dystocia; 87,267 and 71,170 women were analyzed for third- or fourth-degree and cervical lacerations, respectively. Multivariable logistic regressions were used to adjust for other factors.

**Results**—Third- or fourth-degree lacerations occurred in 2,516 women (2,223 nulliparous [5.8%], 293 [0.6%] multiparous) and cervical lacerations occurred in 536 women (324 nulliparous [1.1%], 212 multiparous [0.5%]). Risks for third or fourth-degree lacerations included nulliparity (7.2-fold risk), being Asian or Pacific Islander, increasing birth weight, operative vaginal delivery, episiotomy, and longer second stage of labor. Increasing body mass index was associated with fewer lacerations. Risk factors for cervical lacerations included young maternal age, vacuum vaginal delivery, and oxytocin use among multiparous women, and cerclage regardless of parity.

**Conclusion**—Our large cohort of women with severe obstetric lacerations reflects contemporary obstetric practices. Nulliparity and episiotomy use are important risk factors for third- or fourth-degree lacerations. Cerclage increases the risk for cervical lacerations. Many identified risk factors may not be modifiable.

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## Level of Evidence: II

Severe perineal (third- or fourth-degree lacerations) and cervical lacerations sustained during delivery can have significant short-term and long-term effects.<sup>1-4</sup> Various risk factors have been reported for severe perineal lacerations developing during child birth, including increased maternal age, Asian race, nulliparity, higher birth weight, instrumented vaginal delivery, occiput posterior fetal position, and midline (median) episiotomy.<sup>5-7</sup>

Over time, with an increase in the cesarean delivery rate, data have demonstrated a reduction in severe perineal lacerations in association with restrictive episiotomy use<sup>8</sup> and a decrease in the incidence of forceps deliveries. Decreasing rates of episiotomy and forceps use combined with increasing cesarean delivery explains 70% of the variance of the decline in severe perineal trauma at one institution over an 11-year period.<sup>9</sup>

Compared with the wealth of published information on risk factors for sustaining third- or fourth-degree perineal lacerations, less is known about cervical lacerations. Two small studies of women with cervical lacerations (n\_32 and n\_131, respectively) found that cervical cerclage during pregnancy was associated with an increased risk of cervical laceration.<sup>9,10</sup> The 2007 study by Parikh et al<sup>9</sup> also found an association with labor induction, whereas the 2009 study by Melamed et al<sup>10</sup> described higher rates in association with precipitous labor, vacuum delivery, and episiotomy.

We used data from the Consortium on Safe Labor, a multicenter collaborative study designed to characterize labor and delivery, to explore the risk factors for severe perineal and cervical lacerations in contemporary obstetric practice in the United States. Our objective was to explore characteristics associated with third- and fourth-degree perineal lacerations and cervical lacerations in an attempt to evaluate potentially modifiable risk factors.

## Materials and Methods

The Consortium on Safe Labor retrospectively collected data from electronic medical records from 2002 to 2008 at 12 institutions (19 hospitals) for 228,668 deliveries of 233,844 neonates (including multiples). This study was approved by the Institutional Review Boards of all participating institutions. Data included patient characteristics, prenatal complications, labor and delivery information, and maternal and neonatal outcomes. We excluded five centers that did not report data pertaining to obstetric lacerations sustained at the time of vaginal delivery. For patients who had more than one pregnancy during the study period, only the first singleton pregnancy was included to avoid intra-person correlation. Only patients who underwent successful vaginal deliveries of cephalic singletons at 34 weeks of gestation or later were included; deliveries that were complicated by shoulder dystocia were

excluded. Five sites were excluded that lacked information on third- or fourth-degree lacerations. The final group that met the inclusion criteria for third- or fourth-degree perineal lacerations comprised 87,267 women (38,196 nulliparous and 49,071 multiparous women). An additional two sites lacked information on cerclage and were excluded from the analysis for cervical lacerations, for a total of 71,170 women (30,213 nulliparous and 40,957 multiparous women).

General maternal characteristics including race, age, parity, body mass index (BMI, calculated as weight (kg)/[height (m)]<sup>2</sup> at time of delivery, previous uterine scar, gestational age at delivery, and maternal and neonatal outcomes were recorded. Intrapartum characteristics including labor induction and method of induction or cervical ripening (eg, amniotomy, prostaglandin E1 or prostaglandin E2, mechanical method using Foley bulb, or oxytocin), use of epidural anesthesia, length of the first and second stages of labor, type of vaginal delivery (spontaneous or operative), use of episiotomy, and neonatal birth weight were recorded. The length of the first stage of labor was calculated from time of admission to the first time of documentation that the cervix was 10 cm dilated; the length of the second stage of labor was calculated from the first time the cervix was noted to be 10 cm dilated to the time of delivery. To evaluate the potential effect of any oxytocin use, we chose to combine oxytocin use for either labor induction or augmentation. In evaluating a previous uterine scar, we reasoned that only multiparous women would have had a previous cesarean delivery; therefore, to account for this effect of parity, we re-coded parity for multiparous women with a previous uterine scar as “parity minus 1” (for example, a woman with a previous cesarean delivery whose parity was 1 was recorded as a parity of 0). Categories for the durations of the first and second stages of labor were determined based on published data.<sup>11–13</sup> Data were validated using four key variables, concluding that Consortium data from electronic medical records were a reasonably accurate representation of medical charts.<sup>14</sup>

The  $\chi^2$  test was performed when appropriate. A multivariable logistic regression was first used to investigate the association between parity and third- or fourth-degree perineal or cervical lacerations and adjusted for maternal race, maternal age, BMI at admission, induction of labor, method of induction, epidural analgesia, oxytocin augmentation, operative vaginal delivery, episiotomy, gestational age at delivery, birth weight, previous uterine scar, and duration of first and second stages of labor. Both analyses were adjusted for hospital site. The analysis for cervical lacerations additionally was adjusted for cerclage. Because labor and delivery differ significantly between nulliparous and multiparous women, the cohort was then stratified by parity. Multivariable logistic regression was performed to investigate the association of maternal, neonatal, and obstetric risk factors for third- or fourth-degree perineal or cervical lacerations and included the same characteristics. All analyses were performed using SAS 9.1 (SAS Institute, Cary, NC).

## Results

A total of 2,516 third- or fourth-degree perineal lacerations (2.9%) and 536 cervical lacerations (0.8%) were noted. Third- or fourth-degree lacerations were sustained in 2,223 nulliparous women (5.8%) and in 293 multiparous women (0.6%). Cervical lacerations were sustained in 324 nulliparous (1.1%) and in 212 multiparous women (0.5%).

The incidence of third- or fourth-degree perineal lacerations by maternal, neonatal, and obstetric characteristics is presented in Table 1. African American women had fewer third- or fourth-degree perineal lacerations develop, whereas Asian and Pacific Islander women had the highest incidence. The peak incidence of lacerations was seen in women aged 20–24, and the lowest incidence was seen in women 35 years or older. Fewer third- or fourth-

degree lacerations occurred among obese (BMI 30 or more) and morbidly obese women (BMI 35 or more). Other factors associated with an increased risk of third- or fourth-degree lacerations included nulliparity, oxytocin administration, epidural anesthesia, episiotomy, advancing gestational age, and increasing birth weight. Nulliparous women with longer durations of either the first or the second stages of labor and multiparous women with longer second stages of labor were at higher risk for perineal lacerations.

Controlling for other factors, multivariable analysis resulted in nulliparity conferring a 7.2-fold increased risk for sustaining third- or fourth-degree lacerations (adjusted odds ratio [OR] 7.2, 95% confidence interval [CI] 6.3–8.5) (Table 2). When stratified by parity, Asian or Pacific Islander race was associated with an increased risk for third- or fourth-degree lacerations, more so among multiparous women (adjusted OR 2.2). African American race was not protective (nulliparous OR 0.9, 95% CI 0.7–1.1; multiparous OR 1.3, 95% CI 0.8, 2.2). Among nulliparous women, compared with women younger than age 25, those older than age 25 had an increased risk for third- or fourth-degree lacerations (OR ranging from 1.6 to 1.9 for women older than 25). Increasing maternal BMI was protective in nulliparous, but not multiparous, women. A small protective effect of epidural anesthesia was observed in all parities (nulliparous OR 0.7, 95% CI 0.6–0.8; multiparous OR 0.5, 95% CI 0.4–0.7).

Regardless of parity or type of instrument, women who underwent operative vaginal deliveries experienced three- to five-times the number of third- or fourth-degree lacerations compared with those who underwent spontaneous vaginal deliveries. Episiotomy was performed in 1,575 of the 2,516 (61.6%) women who sustained third- or fourth-degree lacerations, 78% of which were midline. Gestational age itself was not associated with an increased risk for severe perineal laceration, but an increasing birth weight was a strong risk factor in a dose–effect pattern. The presence of a previous uterine scar did not influence the risk of sustaining third- or fourth-degree lacerations, but the risk increased with duration of the second stage.

The fourth column of Table 1 presents characteristics of the 536 women who had cervical lacerations develop. More frequent cervical lacerations occurred in African American and Hispanic women compared with the white and Asian and Pacific Islander populations. Other maternal characteristics included nulliparity, labor induction, oxytocin use, and cerclage. Cervical lacerations were seen more frequently in women with shorter second stages of labor in nulliparous patients.

Multivariable analysis controlling for other factors resulted in nulliparity conferring a small increased risk for sustaining a cervical laceration (adjusted OR 1.3; 95% CI 1.0–1.7). Table 3 illustrates the data for patients with cervical laceration when stratified by parity and adjusted by site. Epidural use in nulliparous women was associated with a small increased risk of cervical laceration (OR 1.5, 95% CI 1.1–2.1) without a relationship to length of labor, gestational age at delivery, or birth weight. For multiparous women, sustaining a cervical laceration was associated with younger age (20 years or younger) oxytocin use (OR 2.5, 95% CI 1.2–5.6), and vacuum vaginal delivery (OR 3.1, 95% CI 1.1–8.7).

Cerclage was highly associated with an increased risk of cervical laceration, with a 3.7-fold increased risk in nulliparous women (adjusted OR 3.7, 95% CI 1.1–12.8) and a 12.7-fold increased risk in multiparous women (adjusted OR 12.7, 95% CI 5.7–28.2; Table 3).

## Discussion

In current obstetric practice with less episiotomy and forceps use combined with an increased cesarean delivery rate, previously reported risk factors for third- and fourth-degree lacerations continue to be significantly associated with risk of laceration. These include

nulliparity,<sup>11,15</sup> increasing gestational age,<sup>16</sup> increasing birth weight,<sup>4,7,15</sup> operative vaginal delivery,<sup>4,7,15,17</sup> increasing length of the second stage of labor,<sup>7,11,18</sup> and episiotomy.<sup>4,14,17,19</sup> Ethnic variability also has been reported with higher risks among women of non-African American ethnicity,<sup>20</sup> particularly among Asian women.<sup>5</sup> In addition, cervical lacerations represent a complication that is not well detailed in the literature. From our sizeable patient population, we determined a major risk factor for cervical lacerations to be cervical cerclage. Other risk factors included epidural use in nulliparous women and, among multiparous patients, age 20 years or younger, oxytocin use, and vacuum vaginal delivery were identified.

A decreased association of third- or fourth-degree lacerations was identified among patients with epidural, which is something not previously reported. Epidural use is associated with a longer second stage of labor and higher rates of operative vaginal delivery, both of which increase the risk of perineal lacerations.<sup>21,22</sup> In a multivariable model controlling for these variables, our reported lower risk of third- or fourth-degree lacerations associated with epidural use perhaps might also be explained by having more controlled crowning and delivery of the head with resulting fewer lacerations.

We found third- or fourth-degree lacerations to be highly associated with episiotomy use: 2.4-fold in nulliparous women and 4.4-fold in multiparous women. More than 62% of women with third- or fourth-degree lacerations had episiotomies performed (1,575 of 2,516 patients); this is concerning given clear published recommendations for restrictive episiotomy use.<sup>6</sup> It can be postulated that in a scenario involving a patient with key clinical characteristics (eg, nulliparity, increased gestational age, increased fetal weight, and increased duration of the second stage of labor), an obstetrician would be inclined to undertake clinical actions to facilitate a vaginal delivery, proceeding with episiotomy and use of vacuum or forceps. Our data provide more support and strongly confirm the practice of restrictive episiotomy in modern obstetrics.

The major strength of this study is the large amount of data pertaining to 536 women with cervical lacerations. Melamed et al<sup>10</sup> described 131 cases of women with cervical lacerations, identifying risk factors of cervical cerclage during pregnancy, precipitous labor (delivery 3 hours or less after the onset of active labor), episiotomy, and vacuum extraction.<sup>10</sup> Another 2007 study retrospectively identified 32 patients from a cohort of 16,391 deliveries and described significant associations with labor induction and cervical cerclage during pregnancy similar to our findings. These authors<sup>9</sup> did not find an association with operative vaginal delivery, contrary to Melamed's report,<sup>10</sup> and our data demonstrating an association with vacuum delivery in multiparous patients, perhaps because of the small numbers in their study.<sup>9</sup> In our study, oxytocin use in multiparous women conferred a 2.5-fold risk of cervical laceration and the major risk factor for cervical lacerations was found to be cerclage regardless of parity (3.7-fold risk in nulliparous and 12.7-fold increased risk in multiparous women).

Our study provides insight into current obstetric practice in a large diverse population. However, the results and conclusions are limited by a phenomenon known as informative censoring attributable to the high rate of cesarean delivery, which occurred in 43.8% of women attempting vaginal delivery from the entire cohort.<sup>14</sup> Only women who had a vaginal delivery were at risk for laceration, which may to some degree explain the association between the decreased risk of third- or fourth-degree lacerations with higher maternal BMI that has not been observed in other studies.<sup>24,25</sup> It is known that women with an increased BMI have a higher risk of cesarean delivery.<sup>23–25</sup> Perhaps in our population, the women with a higher BMI who achieved successful vaginal deliveries are different than women with a higher BMI who had cesarean delivery (eg, having smaller fetuses, which

would be associated with a decreased risk for severe perineal laceration). The lower laceration risk we describe with higher BMI also could be explained by less willingness for obstetricians to attempt operative vaginal deliveries in patients at high risk, such as obese women, because of uncertainty about fetal weight and risks of shoulder dystocia. Another possibility is that in this select group of women, their extra soft tissue might protect against development of these lacerations. Thus, the risk factors associated with laceration in the present study only apply to a population of women in whom the cesarean rate is very high, which is in the context of current U.S. obstetric practice.

Limitations of our study include the fact that some areas of interest could not be explored to the fullest because of its retrospective nature and inherent reliance on data that were entered into patients' electronic medical records, such as unspecified or unknown method of induction, type of operative vaginal delivery, or identification of multiparous women with previous severe obstetric lacerations. Additionally, our findings are not fully generalizable to the U.S. population because of the need to eliminate a number of sites that did not record information on perineal laceration or cerclage use, which was an important risk factor for cervical laceration. However, a major strength of this study is the direct clinical information derived from our large, diverse, and contemporary population, reflecting current obstetric practice, as well as the considerable amount of data pertaining to 536 women with cervical lacerations.

In summary, third- or fourth-degree lacerations and cervical lacerations represent significant morbidities associated with vaginal deliveries. In an era of high rates of cesarean delivery, we found the risk factors for third- or fourth-degree lacerations to be unchanged. Episiotomy continues to be a major potentially modifiable risk factor and efforts should be made to continue to limit this procedure to only when medically necessary. Cervical lacerations are associated with cerclage placement and some instances of oxytocin use, which may not be fully modifiable; however, full assessment of risks and benefits should be considered before their implementation. Many clinical risk factors are predetermined and use of episiotomy, oxytocin use, and cerclage represent three potentially modifiable practices.

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## References

1. Fenner DE, Genberg B, Brahma P, Marek L, DeLancey JO. Fecal and urinary incontinence after vaginal delivery with anal sphincter disruption in an obstetrics unit in the United States. *Am J Obstet Gynecol.* 2003; 189:1543–9. discussion 1549–50. [PubMed: 14710059]
2. Kammerer-Doak D, Rogers RG. Female sexual function and dysfunction. *Obstet Gynaecol Clin N Am.* 2008; 35:169–83.
3. American College of Obstetricians and Gynecologists. *Cervical Insufficiency, Practice Bulletin 48.* Washington, DC: American College of Obstetricians and Gynecologists; 2003.
4. Lowder JL, Burrows LJ, Krohn MA, Weber AM. Risk factors for primary and subsequent anal sphincter lacerations: a comparison of cohorts by parity and prior mode of delivery. *Am J Obstet Gynecol.* 2007; 196:344.e1–5. [PubMed: 17403415]
5. Hopkins LM, Caughey AB, Glidden DV, Laros RK Jr. Racial/ethnic differences in perineal, vaginal and cervical lacerations. *Am J Obstet Gynecol.* 2005; 193:455–9. [PubMed: 16098870]
6. Carroli G, Mignini L. Episiotomy for vaginal birth. *The Cochrane Database of Systemic Reviews.* 2009; (1) Art. No.: CD000081.
7. Mikolajczyk RT, Zhang J, Troendle J, Chan L. Risk factors for birth canal lacerations in primiparous women. *Am J Perinatol.* 2008; 25:259–64. [PubMed: 18509884]

8. Frankman EA, Wang L, Bunker CH, Lowder JL. Episiotomy in the United States: has anything changed? *Am J Obstet Gynecol.* 2009; 200:573.e1–7. [PubMed: 19243733]
9. Parikh R, Brotzman S, Anasti JN. Cervical lacerations: some surprising facts. *Am J Obstet Gynecol.* 2007; 196:e17–8. [PubMed: 17466666]
10. Melamed N, Ben-Haroush A, Chen R, Kaplan B, Yogev Y. Intrapartum cervical lacerations: characteristics, risk factors, and effects on subsequent pregnancies. *Am J Obstet Gynecol.* 2009; 200:388.e1–4. [PubMed: 19200938]
11. Rouse DJ, Weiner SJ, Bloom SL, Varner MW, Spong CT, Ramin SM, et al. Second-stage labor duration in nulliparous women: relationship to maternal and perinatal outcomes. *Am J Obstet Gynecol.* 2009; 201:357.e1–7. [PubMed: 19788967]
12. American College of Obstetrics and Gynecology. ACOG Practice Bulletin Number 49, December 2003. Dystocia and augmentation of labor. *Obstet Gynecol.* 2003; 102:1445–54. [PubMed: 14662243]
13. Zhang J, Troendle JF, Yancey MK. Reassessing the labor curve in nulliparous women. *Am J Obstet Gynecol.* 2002; 198:824–8. [PubMed: 12388957]
14. Zhang J, Troendle J, Reddy UM, Laughon SK, Branch DW, Burkman R, et al. Contemporary cesarean delivery practice in the United States. *Am J Obstet Gynecol.* 2010; 203:326.e1–10. [PubMed: 20708166]
15. Richter HE, Brumfield CG, Cliver SP, Burgio KL, Neely CL, Varner RE. Risk factors associated with anal sphincter tear: a comparison of primiparous patients, vaginal births after cesarean deliveries, and patients with previous vaginal delivery. *Am J Obstet Gynecol.* 2002; 187:1194–8. [PubMed: 12439502]
16. Caughey AB, Stotland NE, Washington EW, Escobar GJ. Maternal and obstetric complications of pregnancy are associated with increasing gestational age at term. *Am J Obstet Gynecol.* 2007; 196:155.e1–6. [PubMed: 17306661]
17. Kudish B, Blackwell S, Mcneeley G, Bujold E, Kruger M, Hendrix SL, et al. Operative vaginal delivery and midline episiotomy: A bad combination for the perineum. *Obstet Gynecol.* 2006; 195:749–54.
18. Cheng YW, Hopkins LM, Caughey AB. How long is too long: Does a prolonged second stage of labor in nulliparous women affect maternal and neonatal outcomes? *Am J Obstet Gynecol.* 2004; 191:9833–8.
19. Rodriguez A, Arenas EA, Osorio AL, Mendez O, Zuleta JJ. Selective vs routine midline episiotomy for the prevention of third- or fourth- degree lacerations in nulliparous women. *Am J Obstet Gynecol.* 2008; 198:285.e1–4. [PubMed: 18221925]
20. Howard D, Davies PS, DeLancey JO, Small Y. Differences in perineal lacerations in black and white primiparas. *Obstet Gynecol.* 2000; 96:622–4. [PubMed: 11004370]
21. Anim-Somuah M, Smyth RMD, Howell CJ. Epidural versus non-epidural or no analgesia in labour. *The Cochrane Database of Systemic Reviews.* 2005; (4) Art. No.:CD000331.
22. Liu EH, Sia AT. Rates of caesarean section and instrumental vaginal delivery in nulliparous women after low concentration epidural infusions or opioid analgesia: systematic review. *BMJ.* 2004; 328:1410–5. [PubMed: 15169744]
23. Minaglia SM, Kimata C, Soules KA, Pappas T, Oyama IA. Defining an at-risk population for obstetric anal sphincter laceration. *Am J Obstet Gynecol.* 2009; 201:526.e1–6. [PubMed: 19762002]
24. Kominiarek MA, VanVeldhuisen P, Hibbard J, Landy H, Haberman S, Learman L, et al. The maternal body mass index: a strong association with delivery route. *Am J Obstet Gynecol.* 2010; 203:264.e1–7. [PubMed: 20673867]
25. Heslehurst N, Simpson H, Ellis LJ, Rankin J, Wilkinson J, Lang R, et al. The impact of maternal BMI status on pregnancy outcomes with immediate short-term obstetric resource implications: a meta-analysis. *Obes Rev.* 2008; 9:635–83. [PubMed: 18673307]

**Table 1**  
**Maternal, Neonatal and Obstetrical Characteristics and Incidence of Lacerations**

MATERNAL CHARACTERISTIC	Total Population for Analysis of Third- or Fourth-Degree Lacerations (n=87,267)	Third- or Fourth- Degree Laceration Incidence (n=2,516)	Total Population for Analysis of Cervical Lacerations (n=71,170)	Cervical Laceration Incidence (n=536)
<b>Race:</b>				
White	51,063 (58.5)	1,553(3.0)*	42,475 (59.7)	159 (0.4)*
African American	14,079 (16.1)	235 (1.7)	10,908 (15.3)	196 (1.8)
Hispanic	13,831 (15.8)	320 (2.3)	10,937 (15.4)	141 (1.3)
Asian/Pacific Islander	8,294 (9.5)	408 (4.9)	6,850 (9.6)	40 (0.6)
<b>Age (years):</b>				
<20	7,685 (8.8)	232 (3.0)*	6,297 (8.8)	122 (1.9)*
20-24	23,860 (27.4)	787 (3.3)	20,839 (29.3)	158 (0.8)
25-29	26,634 (30.5)	797 (3.0)	22,863 (32.1)	127 (0.6)
30-34	18,740 (21.5)	499 (2.7)	14,399 (20.2)	95 (0.7)
≥35	10,310 (11.8)	201 (1.9)	6,762 (9.5)	34 (0.5)
<b>Parity<sup>†</sup>:</b>				
Nulliparous	37,262 (42.7)	2,223(5.8)*	29,492 (41.4)	324 (1.1)*
Multiparous	50,005 (57.3)	293 (0.6)	41,678 (58.6)	212 (0.5)
<b>Admission BMI:</b>				
<25.0	12,910 (14.8)	405 (3.1)*	9,916 (13.9)	84 (0.9)*
25.0-29.9	31,759 (36.4)	1,069 (3.4)	24,843 (34.9)	208 (0.8)
30.0-34.9	18,918 (21.7)	517 (2.7)	15,123 (21.2)	114 (0.8)
≥35	11,578 (13.3)	254 (2.2)	9,518 (13.4)	100 (1.1)
Data missing	12,102 (13.9)	217 (1.8)	11,770 (16.5)	30 (0.3)
<b>Labor Induction:</b>				
No	54,349 (62.3)	1,566 (2.9)	45,758 (64.3)	3,280(0.6)*
Yes	32,918 (37.7)	950 (2.9)	25,412 (35.7)	256 (1.0)
<b>Induction Method: AROM</b>				
No	72,514 (83.1)	2,102 (2.9)	56,556 (79.5)	479 (0.9)*
Yes	14,753 (16.9)	414 (2.8)	14,614 (20.5)	66 (0.5)
<b>Misoprostol</b>				
No	85,247 (97.7)	2,408(2.8)*	69,512 (97.7)	528 (0.8)
Yes	2,020 (2.3)	108 (5.3)	1,658 (2.3)	8 (0.5)
<b>Mechanical</b>				
No	86,038 (98.6)	2,457(2.9)*	69,944 (98.3)	531 (0.8)



MATERNAL CHARACTERISTIC	Total Population for Analysis of Third- or Fourth-Degree Lacerations (n=87,267)	Third- or Fourth- Degree Laceration Incidence (n=2,516)	Total Population for Analysis of Cervical Lacerations (n=71,170)	Cervical Laceration Incidence (n=536)
Yes	1,229 (1.4)	59 (4.8)	1,226 (1.7)	8 (0.5)
<b>PGE2</b>				
No	84,520 (96.9)	2,437 (2.9)	68,775 (96.6)	522 (0.8)
Yes	2,747 (3.1)	79 (2.9)	2,395 (3.4)	14 (0.6)
<b>Unknown</b>				
No	29,757 (34.1)	879 (3.0)	22,557 (31.7)	240 (1.1)*
Yes	57,510 (65.9)	1,637 (2.8)	48,613 (68.3)	296 (0.6)
<b>Any Oxytocin Use:</b>				
No	27,898 (32.0)	710 (2.5)*	22,565 (31.7)	28 (0.1)*
Yes	59,369 (68.0)	1,806 (3.0)	48,605 (68.3)	508 (1.1)
<b>EPIDURAL:</b>				
No	20,808 (23.8)	471 (2.3)*	17,186 (24.1)	127 (0.8)
Yes	66,459 (76.2)	2,045 (3.1)	53,984 (75.9)	409 (0.7)
<b>Operative Delivery:</b>				
No	79,461 (91.1)	1,579	64,775 (91.0)	477 (0.7)*
Vacuum	4,808 (5.5)	(2.0)* 514	3,508 (4.9)	12 (0.3)
Forceps	2,199 (2.5)	(10.7) 365	2,120 (3.0)	22 (1.0)
Yes/not specified	799 (0.9)	(16.6)	767 (1.1)	25 (3.3)
		58 (7.3)		
<b>Episiotomy:</b>				
No	65,153 (74.7)	966 (1.5)*	50,981 (71.6)	386 (0.8)
Yes	22,114 (25.3)	1,575 (7.0)	20,189 (28.4)	150 (0.7)
<b>Gestational age:</b>				
34w0d - 36w6d	5,945 (6.8)	91 (1.5)*	4,996 (7.0)	48 (1.0)*
37w0d - 38w6d	26,532 (30.4)	550 (2.1)	22,205 (31.2)	208 (0.9)
39w0d - 40w6d	48,656 (55.8)	1626 (3.3)	39,355 (55.3)	250 (0.6)
≥ 41w0d	6,134 (7.0)	249 (4.1)	4,614 (6.5)	30 (0.7)
<b>Birth weight (g):</b>				
<2500	3,503 (4.1)	33 (0.9)*	2,905 (4.1)	2 (1.1) <sup>‡</sup>
2500 - 2999	17,359 (20.1)	279 (1.6)	14,408 (20.5)	132 (0.9)
≥3000 - 3499	37,437 (43.4)	1,010 (2.7)	30,538 (43.5)	230 (0.8)
≥3500 - 3999	22,778 (26.4)	885 (3.9)	18,315 (26.1)	113 (0.6)
≥4000 - 4499	4,745 (5.5)	256 (5.4)	3,692 (5.3)	26 (0.7)

MATERNAL CHARACTERISTIC	Total Population for Analysis of Third- or Fourth-Degree Lacerations (n=87,267)	Third- or Fourth- Degree Laceration Incidence (n=2,516)	Total Population for Analysis of Cervical Lacerations (n=71,170)	Cervical Laceration Incidence (n=536)
≥4500	435 (0.5)	35 (8.0)	336 (0.5)	2 (0.6)
<b>Uterine scar:</b>				
No	84,417 (96.7)	2,450 (2.9)	68,803 (96.7)	515 (0.7)
Yes	2,850 (3.3)	66 (2.3)	2,367 (3.3)	21 (0.9)
<b>Cerclage:</b>				
No/unknown	70,940 (81.3)	2,023 (2.9)	70,940 (99.7)	525 (0.7)*
Yes	230 (0.3)	4 (1.7)	230 (0.3)	11 (4.8)
Missing	16,097 (18.4)	489 (3.0)		
<b>Nulliparous 1<sup>st</sup> stage:</b>				
<5 hrs	6,840 (20.4)	349 (5.1) <sup>§</sup>	5,734 (21.7)	49 (0.9) <sup>§</sup>
5-12 hrs	17,126 (51.2)	1086 (6.3)	13,841 (52.3)	142 (1.0)
>12 hrs	9,492 (28.4)	560 (5.9)	6,888 (26.0)	101 (1.5)
<b>Nulliparous 2<sup>nd</sup> stage :</b>				
<60 min	18,052 (50.6)	652 (3.6)*	14,980 (53.3)	216 (1.4)*
60-119 min	10,751 (30.1)	728 (6.7)	8,360 (29.7)	69 (0.8)
120-179 min	4,521 (12.7)	431 (9.5)	3,270 (11.6)	23 (0.7)
≥180 min	2,341 (6.6)	291 (12.5)	1,513 (5.4)	8 (0.5)
<b>Multiparous 1<sup>st</sup> stage:</b>				
<3 hrs	8,896 (20.8)	49 (0.6)	7,424 (20.8)	21 (0.3)*
3-9 hrs	23,824 (55.6)	139 (0.6)	20,430 (57.3)	95 (0.5)
>9 hrs	10,119 (23.6)	71 (0.7)	7,828 (21.9)	74 (1.0)
<b>Multiparous 2<sup>nd</sup> stage:</b>				
<30 min	32,991 (74.7)	121 (0.4)*	28,136 (76.6)	155 (0.6)
30-59 min	7,846 (17.8)	75 (1.0)	6,366 (17.3)	30 (0.5)
60-119 min	2,562 (5.8)	44 (1.7)	1,813 (4.9)	9 (0.5)
≥120 min	740 (1.7)	25 (3.4)	440 (1.2)	2 (0.5)
<b>Type of hospital:</b>				
University-affiliated teaching hospital	39,307 (45.0)	1,011 (2.6)*	23,210 (32.6)	447 (1.9)*
Teaching community hospital	36,104 (41.4)	1,001 (2.8)	36,104 (50.7)	68 (0.2)
Nonteaching community hospital	11,856 (13.6)	504 (4.3)	11,856 (16.7)	21 (0.2)

AROM, artificial rupture of membranes; PGE2, Prostaglandin E2.

Data are n (%).

Number of patients and proportion (%) for each characteristic.

\*  $P < .001$ .

† Parity was recoded for women with prior uterine scar as “parity minus 1” (e.g., if a multipara had a uterine scar and a parity of 1, parity was assigned as 0).

‡  $P < .05$ .

§  $P < .01$ .

**Table 2**Multivariable Analysis of Risk Factors for 3<sup>rd</sup> or 4<sup>th</sup> Degree Lacerations by Parity.

Maternal characteristic	Nulliparous (n=38,196) OR (95% CI)	Multiparous (n=49,071) OR (95% CI)
<b>Race:</b>		
White	1 (referent)	1 (referent)
Black	0.9 (0.7, 1.1)	1.3 (0.8, 2.2)
Hispanic	1.1 (0.9, 1.3)	1.1 (0.7, 1.7)
Asian/Pacific Islander	1.4 (1.2, 1.6)	2.2 (1.5, 3.2)
<b>Age (years):</b>		
<20	1 (referent)	1 (referent)
20-24	1.2 (1.0, 1.5)	0.8 (0.3, 2.0)
25-29	1.6 (1.4, 1.9)	0.8 (0.3, 2.0)
30-34	1.9 (1.5, 2.3)	1.0 (0.4, 2.5)
≥35	1.6 (1.2, 2.0)	0.8 (0.3, 2.1)
<b>Admission BMI:</b>		
<25.0	1 (referent)	1 (referent)
25.0-29.9	0.9 (0.8, 1.0)	1.1 (0.7, 1.6)
30.0-34.9	0.8 (0.7, 0.9)	0.7 (0.5, 1.2)
≥35	0.7 (0.6, 0.8)	0.7 (0.4, 1.3)
<b>Labor induction:</b>		
No	1 (referent)	1 (referent)
Yes	1.1 (0.9, 1.2)	0.8 (0.6, 1.2)
<b>Epidural:</b>		
No	1 (referent)	1 (referent)
Yes	0.7 (0.6, 0.8)	0.5 (0.4, 0.7)
<b>Any oxytocin use:</b>		
No	1 (referent)	1 (referent)
Yes	1.0 (0.9, 1.1)	0.8 (0.6, 1.1)
<b>Operative delivery:</b>		
No	1 (referent)	1 (referent)
Vacuum	2.6 (2.3, 3.0)	4.9 (3.4, 7.1)
Forceps	3.7 (3.2, 4.3)	3.0 (1.7, 5.3)
Yes/not specified	2.4 (1.7, 3.4)	2.3 (0.7, 7.9)
<b>Episiotomy:</b>		
No	1 (referent)	1 (referent)
Yes	2.4 (2.1, 2.7)	4.4 (3.3, 5.8)
<b>Gestational age:</b>		

Maternal characteristic	Nulliparous (n=38,196) OR (95% CI)	Multiparous (n=49,071) OR (95% CI)	
34w0d - 36w6d	1 (referent)	1 (referent)	
37w0d - 38w6d	0.8 (0.6, 1.1)	1.2 (0.5, 3.2)	
39w0d - 40w6d	0.9 (0.7, 1.2)	1.5 (0.6, 3.9)	
≥41w0d	0.9 (0.6, 1.2)	1.6 (0.6, 4.6)	
<b>Birth weight (g):</b>			
<2500	1 (referent)	1 (referent)	
2500 - 2999	1.4 (0.9, 2.2)	2.0 (0.3, 15.9)	
≥3000 - 3499	2.6 (1.7, 3.9)	3.8 (0.5, 28.6)	
≥3500 - 3999	3.8 (2.5, 5.9)	6.3 (0.8, 47.7)	
≥4000 - 4499	5.9 (3.7, 9.3)	9.2 (1.2, 71.5)	
≥4500	10.5 (5.4, 20.6)	13.6 (1.5, 120)	
<b>Previous uterine scar:</b>			
No		1 (referent)	
Yes		1.0 (0.5, 1.8)	
<b>Duration of 1<sup>st</sup> stage</b>			
<5 hrs	1 (referent)	<3 hrs	1 (referent)
5-12 hrs	1.0 (0.9, 1.2)	3-9 hrs	1.1 (0.8, 1.7)
>12 hrs	0.9 (0.8, 1.1)	>9 hrs	1.5 (0.9, 2.3)
<b>Duration of 2<sup>nd</sup> stage</b>			
<60 min	1 (referent)	<30 min	1 (referent)
60-119 min	1.5 (1.3, 1.7)	30-59 min	2.2 (1.6, 2.9)
120-179 min	1.7 (1.5, 2.0)	60-119 min	2.9 (2.0, 4.2)
≥180 min	2.0 (1.7, 2.4)	≥120 min	5.4 (3.3, 9.0)

Analyses were adjusted for hospital site.

**Table 3**  
**Multivariable Analysis of Risk Factors for Cervical Lacerations by Parity**

MATERNAL CHARACTERISTIC	Nulliparous (N=30,213) OR (95% CI)	Multiparous (N=40,957) OR (95% CI)
<b>Race:</b>		
White	1 (referent)	1 (referent)
Black	1.0 (0.7, 1.5)	1.8 (0.8, 1.9)
Hispanic	1.4 (1.0, 2.0)	1.1 (0.7, 1.7)
Asian/Pacific Islander	1.3 (0.8, 2.0)	1.2 (0.6, 2.3)
<b>Age (years):</b>		
<20	1 (referent)	1 (referent)
20-24	0.9 (0.6, 1.2)	0.5 (0.3, 0.8)
25-29	1.0 (0.7, 1.5)	0.4 (0.2, 0.6)
30-34	0.8 (0.5, 1.3)	0.4 (0.2, 0.8)
≥35	0.5 (0.2, 1.2)	0.4 (0.2, 0.8)
<b>Admission BMI:</b>		
<25.0	1 (referent)	1 (referent)
25.0-29.9	0.9 (0.6, 1.2)	1.7 (1.0, 2.9)
30.0-34.9	0.7 (0.5, 1.0)	1.2 (0.7, 2.1)
≥35	0.9 (0.6, 1.4)	1.4 (0.8, 2.5)
<b>Labor induction:</b>		
No	1 (referent)	1 (referent)
Yes	1.0 (0.7, 1.3)	1.3 (0.9, 1.9)
<b>Epidural:</b>		
No	1 (referent)	1 (referent)
Yes	1.5 (1.1, 2.1)	0.8 (0.6, 1.1)
<b>Any oxytocin use:</b>		
No	1 (referent)	1 (referent)
Yes	1.9 (0.9, 3.6)	2.5 (1.2, 5.6)
<b>Operative delivery:</b>		
No	1 (referent)	1 (referent)
Vacuum	1.4 (0.5, 3.5)	3.1 (1.1, 8.7)
Forceps	1.3 (0.7, 2.1)	1.6 (0.5, 5.2)
Yes/not specified	1.1 (0.7, 1.7)	1.2 (0.4, 3.3)
<b>Episiotomy:</b>		
No	1 (referent)	1 (referent)
Yes	0.7 (0.6, 0.9)	0.8 (0.5, 1.3)
<b>Gestational age:</b>		

MATERNAL CHARACTERISTIC	Nulliparous (N=30,213) OR (95% CI)		Multiparous (N=40,957) OR (95% CI)	
34w0d - 36w6d	1 (referent)		1 (referent)	
37w0d - 38w6d	1.5 (0.9, 2.5)		0.8 (0.5, 1.5)	
39w0d - 40w6d	1.2 (0.7, 2.1)		1.2 (0.7, 2.2)	
≥41w0d	1.3 (0.6, 2.7)		1.1 (0.5, 2.7)	
<b>Birth weight (g):</b>				
<2500	1 (referent)		1 (referent)	
2500 - 2999	0.9 (0.5, 1.5)		1.7 (0.7, 4.2)	
≥3000 - 3499	0.9 (0.5, 1.6)		1.6 (0.7, 4.0)	
≥3500 - 3999	1.1 (0.6, 2.1)		1.1 (0.4, 2.9)	
≥4000 - 4499	2.1 (1.0, 4.4)		1.2 (0.4, 3.7)	
≥4500	4.7 (0.6, 39.8)			
<b>Previous uterine scar:</b>				
No			1 (referent)	
Yes			1.8 (0.9, 3.6)	
<b>Duration of 1<sup>st</sup> stage:</b>				
	<5 hrs	1 (referent)	<3 hrs	1 (referent)
	5-12 hrs	0.9 (0.6, 1.2)	3-9 hrs	1.3 (0.8, 2.2)
	>12 hrs	0.8 (0.5, 1.2)	>9 hrs	1.5 (0.8, 2.6)
<b>Duration of 2<sup>nd</sup> stage:</b>				
	<60 min	1 (referent)	<30 min	1 (referent)
	60-119 min	0.9 (0.7, 1.2)	30-59 min	1.3 (0.8, 1.9)
	120-179 min	0.9 (0.6, 1.6)	60-119 min	1.3 (0.7, 2.7)
	≥180 min	1.0 (0.5, 2.0)	≥120 min	1.2 (0.3, 5.2)
<b>Cerclage:</b>				
No/Unknown	1 (referent)		1 (referent)	
Yes	3.7 (1.1, 12.8)		12.7 (5.7, 28.2)	

Analyses were adjusted for hospital site.