Published in final edited form as:

Int J Gynaecol Obstet. 2008 August ; 102(2): 165–170. doi:10.1016/j.ijgo.2008.02.017.

Trends in major modifiable risk factors for severe perineal trauma, 1996–2006

Bela Kudish¹, Robert J. Sokol², and Michael Kruger²

¹Department of Obstetrics and Gynecology, Division of Female Pelvic Medicine and Reconstructive Surgery, Washington Hospital Center, Washington DC, USA

²Department of Obstetrics and Gynecology, Wayne State University, Detroit, Michigan, USA

Abstract

Objective—To examine what effect the major modifiable risk factors for severe perineal trauma have had on the rates of this trauma over time.

Methods—A retrospective observational cohort study of singleton vaginal deliveries taken from a perinatal database for the period 1996 through 2006.

Results—A total of 46 239 singleton vertex vaginal deliveries met the inclusion criteria. Major risk factors for severe perineal trauma were increased maternal age (odds ratio [OR] 1.28, 95% confidence interval [CI] 1.1–1.5), non–African American ethnicity (OR 1.5, 95% CI 1.3–1.7), nulliparity (OR 4.8, 95% CI 4.11–5.6), fetal birth weight (OR 2.2, 95% CI 1.9–2.4), forceps (OR 8.3, 95% CI 5.4–10.8), vacuum (OR 2.9, 95% CI 1.9–4.4), and midline episiotomy (OR 5.7, 95% CI 5.0–6.4). Evaluation of the changes in rates of these factors over the study period revealed that decline in the rates of episiotomy and use of forceps accounted for a reduction in severe lacerations of more than 50%.

Conclusion—Reduction of severe perineal trauma by restricted use of the 2 modifiable clinical variables, episiotomy and forceps, is evident over time.

Keywords

Cesarean delivery; Episiotomy; Forceps; Severe perineal trauma; Trends

1. Introduction

Severe obstetric perineal trauma is thought to be the primary cause of fecal and flatus incontinence in young women [1,2]. The rate of clinically visible anal sphincter lacerations is estimated to be between 0.5% and 18% [3–5]. However, the actual rate of anal sphincter trauma is underestimated dramatically. Some studies have shown that occult sphincter tears are detectable in up to 35% of vaginal deliveries [3,6,7]. Even when severe perineal trauma is recognized and adequate primary repair is attempted immediately post partum, the outcome is often suboptimal as up to 59% of these women suffer from some form of anal incontinence,

---

Corresponding Author: Bela Kudish, Department of Obstetrics and Gynecology, Division of Female Pelvic Medicine and Reconstructive Surgery, 106 Irving St NW, POB North Suite 2100, Washington, DC 20010, USA, Tel: +1 202 877-9032; Fax: +1 202 877-0530, E-mail: Bela.I.Kudish@medstar.net.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

fecal urgency, and dyspareunia [3,8-10]. In addition, it has been demonstrated that 71% of women with late-onset fecal incontinence evidenced ultrasonographic anal sphincter defects thought to have occurred during vaginal delivery [11]. Although the association between anal sphincter tears and anal incontinence might not be direct, a possible reduction of the rate of anal sphincter injury during childbirth through knowledge, modification, or prevention of the key risk factors should be investigated.

Over the last 20 years many studies have attempted to isolate the risk factors for anal sphincter trauma. The results of these studies have indicated that midline episiotomy, operative vaginal delivery (particularly forceps delivery), macrosomia, shoulder dystocia, epidural anesthesia, occiput posterior presentation, prolonged second stage of labor, and nulliparity are major risk factors [2,12-14]. The aim of the present study was to evaluate data from our tertiary care institution to assess whether a reduction in the potentially modifiable risk factors for severe perineal trauma would result in a reduction in its rate.

2. Materials and methods

Data were extracted from the computerized perinatal database at our tertiary care teaching institution for the 11-year period from 1996 through 2006 for all singleton vaginal deliveries and maternal age, parity, race, marital status, epidural anesthesia, birth weight, newborn head circumference, use of midline episiotomy, operative vaginal delivery indication and type (forceps, vacuum), type of forceps (mid, low, outlet), and type of perineal laceration. Exclusion criteria were women who delivered at less than 24 weeks of gestation, women who had a multiple pregnancy, multiple births at the same institution, nonvertex presentation, stillbirth, operative delivery with both forceps and vacuum extraction, or cesarean delivery. Obstetric care providers at our institution included general obstetrics/gynecology and maternal-fetal-medicine attending physicians, interns and residents, and midwives. All deliveries by interns and residents were performed under the supervision of attending physicians. Repairs of episiotomies and severe perineal lacerations were performed by attending physicians or residents under the supervision of attending physicians.

The primary outcome variable was development of severe perineal injury, defined as either a third- or fourth-degree perineal laceration/extension. The classification of the degree of perineal tearing was based on the standard definitions used in American obstetric practice: third-degree laceration defined as perineal laceration involving the anal sphincter, and fourth-degree perineal laceration defined as an injury involving both the anal sphincter and the anorectal mucosa [15]. We used the smallest odds ratio of 1.2 for ethnicity from one of our previous studies [16] to obtain a sample size of 33 000; this provided 80% power to identify a 20% difference in anal sphincter trauma between women with and without clinically visible severe perineal lacerations, with a 2-sided 5% test of significance.

Validation analysis of the major risk factors for the development of severe perineal injury was performed using a random split-half method. Participants were randomly split into 2 independent datasets, training and validation, of approximately equal size (23 183 and 23 056 women, respectively) using a computer generated algorithm. Factors that best predicted anal sphincter trauma ($P<0.1$) were selected from the univariate analysis of the training dataset and entered into a stepwise multiple logistic regression to create a model ($P<0.05$). Using this model, we computed the probability of severe perineal laceration for the women in the validation dataset. Subsequently, a z-test was used to examine robustness versus shrinkage of performance of the model by comparing the areas under receiver operator characteristic curves for the predicted versus observed rates of severe perineal lacerations in the 2 datasets. This was done to measure how well the model from the training dataset predicted severe perineal trauma in the validation dataset. Large shrinkage would indicate that the model only worked well in

the first or training dataset, whereas small shrinkage would indicate that the model was generalizable i.e. robust and therefore would validate the major risk factors for severe perineal trauma.

The continuous variables of age and neonatal weight were included in the analysis as categorical variables. The best discriminative cut-off points were 24 years for age and 3300 g for neonatal weight from the 2 respective receiver operator curves for predicted versus observed anal sphincter trauma in the training dataset. In addition, based on the results of previous studies, including our own, which demonstrated that women of African American descent had a significantly lower risk of anal sphincter tears than white, Hispanic, and Asian women, a dichotomous variable for ethnicity was created: African American and non-African American (Table 1). The impact of mediolateral episiotomy was evaluated together with midline episiotomy because the rate of mediolateral episiotomy was extremely low (Table 1) and the risk of severe perineal trauma, compared with midline episiotomy, was not significantly different.

Finally, we evaluated what effect the validated major risk factors had on the rate of severe perineal trauma over time. Cesarean deliveries were separated into primary and repeat, examined in a separate descriptive analysis, and were then combined with all vaginal deliveries to evaluate the effect of various operative interventions on the rate of severe perineal trauma. Over the 11-year period we examined the changes in the monthly rates per 100 deliveries of the validated risk factors (nulliparity, maternal age, neonatal weight, ethnicity, vacuum and forceps deliveries, midline episiotomy) in addition to the other 2 factors (primary and repeat cesarean deliveries) on our service to estimate the contribution of these factors to the decline in rate of severe perineal laceration. Only statistically significant factors from a univariate analysis ($P<0.1$) were entered into multivariate linear regression analysis. Statistical analyses were carried out using SPSS 14.0 (SPSS, Chicago, IL, USA).

The study was approved by the Human Investigation Committee of the Wayne State University/Detroit Medical Center-Hutzel Hospital.

3. Results

Over the 11-year study period (1996–2006), 46 239 vaginal deliveries met the inclusion criteria and 13 321 cesarean deliveries (8258 primary and 5063 repeat) were performed at our tertiary care institution. Severe perineal trauma was experienced by 2.9% of women included in the study. Patient characteristics are given in Table 1.

Univariate analyses of the training dataset found that maternal age, nulliparity, race, marital status, gestational age, epidural anesthesia, birth weight, newborn head circumference, use of midline episiotomy, forceps, vacuum, and ethnicity were associated with severe perineal trauma. However, of these variables, only 7 (maternal age, ethnicity, nulliparity, forceps, vacuum extraction, and neonatal birth weight) were found to be the major risk factors for anal sphincter lacerations in multiple logistic regression analysis (Table 2). Using the training dataset model based on the above 7 variables, we computed the probability of severe perineal laceration for the women in the validation dataset. Minimal shrinkage was observed, indicating that the proposed model was robust and its results were generalizable (z-statistic 1.3, $P=0.097$). Thus, this statistical method allowed for validation of the 7 risk factors for severe perineal trauma.

The impact of the validated risk factors on the development of severe perineal trauma was examined by evaluating the changes in obstetric practice at our tertiary care institution. This was done because a randomized controlled trial of the second-stage interventions versus no intervention, or planned elective cesarean delivery versus vaginal delivery is not feasible at

this time [17]. Specifically, we wanted to evaluate whether a reduction in the validated potentially modifiable factors would result in a reduction in the rate of severe perineal trauma. Evaluation of the 11-year trend in obstetric practice at our tertiary center resulted in finding more convincing inferences of causality between the modifiable factors in the model described above and severe perineal trauma. We noted a significant reduction in anal sphincter trauma from 5.4% in 1996 to 1.3% in 2006 and a dramatic drop in the rates of episiotomy and operative vaginal deliveries, with a concurrent overall increase in the rate of cesarean deliveries from 18.9% in 1995 to 29.4% in 2006 (Figures 1 and 2). In order to evaluate a change in the rate of anal sphincter trauma over time, we looked at the month-by-month changes in the rates of nulliparity, ethnicity, episiotomy, forceps and vacuum deliveries, primary and repeat cesarean deliveries, and in the mean maternal age and neonatal weight. No changes in the monthly rates of nulliparity, mean monthly maternal age, and mean monthly neonatal weight were observed over the 11-year period. The final model consisted of the following 4 factors: monthly rates of episiotomy, primary cesarean delivery, forceps, and repeat cesarean delivery. This model explained 70% of the variance in the decrease in the rate of severe perineal trauma. It confirmed that the reduction in anal sphincter lacerations was strongly associated with the fall in the rate of episiotomy ($R^2=48.7\%$), followed by a rise in the rate of primary cesarean delivery ($R^2=16.3\%$), with a concurrent reduction in the rate of forceps use and an increase in the rate of repeat cesarean delivery (Table 3). More than two-thirds of the explained variance was due to the fall in the rate of episiotomy and forceps which suggests what might be accomplished by reducing the number of operative interventions.

4. Discussion

This study examined which factors among the major validated antecedents of anal sphincter trauma (age, nulliparity, non-African American ethnicity, increased neonatal weight, use of forceps and vacuum extraction, and episiotomy, also described by other authors [2,4,10, 12-15]) truly contribute to a reduction in the rate of severe perineal lacerations. Our findings have revealed that a reduction in the rates of the potentially modifiable validated risk factors, such as episiotomy and use of forceps, and the rise in the rate of primary cesarean delivery are, in fact, largely responsible for the reduction in the rate of severe perineal trauma over time.

The observed changes in the rates of severe perineal lacerations, episiotomy, forceps, and primary and repeat cesarean deliveries over the 11-year period at our center were found to be consistent with the national practice of obstetrics [4,18]. In the United States the overall rates for episiotomy have declined from 31% in 1997 [19] to less than 19% in 2001 [20], and rates for operative delivery have declined from 12.1% in 1989–1997 [21] to 3.5% in 2004 [20]. However, the overall rate of cesarean deliveries has risen from 20.7% in 1996 to over 30% in 2004 [22]. At our institution the change in the rate of operative deliveries consisted of a near-abandonment of the use of forceps from 7.6% in 1997 to 0.4% in 2006, which was accompanied by a low, almost unchanged, rate of vacuum extraction from 2.5% in 1996 to 2.8% in 2006 (Figure 1). On the other hand, the rate of episiotomy declined dramatically from 18.9% in 1996 to 3.1% in 2006, while the rate of primary cesarean deliveries rose from 12.4% in 1996 to 18.7% in 2006. These trends might explain why the contribution of the use of forceps to the overall decline in rate of severe perineal lacerations is significantly lower than that of episiotomy and primary cesarean deliveries. In fact, 70% of the four-fold reduction in anal sphincter trauma rate from 5.4% in 1996 to 1.3% in 2006 was primarily explained by a dramatic fall in the rate of episiotomy and a rise in primary cesarean delivery (Table 3).

Despite the obvious strengths, such as sample size and appropriate power to assess the presence of obstetrically-incurred anal sphincter trauma, the present study has several limitations. First, the study is based on the experience of a single center. Second, it is observational, rather than a trial, with attendant biases. Third, our analysis is limited to information previously collected.

Therefore, because of their absence in our computerized perinatal database, position of fetal head (occiput anterior, occiput posterior) [23], length of second stage of labor [24], and body mass index—all potential predictors of severe perineal laceration—are not included in the current analysis. Furthermore, the proportion of women with severe perineal trauma who are asymptomatic cannot be identified. Finally, we were unable to evaluate and control for the training and expertise of the delivering attendants.

Despite these issues, the present study adds valuable information to the understanding of the major factors influencing the rates of severe perineal trauma. Given that most risk factors for anal sphincter lacerations (i.e. age, nulliparity, ethnicity, pelvic architecture, neonatal weight) are nonmodifiable, an obstetrician and a pregnant woman face difficult decisions regarding the risks and benefits of the modifiable interventions (i.e. episiotomy and operative vaginal delivery) when they are confronted with the need for expedited delivery in the second stage of labor or when spontaneous laceration is inevitable. In the authors' opinion, if episiotomy and/or operative delivery are indicated in women who are at a higher risk for severe perineal laceration (women who have never delivered vaginally, are older, of non-African American descent, who carry a large fetus, and desire to have 2 children [25]), after balancing the maternal and fetal risks of a vaginal delivery an obstetrician should first consider vacuum-assisted delivery rather than forceps, followed by episiotomy, possibly of the mediolateral type. There is some evidence which suggests that mediolateral episiotomy might not be as strongly associated with severe perineal trauma and genital prolapse [10]; it creates more perineal space for delivery rather than the midline technique, the most popular type of episiotomy used in the United States that frequently progresses to third- or fourth-degree perineal trauma. Finally, in some cases, an elective primary cesarean delivery might be desired. A study by Lowder et al. [2] supports the finding that primary cesarean deliveries contribute to the decline in severe perineal trauma. Their study demonstrated that women have a similar risk for severe perineal trauma after their first vaginal delivery (OR 5.1, 95% CI 4.4–5.9) and after vaginal birth after cesarean (OR 5.1, 95% CI 4.2–6.2), which suggests that severe perineal trauma can be avoided in women at risk who undergo cesarean delivery. However, a discussion regarding the indications for elective cesarean delivery is beyond the scope of this paper. Further studies are needed to evaluate an appropriate clinical decision-making process.

The findings of this study represent the results of an unintended, natural experiment at a tertiary teaching hospital (“surrogate” model) that reflect the major changes in the obstetric practice in the United States and changes in recommendations by the American College of Obstetricians and Gynecologists (ACOG) and the Agency for Healthcare Research and Quality practice. Our results show that reduction in rates of midline episiotomy, use of forceps, and rising cesarean delivery rates are major factors associated with the reduction in rates of perineal trauma. Thus, even though severe perineal trauma cannot be accurately predicted and the ideal rate of episiotomy for maximizing maternal and fetal well-being is unknown, time trends support a reduction in the rate of severe perineal trauma by restricting the liberal use of the 2 modifiable clinical variables: midline episiotomy and use of forceps.

References

1. Sultan AH, K M, Hudson CN, Hudson CN, Thomas JM, Bartram CI. Anal-sphincter disruption during vaginal delivery. *N Engl J Med* 1993;329:1905–11. [PubMed: 8247054]
2. 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(4):344 e1–5. [PubMed: 17403415]
3. 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(6):1543–9. [PubMed: 14710059]

4. Handa VL, Danielsen BH, Gilbert WM. Obstetric anal sphincter lacerations. *Obstet Gynecol* 2001;98(2):225–30. [PubMed: 11506837]
5. Oberwalder M, Connor J, Wexner SD. Meta-analysis to determine the incidence of obstetric anal sphincter damage. *Br J Surg* 2003;90(11):1333–7. [PubMed: 14598410]
6. Richter HE, Fielding JR, Bradley CS, Handa VL, Fine P, Fitzgerald MP, et al. Endoanal ultrasound findings and fecal incontinence symptoms in women with and without recognized anal sphincter tears. *Obstet Gynecol* 2006;108(6):1394–401. [PubMed: 17138772]
7. Borello-France D, Burgio KL, Richter HE, Zyczynski H, Fitzgerald MP, Whitehead W, et al. Fecal and urinary incontinence in primiparous women. *Obstet Gynecol* 2006;108(4):863–72. [PubMed: 17012447]
8. Zetterstrom J, Lopez A, Anzen B, Norman M, Holmstrom B, Mellgren A. Anal sphincter tears at vaginal delivery: risk factors and clinical outcome of primary repair. *Obstet Gynecol* 1999;94(1):21–8. [PubMed: 10389712]
9. Norderval S, Nsubuga D, Bjelke C, Frasunek J, Myklebust I, Vonen B. Anal incontinence after obstetric sphincter tears: incidence in a Norwegian county. *Acta Obstet Gynecol Scand* 2004;83(10):989–94. [PubMed: 15453900]
10. Hartmann K, Viswanathan M, Palmieri R, Gartlehner G, Thorp J Jr, Lohr KN. Outcomes of routine episiotomy: a systematic review. *JAMA* 2005;293(17):2141–8. [PubMed: 15870418]
11. Oberwalder M, Dinnewitzer A, Baig MK, Thaler K, Cotman K, Nogueras JJ, et al. The association between late-onset fecal incontinence and obstetric anal sphincter defects. *Arch Surg* 2004;139:429–432. [PubMed: 15078712]
12. Fitzgerald MP, Weber AM, Howden N, Cundiff GW, Brown MB. Risk factors for anal sphincter tear during vaginal delivery. *Obstet Gynecol* 2007;109(1):29–34. [PubMed: 17197584]
13. Donnelly V, Fynes M, Campbell D, Johnson H, O'Connell PR, O'Herlihy C. Obstetric events leading to anal sphincter damage. *Obstet Gynecol* 1998;92(6):955–61. [PubMed: 9840557]
14. Baumann P, Hammoud A, McNeeley SG, DeRose E, Kudish B, Hendrix S. Factors associated with anal sphincter laceration in 40,923 primiparous women. *Int Urogynecol J Pelvic Floor Dysfunct* 2007;18(9):985–90. [PubMed: 17211527]
15. Cunningham, FG.; Gant, NF.; Leveno, KJ.; Gillstrap, LC., III; Hauth, JC.; Wenstrom, KD., editors. *Williams Obstetrics*. Vol. 21st. New York: McGraw-Hill; 2001.
16. Kudish B, Blackwell S, McNeeley SG, Bujold E, Kruger M, Hendrix SL, et al. Operative vaginal delivery and midline episiotomy: a bad combination for the perineum. *Am J Obstet Gynecol* 2006;195(3):749–54. [PubMed: 16949408]
17. Salisbury KP, Ivester TS, Meier A, Visco AG. Formative research on the feasibility of a randomized controlled trial of planned vaginal versus planned cesarean delivery. *J Pelvic Medicine & Surg* 2007;13(5):267–8.
18. Martin JA, Menacker F. Expanded health data from the new birth certificate, 2004. *Natl Vital Stat Rep* 2007;55(12):1–24.
19. Weber AM, Meyn L. Episiotomy Use in the United States, 1979-1997. *Obstet Gynecol* 2002;100(6):1177–1182. [PubMed: 12468160]
20. Goldberg J, Holtz D, Hyslop T, Tolosa JE. Has the use of routine episiotomy decreased? Examination of episiotomy rates from 1983 to 2000. *Obstet Gynecol* 2002;99(3):395–400. [PubMed: 11864665]
21. Curtin SC, Park MM. Trends in the attendant, place, and timing of births, and in the use of obstetric interventions: United States, 1989-97. *Natl Vital Stat Rep* 1999;47(27):1–12.
22. Hamilton BE, Martin JA, Ventura SJ. Births: preliminary data for 2005. *Natl Vital Stat Rep* 2006;55(11):1–18.
23. Benavides L, Wu JM, Hundley AF, Ivester TS, Visco AG. The impact of occiput posterior fetal head position on the risk of anal sphincter injury in forceps-assisted vaginal deliveries. *Am J Obstet Gynecol* 2005;192(5):1702–6. [PubMed: 15902181]
24. 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(3):933–8. [PubMed: 15467567]

25. Landon MB, Spong CY, Thom E, Hauth JC, Bloom SL, Varner MW, et al. Risk of uterine rupture with a trial of labor in women with multiple and single prior cesarean delivery. *Obstet Gynecol* 2006;108(1):12–20. [PubMed: 16816050]

Figure 1.

Trends in the rates of severe perineal lacerations, primary and repeat cesarean deliveries, midline episiotomy, and operative vaginal delivery over the study period (per 100 vaginal deliveries)

Figure 2.
Trends in the rates of cesarean deliveries over the study period (per 100 deliveries)

Table 1
Demographic and obstetric characteristics of the women with and without anal sphincter laceration^a

Characteristics	No anal sphincter laceration (n=44 862; 97.02%)	Anal sphincter laceration (n=1377; 2.98%)	Univariate <i>P</i> value
Maternal age, y Missing (n=15)	23.4 ± 6.0	24.7 ± 6.2	<0.001
Ethnic background			<0.001
Black	33 024 (73.6)	837 (60.8)	
White and other	11 443 (25.5)	489 (35.5)	
Asian	395 (0.9)	51 (3.7)	
Missing (n=15)			
Marital status			<0.001
Married	8466 (18.9)	400 (29)	
Not married	36 391 (81.1)	977 (71)	
Missing (n=20)			
Parity			<0.001
Nulliparity	15 336 (34.2)	1088 (79)	
Multiparity	29 497 (65.8)	288 (21)	
Missing (n=45)			
Gestational age, weeks	38.7 ± 2.4	39.5 ± 1.6	<0.001
Neonatal weight, g	3137 ± 577	3392 ± 477	<0.001
Missing (n=6)			
Head circumference, cm	33.5 ± 1.9	34.1 ± 1.7	<0.001
Missing (n=4496)			
Length, cm	49.7 ± 3.3	51.1 ± 2.6	<0.001
Missing (n=427)			
Anesthesia			<0.001
Epidural	23 316 (52)	952 (69.1)	
No epidural	21 560 (48)	425 (30.9)	
Missing (n=1)			
Vaginal deliveries			<0.001
Spontaneous	42 701 (95.2)	823 (59.8)	
Forceps	1406 (3.1)	406 (29.5)	
Vacuum	755 (1.7)	148 (10.7)	
Episiotomy			
Midline	2851 (6.4)	722 (52.4)	<0.001
Mediolateral	43 (0.1)	6 (0.4)	0.34

^aValues are given as number (percentage) or mean ± SD unless otherwise indicated.

Table 2
Results of multiple logistic regression analysis for training and validation datasets

Clinical variables	Training dataset (n=23 183)	Validation dataset (n=23 056)
	OR (95% CI)	OR (95% CI)
Age, ≥ 24 years ^a	1.4 (1.1–1.6)	1.2 (1.1–1.5)
Ethnicity	1.6 (1.3–1.9)	1.4 (1.2–1.7)
Birth weight, ≥ 3300 g ^b	2.2 (1.8–2.6)	2.1 (1.8–2.5)
Episiotomy	5.6 (4.7–6.7)	5.8 (4.9–6.9)
Nulliparity	4.5 (3.7–5.5)	4.8 (3.9–5.8)
Forceps ^c	8.1 (5.9–10.1)	8.5 (6.1–10.9)
Vacuum ^c	2.9 (1.9–4.2)	3.1 (1.9–4.5)

^a Age: categorical age variable, ≥ 24 years of age, based on the best ROC cut-off point.

^b Birth weight: categorical neonatal birth weight variable, ≥ 3300 g, based on the best ROC cut-off point.

^c Operative vaginal delivery that includes forceps and vacuum together.

Table 3
Factors influencing the decline in rate of severe perineal trauma

Variables	Adjusted R^2	R^2 change (%)	F statistic	P value
Primary cesarean	0.163	16.3	25.04	<0.001
Episiotomy	0.648	48.7	178.34	<0.001
Forceps	0.692	4.4	18.06	<0.001
Repeat cesarean	0.703	1.1	5.39	0.022
Total explained variance		70.3		