Obstetric anal sphincter injuries among women with gestational diabetes and women without gestational diabetes: a NSW population-based cohort study.

Obstetric anal sphincter injuries and GDM

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Keywords

Gestational diabetes, Obstetric anal sphincter injury, Perineal trauma, Episiotomy, Birth, Birthweight, Perineum, Lacerations

Abstract

Background:

Obstetric anal sphincter injuries (OASIs) are associated with maternal morbidity, however it is uncertain whether Gestational Diabetes (GDM) is an independent risk factor when considering birth weight, mode of birth and episiotomy.

Aims:

To compare rates of OASIs between women with gestational diabetes (GDM) and women without GDM by mode of birth and birthweight. To investigate the association between episiotomy, mode of birth and the risk of OASIs.

Methods:

A population-based cohort study of women who gave birth vaginally in NSW, from 2007 to 2013. Rates of OASIs were compared between women with and without GDM, stratified by mode of birth, birthweight and a multi-categorical variable of mode of birth and episiotomy. Adjusted Odds Ratios (AOR) and 95% Confidence interval (CI) were calculated by multivariable logistic regression.

Results:

The rate of OASIs was 3.6% (95% CI 2.6-2.7) versus 2.6% (95% CI 3.4-2.8) ($p<0.001$) among women with and without GDM, respectively. Women with GDM and a macrosomic baby (birthweight ≥4000g), had a higher risk of OASIs with forceps (AOR 1.76, 95% CI (1.08-2.86), $p=0.02$) or vacuum (AOR 1.89, 95% CI (1.17-3.04), $p=0.01$), compared with those without GDM. For primiparous women with GDM and all women without GDM, an episiotomy with forceps was associated with lower odds of OASIs than forceps only (primiparous GDM, forceps-episiotomy AOR 2.49, 95% CI (2.00-3.11), forceps AOR 5.30, 95% CI (3.72-7.54)), (primiparous without GDM, forceps-episiotomy AOR 2.71, 95% CI (2.55-2.89), forceps AOR 5.95, 95% CI (5.41-6.55)) and (Multiparous without GDM, forceps-episiotomy AOR 3.75, 95% CI (3.12-4.50), forceps AOR 6.20, 95% CI (4.96-7.74)).

Conclusion:

Women with GDM and a macrosomic baby should be counselled about the increased risk of OASIs with both vacuum and forceps. With forceps birth this risk can be partially mitigated by performing a concomitant episiotomy.

Short Communications

Women with GDM and a macrosomic baby should be counselled about the increased risk of OASIs with instrumental birth. For forceps births this risk can be reduced by performing an episiotomy.

Introduction

Obstetric anal sphincter injuries (OASIs) occurred in 4322 (2.1%) women who gave birth vaginally in Australia in 2012[1]. OASIs include both third- and fourth-degree perineal tears[2]. Third-degree tears are defined as perineal injury affecting the anal sphincter complex [2]. Fourth-degree perineal tears affect the anal mucosa and the anal sphincter complex[2]. Short- and long-term health problems have been reported to be associated with OASIs. Short-term complications can include perineal pain, oedema, bruising, and urinary retention[3, 4]. Long-term complications can include anxiety, depression, sexual dysfunction, and anal incontinence, including flatal incontinence and leakage of stool[3-5].

Several demographic factors have been identified as associated with OASIs. Asian ethnicity, maternal older age, first-time mother and giving birth in public hospitals are all associated with an increase in the risk of OASIs[6-8]. Instrumental vaginal birth, including forceps and vacuum births, has been identified as a major risk factor for OASIs[7, 9]. Birthweight is associated with OASIs, with a NSW population-based study showing a rate increase of 21% and 25% for every 200g increase in birthweight, in primiparous and multiparous women, respectively[6]. For macrosomic babies (birthweight ≥4000g) there was a significant increase with adjusted odd-ratio of 2.64[9]. In addition to high birthweight, shoulder dystocia has been identified as an independent risk factor for OASIs[10]. Women with gestational diabetes mellitus (GDM) are at increased risk of OASIs due to the high birthweight baby compared to women without GDM[6, 7, 11, 12]. Previously published research shows that among women with GDM, the odds ratio of OASIs was 1.3 (95% CI; 1.1-1.6), compared to women without GDM[7].

There is evidence that selective episiotomy can reduce the risk of OASIs[2]. A Cochrane systematic review shows that compared to routine episiotomy, selective episiotomy with spontaneous vaginal birth is associated with a slight reduction in the rate of OASIs[13]. The most recent Royal College of Obstetricians and Gynaecologists (RCOG) 3rd and 4th degree tear green-top guideline recommended performing mediolateral episiotomy with instrumental vaginal birth, citing a significant reduction in OASI[2]. To date, no published population-based study has investigated the association between GDM and the risk of OASIs by both mode of birth and birthweight.

Our population-based study of women who gave birth vaginally in NSW has two aims:

1. To compare the rate of OASIs between women with or without GDM by mode of birth and birthweight.
2. To investigate the association between episiotomy, mode of birth and the risk of OASIs.

Method

Data source

The New South Wales (NSW) Perinatal Data Collection (PDC) was used as the data source. The PDC is a population-based surveillance system that covers all births occurring in NSW public and private hospitals as well as home births. The PDC includes all live births and stillbirths of at least 20 weeks or at least 400g birthweight[14].

Information on maternal demographics, maternal health, pregnancy, obstetric complications, labour and birth as well as perinatal outcomes are included in the completed form. The NSW Ministry of Health receives the completed form, validates and compiles the information into a statewide PDC[14].

Study population

All women who gave birth vaginally in NSW (465,124) from 1 January 2007 to 31 December 2013 were included. Women with pre-existing diabetes (2296, 0.5%) and women who had breech presentation (2518, 0.5%) were excluded from the analysis. Of the 460,310 women remaining in the analysis, 23,965 (5.2%) women had GDM and 436,345 (94.8%) women were without a diagnosis of GDM during pregnancy.

Study factors and outcome measurements

GDM is defined as glucose intolerance that is diagnosed for the first time during pregnancy. It may include pregnancy-induced hyperglycemia or undiagnosed hyperglycemia that existed before pregnancy[15].

Between 2007 and 2012, the Australian guidelines[16] recommended screening for GDM using the glucose challenge test (GCT) at 26 to 28 weeks gestation. A 75g two-hour oral glucose tolerance test (OGTT) was recommended if the non-fasting GCT measured at one-hour post-load plasma glucose level was

- ≥7.8 mmol/L after 50g glucose load, or
- ≥ 8.0 mmol/L after 75g glucose load

GDM was diagnosed if

- fasting venous plasma glucose level was ≥ 5.5 mmol/L, and/or
- venous plasma glucose level was ≥8.0 mmol/L at two hours following the 75g glucose load.

In 2013 a new guideline was published by the Australasian Diabetes In Pregnancy Society (ADIPS)[15]. This guideline recommends routine testing for GDM at 24 to 28 weeks gestation using 75g OGTT. GDM is diagnosed if

- fasting glucose is ≥5.1 mmol/L or
- 1-hr glucose is ≥ 10.0 mmol/L or
- 2-hr glucose is ≥ 8.5 mmol/L.

The mode of birth includes spontaneous vaginal birth (vaginal birth which did not require instrumental assistance), and instrumental vaginal birth including both forceps and vacuum extraction. Episiotomy is recorded dichotomously as yes, no.

The outcome of the study was third- and fourth-degree perineal tears referred to as Obstetric Anal Sphincter Injuries (OASIs). In the PDC, perineal status is recorded as intact, 1st-degree tear/graze, 2nd-degree tear, 3rd-degree tear, 4th-degree tear, and ‘other’. Third- and fourth-degree tears were combined, and all other types of tears were combined with ‘intact’. A previously published validation study of the NSW PDC found third- and fourth-degree tears were adequately recorded in the PDC (Kappa value > 0.75)[17].

Statistical analysis

Maternal sociodemographic factors and obstetric characteristics were compared among women with GDM and women without GDM using a Chi-square test for categorical variables and an Independent Samples t-test for maternal age.

Two multivariate logistic regression models were employed. The first model investigated the odds ratio of OASIs for women with GDM compared with women without GDM. Data were stratified by macrosomia[18] and mode of birth (spontaneous vaginal birth, forceps delivery, and vacuum extraction). The second model investigated the likelihood of OASIs where an episiotomy was employed in the mode of birth.

Parity was included as an interaction term in the analysis to examine if it was an effect modifier. In model one (OASIs among women with GDM compared to women without GDM) parity was stratified into two groups, primiparous and multiparous for women who had a vacuum extraction and gave birth to macrosomic babies. For similar women who had either a spontaneous vaginal birth or forceps birth, the analysis was not stratified by parity as the interaction of parity with GDM were not significant. In model two (OASIs among women who had episiotomies and gave birth vaginally compared to women who had spontaneous vaginal birth without episiotomy), parity was found to be an effect modifier in the association between episiotomy and OASIs. For this reason, the analysis was stratified by parity. For model two, a multi-category variable was created for episiotomy and mode of birth, with spontaneous vaginal birth without episiotomy the reference group.

Odds ratios (OR), adjusted odds ratios (AOR), and 95% confidence intervals (CI) were produced. Variables associated with the outcomes in the univariate analysis ($p<0.2$) and factors identified in the literature as potentially predictive were entered in the logistic regression model (univariate analysis for the covariate included in the model presented in table S1). Adjustment for the first model was made for maternal age groups (< 25 years, 25–34 years, and ≥35 years), maternal country of birth (Australian born, overseas born), parity (nullipara, multipara), plurality (singleton, multiple), last birth by caesarean section (yes, no), onset of labour (spontaneous, induction), episiotomy performed (yes, no), hospital sector (public, private), and baby sex (male, female), gestational age at birth (< 37 weeks, ≥ 37 weeks). Adjustment for the second model was made for maternal age groups, maternal country of birth, plurality (singleton, multiple), last birth by caesarean section (yes, no), onset of labour (spontaneous, induction), hospital sector (public, private), baby sex (male, female), and birthweight (<4000g, ≥4000g). The percentages of combined episiotomy with mode of birth stratified by parity were calculated.

Details of ethics approval

The use of de-identified data was approved by the Executive Director, Centre for Epidemiology and Evidence, NSW Ministry of Health. Ethics approval was granted by University of Technology Sydney Human Research Ethics Committee (UTS HREC ETH16-0219).

Results

During the period studied, 863 (3.6%) of women with GDM had OASIs, and 11,561 (2.6%) women without GDM had OASIs (p <0.001). The majority of women had third-degree perineal tears, 3.4% and 2.5% for women with and without GDM, repectively, with similar fourth-degree tear rates of 0.2% between the groups.

Table 1 presents the maternal and newborn characteristics of women with and without GDM. As seen in Table 1, the baseline maternal and newborn characteristics, there were significant differences between women with and without GDM. Those with GDM were significantly older (≥35y: 30.8% vs 19.5%, p<0.001), more likely to be born overseas (51.4% vs 31.0%, p<0.001), more likely to be induced (52.1% vs 28.6%, p<0.001), had a higher rate of episiotomy (20.5% vs17.4%, p<0.001). However the GDM group had a lower rate of macrosomia (7.8% vs 11.4%, p<0.001). Among women who gave birth to macrosomic babies, there was no significant difference in the percentage of instrumental vaginal birth between women with GDM (14.7%) and those without GDM (15.7%) (p= 0.29).

The results of the multivariate analysis are shown in Table 2. For women who gave birth to macrosomic babies, the odds of OASIs were significantly higher among women with GDM who gave birth by forceps (AOR 1.76, 95% CI (1.08-2.86)) or vacuum (AOR 1.89, 95% CI (1.17-3.04)) compared to women without GDM. Women with GDM who gave birth to macrosomic babies by spontaneous vaginal birth did not have a significant increase in the odds of OASIs (AOR 1.07, 95% CI (0.79-1.43)) compared with those without GDM.

A subgroup analysis, by parity, of women with macrosomic babies, showed vacuum births in multiparous women with GDM had a significant increase in the odds of OASIs compared to women without GDM (AOR 2.66, 95% CI (1.14-6.22)). There was no statistically significant increase in the primiparous groups (AOR 1.67, 95% CI (0.94-2.98)).

Table 3 compares the rates of episiotomy, in women with and without GDM, analysed by parity and mode of birth. For primarous and multiparous women who had spontaneous vaginal birth, there was a statistically significant difference in rates of episiotomy, when comparing GDM status (p<0.001). This difference was not statistically significant for primiparous (p=0.68) and multiparous (p=0.05) women who had forceps-assisted birth and multiparous women who had vacuum extraction (p=0.083). The percentage of episiotomy among primiparous women with GDM who had vacuum extraction was slightly higher than those without GDM (p=0.04) (Table 3).

Table 4 presents the odds ratio of OASIs by episiotomy and mode-of-birth, using the spontaneous vaginal birth without episiotomy, analysed by GDM status and parity. Primiparous women with GDM, who had a forceps-assisted birth, had the highest odds of OASIs (AOR 5.30, 95% CI (3.72-7.54)). This odds ratio was reduced to 2.49, 95% CI (2.00-3.11)) when episiotomy was performed. For primiparous women without GDM, combined episiotomy with forceps birth or vacuum extraction significantly lowered the odds of OASIs (from 5.95, 95% CI (5.41-6.55) to 2.71, 95% CI (2.55-5.89) forceps) and (from 1.99, 95% CI (1.89-2.14) to 1.44, 95% CI (1.33-1.55) vacuum). A subgroup analysis was done for primiparous women who gave birth to macrosomic babies. Among women with GDM, episiotomy with forceps reduces the odds ratio of OASIs from 5.38, 95% CI (1.42-20.38) to 3.21, 95% CI (1.47-7.05) compared to forceps alone. However, this reduction was not statistically significant. For primiparous women without GDM, the odds of OASIs was lower for women who had an episiotomy with forceps than women who did not have an episiotomy, (from 4.07, 95% CI (3.15-5.26) to 1.86, 95% CI (1.58-2.18)).

Discussion

Our study results show that women with GDM who gave birth to macrosomic baies and had an instrumental vaginal birth, had an increase in the odds of OASIs compared to women without GDM. However, this association was not significant among women who gave birth to macrosomic babies by spontaneous vaginal birth. This study confirms that among primiparous with GDM and all women without GDM, that when a forceps birth is indicated performing an episiotomy is protective against OASIs.

Gestational diabetes is associated with an increase in birthweight[19] and the risk of shoulder dystocia when compared with women without GDM giving birth to babies within the same birthweight group[20, 21]. In addition, among women with GDM, instrumental vaginal birth is associated with increased risk of shoulder dystocia compared to spontaneous vaginal birth[22]. The combination of these risk factors may explain why women with GDM who gave birth to macrosomic babies by instrumental vaginal birth had significantly higher odds of having OASIs compared to women without GDM. This interaction could be supported by our findings that there was no significant increase in odds of OASIs in GDM women who gave birth to macrosomic babies spontaneously or, in women without GDM with instrumental birth to babies less that 4000g. However, these non-significant results may be due to the small numbers in these subgroups.

Previously published studies show that an episiotomy with an instrumental vaginal birth is associated with reducing the risk of OASIs[6, 10, 23]. Guidelines published by both the Royal College of Obstetricians and Gynaecologists (RCOG) in 2011[24] and the Royal Australian and New Zealand College of Obstetricians and Gynaecologists (RANZCOG) in 2016[25] state that in the absence of robust evidence, routine episiotomy with instrumental delivery cannot be recommended and that the use of an episiotomy should be at the decision of the operator. In contrast, the 2015 RCOG practice guideline (The Management of Third- and Fourth-Degree Perineal Tears) recommends performing an episiotomy with instrumental births[2]. Our results among primiparous women with GDM and all women without GDM, confirm the results published by Ampt et al. (2013) and Gurol-Urganci et al. (2013) that an episiotomy with forceps birth reduces the odds of OASIs compared to forceps alone[6, 10]. However, we found that episiotomy at the time of spontaneous vaginal birth increased the odds of OASIs among multiparous women with and without GDM. In contrast, amongst primiparous women with GDM having a spontaneous vaginal birth there was no difference with episiotomy. Even though, episiotomy with spontaneous vaginal birth was associated with statistically significant increase in the odds of OASIs among primiparous women without GDM. This increase may not be clinically significant as the difference in the percentage of OASIs was only 0.3% between spontaneous vaginal birth with and without episiotomy.

Strengths and limitations

A strength of this study is the use of the PDC, a statewide epidemiological collection of all births in NSW. We provide population-based evidence of an association between episiotomy and a reduction of OASIs among women with GDM. However, a validation study of the GDM detection in PDC shows a sensitivity of 63.3% (95% CI 49.4-75.7)[26]. This sensitivity suggests information bias as it reflects the period before the 2013 ADIPS guideline stating all women should have universal screening for GDM[15]. Therefore, our findings should be interpreted with this caveat.

A limitation of this study is that information on shoulder dystocia is not collected or available from the PDC, therefore we were unable to adjust for this condition in the analysis. Country of birth was used as a proxy for the OASIs and GDM risk factor[10, 27] ethnicity, which was not available in the PDC. There was no information available on the compliance of antenatal care providers to the ADIPS GDM screening and diagnosis guidelines.

Conclusion

There was a higher rate of OASIs among women with GDM. The risk of OASIs associated with instrumental births and birthweight ≥ 4000g should be discussed with women with GDM. Our results among primiparous women with GDM and all women without GDM who have forceps birth provide evidence to support the RCOG's general recommendation to perform mediolateral episiotomy with instrumental vaginal birth.

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Table 1: Maternal and newborn characteristics of women who had GDM and women without GDM

	Without GDM (n=436345) n (%)	**With GDM** (n= 23965) n (%)	**P value**[‡]
Age (Years)			
Mean (SD)	29.5 (5.6)	31.7 (5.2)	< 0.001
less than 25	86 451 (19.8)	2090 (8.7)	
25 - 34	264 791 (60.7)	14 485 (60.4)	< 0.001
35 or more	85 023 (19.5)	7389 (30.8)	
Not stated	80 (0.0)	1 (0.0)	
Country of birth			
Australian born	299 042 (68.5)	11 529 (48.1)	< 0.001
Overseas born	135 364 (31.0)	12 326 (51.4)	
Not stated	1939 (0.4)	110 (0.5)	
Parity			
Nulliparous	183 742 (42.1)	9995 (41.7)	0.185
Multiparous	252 258 (57.8)	13 969 (58.3)	
Not stated	345 (0.1)	1 (0.0)	
Last birth by caesarean section[†]			
Yes	11476 (4.5)	565 (4.0)	
No	240 691 (95.4)	13 399 (95.9)	0.005
Not stated	91 (0.0)	5 (0.0)	
Onset of labour			
Spontaneous	311 695 (71.4)	11473 (47.9)	
Induced	124 601 (28.6)	12491 (52.1)	<0.001
Not stated	49 (0.0)	1 (0.0)	
Mode of birth			
Spontaneous vaginal birth	366 255 (83.9)	19 595 (81.8)	< 0.001
Forceps	24 634 (5.6)	1666 (7.0)	

Vacuum	45 456 (10.4)	2704 (11.3)	
Plurality			
Singleton	433 210 (99.3)	23 743 (99.1)	< 0.001
Multiple	3135 (0.7)	222 (0.9)	
Episiotomy			
Yes	75 852 (17.4)	4923 (20.5)	< 0.001
No	360 412 (82.6)	19 041 (79.5)	
Not stated	81 (0.0)	1 (0.0)	
Hospital sector			
Public	34 2317 (78.5)	20 287 (84.7)	
Private	89 257 (20.5)	3549 (14.8)	< 0.001
Home birth/birth before arrival	4771 (1.1)	129 (0.5)	
Baby sex			
Male	221 297 (50.7)	12 157 (50.7)	0.988
female	214 932 (49.3)	11 805 (49.3)	
Not stated	116 (0.0)	3 (0.0)	
Birthweight (g)			
Less than 3000	80 855 (18.5)	5831 (24.3)	
3000-3499	164 912 (37.8)	9951 (41.5)	
3500-3999	140 487 (32.2)	6310 (26.3)	< 0.001
4000 and over	49 738 (11.4)	1863 (7.8)	
Not stated	354 (0.1)	10 (0.0)	
Gestational age (weeks)			
Less than 37	22 069 (5.1)	1507 (6.3)	
37 and over	414 206 (94.9)	22 456 (93.7)	< 0.001
Not stated	70 (0.0)	2 (0.0)	

†Mutipara only.

‡ Excludes not stated values.

Table 2: OASIs by mode of birth, birthweight and GDM

Mode of birth	OASIs Number (%) Without GDM (Reference group)	With GDM	OR (95% CI)	AOR† (95% CI)
Birthweight < 4000g				
Spontaneous vaginal birth	5582/323924 (1.7)	439/17995 (2.4)	1.43 (1.29-1.57)	1.21*(1.09-1.34)
Forceps	2063/21434 (9.6)	184/1546 (11.9)	1.27 (1.08-1.49)	1.13 (0.96-1.33)
Vacuum	1860/40813 (4.6)	145/2550 (5.7)	1.26 (1.06-1.5)	1.15 (0.96-1.37)
Birthweight ≥ 4000g				
Spontaneous vaginal birth	1273/41922 (3.0)	50/1590 (3.1)	1.04 (0.78-1.38)	1.07 (0.79-1.43)
Forceps	413/3180 (13.0)	23/120 (19.2)	1.59 (1.00-2.53)	1.76*(1.08-2.86)
Vacuum	369/4618 (8.0)	22/153 (14.4)	1.93 (1.22-3.08)	1.89*(1.17-3.04)

† AOR, odd ratios were adjusted for maternal age, maternal country of birth, parity, plurality, hospital sector, last birth by caesarean section, onset of labour, episiotomy, baby sex and gestational age.

*p<0.05

Table 3: Percentage of women who had episiotomy by mode of birth, parity and GDM

Parity		**Without GDM n(%)**	**GDM n(%)**	**P value**
Primiparous	Episiotomy and spontaneous vaginal birth	21 239 (16.5)	1332 (20.4)	<0.001
	Episiotomy and forceps	16 973 (82.2)	1145 (82.7)	0.68
	Episiotomy and vacuum	18 650 (54.1)	1172 (56.4)	0.04
Multiparous	Episiotomy and spontaneous vaginal birth	13 143 (5.5)	871 (6.7)	<0.001
	Episiotomy and forceps	2511 (63.0)	193 (68.9)	0.05
	Episiotomy and vacuum	3303 (30.2)	209 (33.4)	0.083

Table 4: OASIs by method of birth, episiotomy and diabetes

	OASIs Number (%)	OR (95% CI)	AOR† (95% CI)
	With GDM		
Primiparous			
Spontaneous vaginal birth-no episiotomy	258/5198 (5.0)	Reference	Reference
Spontaneous vaginal birth-episiotomy	66/1332 (5.0)	1.00 (0.76-1.32)	0.97 (0.73-1.29)
Forceps- no episiotomy	47/240 (19.6)	4.66 (3.31-6.57)	5.30*(3.72-7.54)
Forceps- episiotomy	141/1145 (12.3)	2.69 (2.17-3.34)	2.49*(2.00-3.11)
Vacuum-no episiotomy	71/907 (7.8)	1.63 (1.24-2.14)	1.79*(1.35-2.36)
Vacuum- episiotomy	79/1172 (6.7)	1.38 (1.07-1.80)	1.42*(1.09-1.86)
Multiparous			
Spontaneous vaginal birth-no episiotomy	143/12192 (1.2)	Reference	Reference
Spontaneous vaginal birth-episiotomy	22/871 (2.5)	2.18 (1.39-3.44)	2.47*(1.55-3.93)
Forceps- no episiotomy	5/87 (5.7)	5.14 (2.05-12.86)	5.65*(2.21-14.43)
Forceps- episiotomy	14/193 (7.3)	6.59 (3.73-11.63)	5.23*(2.85-9.60)
Vacuum-no episiotomy	7/416 (1.7)	1.44 (0.67-3.10)	1.56 (0.72-3.38)
Vacuum- episiotomy	10/209 (4.8)	4.23 (2.20-8.16)	3.85*(1.94-7.64)
	Without diabetes		
Primiparous			
Spontaneous vaginal birth-no episiotomy	3822/107332 (3.6)	Reference	Reference
Spontaneous vaginal birth-episiotomy	827/21234 (3.9)	1.09 (1.01-1.18)	1.10*(1.02-1.19)
Forceps- no episiotomy	612/3664 (16.7)	5.44 (4.96-5.97)	5.95*(5.41-6.55)
Forceps- episiotomy	1620/16972 (9.5)	2.87 (2.70-3.04)	2.71*(2.55-2.89)
Vacuum-no episiotomy	968/15823 (6.1)	1.77 (1.64-1.90)	1.99*(1.85-2.14)
Vacuum- episiotomy	932/18648 (5.0)	1.42 (1.32-1.53)	1.44*(1.33-1.55)
Multiparous			
Spontaneous vaginal birth-no episiotomy	1966/224097 (0.9)	Reference	Reference
Spontaneous vaginal birth-episiotomy	237/13142 (1.8)	2.07 (1.81-2.38)	2.06*(1.79-2.36)
Forceps- no episiotomy	97/1472 (6.6)	7.91 (6.40-9.76)	6.20*(4.96-7.74)

Forceps- episiotomy	147/2511 (5.9)	7.03 (5.93-8.35)	3.75*(3.12-4.50)
Vacuum-no episiotomy	226/7644 (3.0)	3.45 (3.00-3.96)	3.11*(2.69-3.59)
Vacuum- episiotomy	100/3302 (3.0)	3.61 (2.95-4.41)	2.34*(1.89-2.89)

† AOR, odd ratios were adjusted for maternal age, maternal country of birth, plurality, hospital sector, last birth by caesarean section, the onset of labour, baby sex and birthweight.

*p<0.05.

Table S1: Univariate analysis

	Crude OR (95%CI)	P value
Age (Years)		
less than 25	REF	REF
25 - 34	1.21(1.16-1.27)	<0.001
35 or more	0.73(0.68-0.78)	<0.002
Country of Birth		
Australian born	REF	REF
Overseas born	1.81(1.75-1.88)	<0.001
Parity		
Nulliparous	4.53(4.34-4.72)	<0.001
Multiparous	REF	REF
Last birth by caesarean section		
Yes	1.94 (1.78-2.11)	<0.001
No	REF	REF
Onset of labour		
Spontaneous	REF	REF
Induced	1.09 (1.05-1.13)	<0.001
Plurality		
Singleton	REF	REF
Multiple	0.45 (0.33-0.61)	<0.001
Episiotomy		
Yes	2.48 (2.38-2.57)	<0.001
No	REF	REF
Hospital sector		
Public	REF	REF
Private	0.44 (0.41-0.46)	<0.001
Baby sex		
Male	1.18 (1.14-1.22)	<0.001
female	REF	REF
Macrosomic		

Yes	1.68 (1.6-1.76)	<0.001
No	REF	REF
Term		
Yes	REF	REF
No	0.34 (0.29-0.8)	<0.001