

The incidence and risk factors of severe lacerations during forceps delivery in a single teaching hospital where simulation training is held annually

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A short running title: **Severe lacerations of forceps delivery**

Abstract

Aim: To evaluate the incidence of severe lacerations during forceps delivery and the risk factors associated with such delivery in a hospital where simulation training is held annually, we retrospectively reviewed the medical records of forceps delivery cases.

Methods: Data of 857 women who underwent forceps delivery at term with singleton cephalic presentation from 2010 to 2015 were obtained. The relationship between clinical characteristics and birth canal trauma was analyzed. Birth canal trauma included third- and fourth-degree perineal lacerations. Univariable and multivariable models of logistic regression were employed to estimate the raw odds ratio (OR) and then adjusted for cofactors with 95% confidence intervals (CI). Statistical significance was defined as $P < 0.05$.

Results: The incidence of severe lacerations was 10.1%. Birth weight, fetal head station, the rate of malrotation, and the number of extractions was higher among women with severe lacerations ($P < 0.01$), whereas the use of obstetrical anesthesia was lower among women with such lacerations ($P < 0.01$). Neither the indication for forceps delivery nor qualifications of the operator showed any influence on the incidence of severe lacerations.

Conclusions: The incidence of severe lacerations was relatively low. Risk factors for severe lacerations with forceps delivery were identified as birth weight, fetal head station, malrotation, and the number of extractions. Obstetric anesthesia may be protective against severe lacerations.

Keywords: Forceps delivery, Obstetrical anesthesia, Risk factors, Severe lacerations, Simulation training

Introduction

The use of forceps is an effective method to accomplish vaginal delivery when complications arise during the second stage of labor.¹ It is more likely to achieve vaginal birth in comparison with vacuum extractors and is beneficial for parturients because it avoids cesarean delivery and its associated morbidities.² However, there has been a trend towards a greater occurrence of severe lacerations (third- or fourth-degree lacerations) with forceps deliveries than with the vacuum technique.³ Severe lacerations are associated with substantial maternal morbidity involving severe perineal pain, anal incontinence, and fistula formation.⁴ The number of forceps deliveries has been decreasing worldwide because of the fear of maternal and fetal complications.⁵ In addition, current training circumstances is associated with a decline in forceps deliveries. The employment of forceps makes the operator more cautious about acquisition and the accurate evaluation of the fetal head's rotation, providing a safer option of operative vaginal delivery (OVD).² Most trainees reported that there were attending physicians who were available to teach them the technique of forceps delivery, yet their experience with forceps deliveries had declined along with the declining rate of such deliveries in the United States compared with that a decade ago,⁶ and rate of forceps deliveries appeared to have deteriorated significantly since that time.⁷ The median number of forceps deliveries in the 4-year U.S. training programs totals five for the most recent year; those circumstances are inadequate to provide the technical skills required to perform forceps deliveries safely.⁷ Similarly, the rates of cesarean and vacuum deliveries are 20% and 6%, respectively, while the rate of forceps delivery is only 1% among all deliveries, except for planned cesarean deliveries, including those in high-level Japanese medical facilities.⁸ Much discussion has centered on how to train the resident trainee regarding forceps delivery. Some forms of "quality control" or practices have been studied, and some of them have been shown to be useful.⁹⁻¹⁰

However, using such systems of training may be difficult in community hospitals. Therefore, the prevention of severe lacerations should be emphasized during the training. Gossett et al. reported that simulation-based forceps delivery training is associated with a significant reduction (22%) in severe perineal lacerations.¹⁰ Risk factors of severe laceration have been investigated over the years including vaginal delivery with or without OVD.¹¹⁻¹⁵ However, PubMed search for articles with the key words "simulation training" and "obstetric forceps" limited to the English language identified only 13 reports. There are no reports on complications of and risk factors for forceps delivery from institutions where

residents are trained using a simulation model. Therefore, this study had two aims: first, to report the rates of severe lacerations in a single teaching hospital where simulation training is held annually; second, to clarify the risk factors for severe lacerations in forceps delivery.

Methods

Study design

This was a retrospective cohort study including forceps deliveries in Juntendo University Hospital between January 2010 and December 2015. The study was approved by the Research Ethics Committee of the Juntendo University. For this type of study, formal consent is not required. Clinical and obstetric data from medical records were reviewed. Maternal backgrounds, neonatal characteristics, and characteristics of operation were selected for analysis. Maternal data included age, body mass index (BMI) at delivery, weight gain during pregnancy, parity, the use of obstetric anesthesia, induction, and augmentation. We used epidural anesthesia or combined spinal and epidural anesthesia as obstetric anesthesia. Neonatal characteristics included birth weight and gestational age. Operation characteristics included indication for forceps delivery (non-reassuring fetal status, prolonged 2nd stage of labor, shortening of the 2nd stage of labor), fetal head station (+2, 3 vs. +4, 5), malrotation, number of extractions, and qualifications of the physician (trainee or specialist). Malrotation included occiput posterior and occiput transverse positions (with rotation greater than 45°). The specialists had licenses of obstetrics and gynecology that were qualified by the Japan Society of Obstetrics and Gynecology, and had clinical experience of at least 3.5 years after they specialized in obstetrics and gynecology, which requires them to have experience of no less than 100 deliveries.

Lacerations were defined as follows: third-degree lacerations (laceration extends to the anal sphincter) and fourth-degree lacerations (laceration reaches the rectal mucosa). Severe lacerations included both third- and fourth-degree lacerations. Episiotomy was performed in all forceps delivery cases to reduce spontaneous severe lacerations in our hospital; therefore, episiotomy was not included in the analysis.

Clinical variables analyzed were compared between two groups: patients with severe lacerations and controls. The control group included patients without laceration (only episiotomy) and patients with laceration except for third- and fourth-degree lacerations. The data were analyzed using SAS 9.4 software (SAS institute JAPAN). Univariate and multivariate models of logistic regression were employed to

estimate the raw odds ratio (OR) and were then adjusted for cofactors with 95% confidence intervals (CI). Multivariate analysis included all predictive variables. The set that could best explain the occurrence of severe lacerations was obtained using the backward method (Wald test: P value of 0.10). Statistical significance was defined as $P < 0.05$.

Delivery Procedure

Naegele forceps are mainly used in our institution, and they are the most commonly used forceps in Japan. These forceps have fenestrated blades that make it possible to grasp the fetal head; they also have adequate curves for pelvis and fetal head adjustments.¹⁶ They were made as non-rotational forceps. In Japan, we have modified the Naegele forceps, making them lighter in weight (417 g), shorter in length (35 cm), and with thinner blades, adapted for Japanese women; we have named this modified version the UTokyo Naegele forceps.¹⁷ UTokyo Naegele forceps is mainly used during study period, and the image is shown in (Fig. 1). If they are likened to the type of forceps those used worldwide, they are similar to Elliot forceps for its fenestrated blades and adequate curves.

As prerequisites and precautions for OVD, the guidelines for obstetrical practice in Japan was followed.¹⁸ When forceps are needed, doctors confirm that the fetal head has descended (fetal head station) and the presence or absence of malrotation. This confirmation is done only by internal digital examination or in combination with abdominal ultrasonography when internal examination is unclear. The station is determined where the site of the largest fetal head circumference is passing. This is done as follows: the plane of the pelvic inlet becomes station $> +2$ cm, the plane of the greatest pelvic dimensions becomes station $+2, +3$ cm, the plane of the obstetric outlet becomes station $+3, +4$ cm, and the plane of the anatomical outlet becomes station $+5$ cm. This original station is named the trapezoidal station (T-station) in Japan.¹⁹ The definition is based on the trapezoidal plane, which consists of both the ischial spines and the lower edge of the pubic symphysis along the pelvic axis, measuring the shortest distance from the trapezoidal plane (base level: 0) to the presenting part. The T-station is diagnosed by measuring the palpable distance between the symphysis and the anterior space of the sacrum. While the station is defined according to levels of the leading portion of the fetal head horizontally at or below the levels of maternal ischial spines (in cm) in DeLee's station, the T-station is revised taking into account the fetal head descent along the pelvic axis, which enables us to determine the fetal head descent objectively. Based on the American College of Obstetricians and Gynecologists (ACOG) classification of 1988,²⁰ a

station +2, 3 cm indicates the need for low forceps, whereas a station +4, 5 cm indicates the need for outlet forceps. We perform forceps delivery only when the fetal head has reached no less than station +2 cm. An annual workshop of simulation training is held at our institution where the authors regularly share and evaluate the use of forceps. Senior residents or operators who haven't had enough experience of forceps are intended to participate. Lecture was consists of two parts. First, expert specialist give the lecture with slides in classroom. The content includes prerequisites for forceps application and how to evaluate the fetal presentation, position, and asynclitism, extent of fetal head molding. After the lecture on slides, participants actually perform forceps delivery using a female pelvis model. First, instructor tell trainee the situation of the case and consequently trainee judge the prerequisites were met in that case (they have to explain how they judged with reasons). Second, how to attach and extract forceps is performed using female pelvis model. Participants fill the self-check sheet for performance of simulated forceps delivery at the end of the program.

Results

A total of 5,588 deliveries were recorded during the period under review. The cesarean delivery was performed in 40% without attempted of OVD (n=2,237). Among 3,351 attempted vaginal deliveries, 73% cases (n=2,455) were delivered without OVD. In the remainder of the cases, vacuum extractions were performed in 18 cases and a total 878 cases were attempted by forceps. Among those deliveries, 16 cases were excluded because of preterm (gestational week <37) deliveries, and all resulted in successful forceps deliveries. A total of 862 cases at term were attempted by forceps, and failed forceps delivery occurred in 5 cases (0.58%). Emergent cesarean sections were performed in all of these cases. The rate of success of forceps delivery at term was 99.4%. A final sample of 857 patients in whom successful forceps delivery was performed at term was included in the study (Fig. 2). This number accounted for 15% of all deliveries and 26% of vaginal deliveries in this cohort. Among these, 87 (10.1%) patients had severe lacerations.

The average maternal age of women successfully delivered by forceps at term was 35 years. Obstetric anesthesia was performed in 56% of patients. More than 60% of forceps deliveries were low forceps deliveries (station +4, +5) and performed by a trainee. Malrotations were recognized in 6.8% of the cases. Other clinical and obstetric characteristics are summarized in Table 1.

Univariate analysis indicated that rates of obstetrical anesthesia were significantly lower in the severe lacerations group [448/770 (58.3%) vs. 37/87 (42.5%); OR 0.53, 95%; CI 0.34–0.83; $P < 0.01$]. Maternal age, BMI, weight gain during pregnancy, parity, and performance of induction or augmentation appeared to have no influence on severe lacerations.

Birth weight and rates of the neonate's birth weight > 3.5 kg were significantly higher in the severe lacerations group [3050 (360) vs. 3164 (376); OR (per 100g) 1.04, 95%; CI 1.03–1.16; $P < 0.01$], [85/770 (11.0%) vs. 17/87 (19.5%); OR 1.96, 95%; CI 1.10–3.48; $P = 0.02$], respectively. Gestational age was not significant between two groups. Numbers of the fetal head station +2, +3 cm were significantly higher in the severe laceration group [192/770 (25.3%) vs. 36/87 (41.9%); OR 2.12, 95%; CI 1.34–3.36; $P < 0.01$]. The rates of malrotation and the number of extractions were also higher in severe lacerations group [45/770 (5.8%) vs. 13/87 (14.9%); OR 2.83, 95%; CI 1.47–5.49; $P < 0.01$], [1.12 (0.36) vs. 1.28 (0.53); OR 2.23, 95%; CI 1.40–3.55; $P < 0.01$], respectively. Neither indication nor operator experience had any influence on lacerations. In a multivariate model, after including the OR adjusted for other factors, obstetrical anesthesia, fetal head station, malrotation, the number of extractions remained significant ($P < 0.01$, $P = 0.04$, $P < 0.01$, $P = 0.01$ respectively). The results are shown in Tables 2–5.

Discussion

This study revealed that the rate of severe lacerations was 10.1% and failed forceps deliveries occurred at a rate of only 0.58% in a teaching hospital where simulation training is held annually. This rate is remarkably lower than that reported previously.^{3, 11, 21} An annual workshop for forceps delivery training has been held that includes lectures and performing simulation training on forceps deliveries using a female pelvis model. In simulation training, prerequisites for forceps application for safe delivery is shared and confirmed. In particular, attention is focused on how to evaluate the descent of the fetal head station. Caput succedaneum formation and fetal head molding of cases of prolonged labor make assign the station more difficult. Malrotation also becomes the risk of wrong assignment. For examples in cases of occiput posterior position, the site of the largest fetal head circumference, which corresponds to the site of occipitofrontal diameter became larger and higher than in case of occiput anterior position because the head has extreme molding¹⁹. So the lecture for how to make determination of fetal presentation, position, and asynclitism and extent of molding has also been an important part of simulation training.

Dupuis et al. reported that performing forceps blade placement on a birth simulator allowed obstetricians to improve their skills.⁹ Gossett et al. revealed a 22% reduction in severe perineal laceration in delivery among women managed by residents who had completed forceps simulation training when compared with women who were managed by residents who did not complete forceps stimulation training.¹⁰ Since the number of forceps have fallen down as the rising rates of cesarean sections, how to teach the skill to operators in training and perform forceps safely has been serious problems. And the situation is not peculiar to forceps delivery. Cesarean section is a common operation in obstetrics and gynecology and it is one of the first operations performed by trainees. However, maternal complications at cesarean section increase when the primary surgeon is a trainee, Madsen et al. emphasized structured and validated education and assessment methods should be used.²² Furthermore, managing patient safety and training at once is common concern not only for the fields of obstetrics and gynecology. Quality of care and patient safety have become a significant focus of medical practice, Rodriguez et al. has proposed different training paradigm which integrate knowledge, skill based competencies and a culture of patient safety in both simulated and real environments.²³ As for forceps delivery, effectiveness of simulation training has been already reported, so the training paradigm which integrate skills performing forceps obtained by simulation and knowledge not only about prerequisites but also about the risk for misunderstanding the fetal head station derived from various situations would be important for trainee. Thus simulation training may be useful to avoid maternal complications, both for trainees who do not have enough experience and for specialists to review their own methods.

In this study, risk factors for severe lacerations of forceps delivery were identified as birth weight, fetal head station, malrotation, and the number of extractions. In contrast, we observed that obstetrical anesthesia might be protective against severe laceration. To the best of our knowledge, this is the first report to provide data indicating that obstetric anesthesia may be protective against severe laceration.

Risk factors for severe laceration including vaginal delivery with or without OVD have been investigated in recent years. Birth weight is identified as one of the main factors¹²⁻¹⁴, and our analysis supported this theory. Within OVD, previous reports revealed fetal head station and malrotation were strong risk factors and that decreasing these factors would contribute to fewer severe lacerations.^{11, 15} Similarly, we found that the fetal head station and the rate of malrotation were significantly higher in the severe lacerations group, even on multivariate analysis. Malrotations include occiput posterior as well as

occiput transverse positions in this study. Both forms of malrotation result in the need for a more forceful extraction and an associated increase in severe lacerations. Higher stations also require more forceful extraction than lower stations. In addition, factors of extraction vectors relate to lacerations. Low forceps require extraction close to perpendicular to the ground before horizontal extraction of the fetal head under the pubis. Extraction close to perpendicular to the ground can result in more severe lacerations because the anal sphincter is located under the vagina; thus, higher stations would be considered as posing a risk for lacerations. Authors also speculate the speed of extraction have possibility to influence the lacerations. Compared to normal smooth delivery, fetal head descends more rapidly in forceps delivery. It's one of the reason to have higher rates of severe lacerations than normal delivery. Among forceps delivery, if operator extract forceps rapidly more than necessary, it results in more pressure for birth canal thus leads to severe lacerations. We are usually be careful to extract slowly as if we match the pace which fetal head come down, but we rely on the senses based on experiences and difficult to explain objectively. And also evaluation of the speed extraction is really difficult and because this study was retrospective one, we could not take into account for analysis.

When all vaginal deliveries were analyzed, obstetrical anesthesia seemed to be associated with an increase in severe lacerations because of increased risk of instrument use.²⁴ Among forceps deliveries, we found that the rates of obstetrical anesthesia were significantly lower in the severe lacerations group. We speculate that this is because obstetrical anesthesia relaxes pelvic musculature, which may contribute to fewer lacerations. Administration of analgesics is also known to be associated with a lower risk of failed forceps delivery.²⁵ This also suggests that anesthesia may have an indirect effect on pelvic musculature, making it more relaxed. To identify the role and effect of obstetrical anesthesia on severe lacerations, a larger number of cases including all vaginal deliveries are needed.

Few studies have analyzed the correlation between the number of extractions and morbidities or other factors. Ramphul et al. reported that the rates of pulling more than three times were higher in suboptimal replacement of OVD than in optimal OVD²⁶, indicating that increased extraction derives from suboptimal replacement. If forceps delivery was not completed in the first extraction, there could be inadequate pushing, or partially misled station or direction of extraction, and the following extraction would result in added friction on the vagina, resulting in severe lacerations.

The current study has several limitations. First, as simulation training was held during the entire study

period, we could not compare the rates of complications before and after the training began. Second, current obstetrical practice in this hospital may be associated with lower rates of severe laceration. An obstetrical specialist highly trained for forceps delivery always stays in the ward. If the trainee is not experienced enough to handle the forceps delivery, an obstetrician with more experience can replace the trainee at any time. Similarly, qualifications of the operator did not show any influence in our study, but there was a tendency of specialists preferring to deliver suspected cases having a higher degree of difficulty. Thus, we cannot make any conclusions within observed associations because this was retrospective study under the specific circumstances. Third, as patients who underwent only forceps delivery were included, we cannot compare our data with data obtained from spontaneous deliveries, making it more difficult to evaluate the effect of obstetrical anesthesia on lacerations.

Malrotation can be a risk factor not only for severe lacerations but also for failed forceps delivery. Malrotational forceps deliveries can be managed safely by using Kielland forceps.²⁷⁻²⁸ Employment of Kielland forceps may be crucial for safe delivery in these circumstances. Additionally, fetal morbidity and associated factors need to be clarified in the future, along with maternal morbidity. Therefore, research on frequency, importance, and associated factors for fetal morbidity would enable the more frequent use of forceps delivery more often and in a safer manner. The results of these proposed studies may encourage the use of forceps and thus, evaluation of forceps would be reviewed.

In conclusion, in a setting where simulation forceps delivery training is held annually, the rate of severe lacerations was 10.1% and failed forceps deliveries occurred at a rate of only 0.57%. In this obstetrics practice, risk factors for severe lacerations in forceps deliveries were revealed as birth weight, fetal head station, malrotation, and the number of extractions. Obstetrical anesthesia may be protective against severe lacerations. The accuracy of internal examination, recognition of risk factors, and skill in extraction techniques obtained through simulation training may contribute to reduce severe lacerations.

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Disclosure

None of the authors have any conflicts of interest associated with this study.

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Figure legends

Fig. 1 Image of UTokyo Naegele forceps is shown. This forceps have fenestrated blades and adequate curves for pelvis and fetal head adjustments which was modified lighter weight and shorter length with thinner blades from original Naegele forceps adapted for Japanese women.

Fig. 2 Flowchart showing selection criteria of patients who delivered in the hospital during study period
OVD; operated vaginal delivery

Table1 Overall clinical and obstetrics characteristics of cases successfully delivered by forceps at term

Clinical and obstetrics characteristics	n (%) or mean (SD)
Maternal age (years)	34.6 (4.45)
BMI at delivery (kg/m ²)	24.3 (1.12)
Weight gain (%)	16.2 (5.32)
Primigravida	745 (86.9)
Obstetrics anesthesia	485 (56.6)
Induction or augmentation	621 (72.5)
Birthweight (g)	3061.6 (363.2)
Gestational age (weeks)	39.7 (1.12)
Indication of NRFS	587 (68.4)
Indication of prolonged 2nd stage	246 (28.7)
Indication of shortening of the 2nd stage	22 (2.5)
Malrotation	58 (6.8)
Operator specialized	305 (35.6)
Operator trainee	529 (61.8)

Data are showed in terms of absolute number (n) and relative frequency (%), standard deviation (SD).

BMI, body mass index; NRFS, nonreassuring fetal status.

Table 2 Logistic regression of maternal background predictors of severe lacerations (univariate, n= 857)

Maternal background	Control (770)		Severe Lacerations (87)		P-value
	n (%)	or mean (SD)	n (%)	or mean (SD)	
Age (years)	34.5	(4.4)	35.0	(4.6)	n.s.
BMI† (kg/m ²)	24.2	(2.8)	24.7	(2.8)	n.s.
Weight gain (%)	16.1	(5.3)	17.3	(5.8)	n.s.
Primigravida,	665	(86.4)	80	(92.0)	n.s.
Obstetric anesthesia	448	(58.3)	37	(42.5)	<0.01
Induction or Augmentation	559	(72.6)	67	(77.0)	n.s.

†BMI at delivery. n.s., not significant.

Data are presented as absolute number (n) and relative frequency (%), standard deviation (SD).

Table 3 Logistic regression of obstetrical characteristics as predictors of severe lacerations (univariate n=857)

Obstetrical characteristics	Control (770)		Severe Lacerations (87)		P-value
	n (%)	or mean (SD)	n (%)	or mean (SD)	
Birth weight (g)	3050	(360)	3164	(376)	<0.01
Birth weight					
≥3.5 (kg)	85	(11)	17	(19.5)	0.02
<3.5 (kg)	685	(89)	70	(80.5)	
Gestational age, weeks (SD)	39.7	(1.1)	40	(1.1)	n.s.

n.s., not significant.

Data are presented as absolute number (n) and relative frequency (%), standard deviation (SD).

Table 4 Logistic regression of operation's characteristics as predictors of severe lacerations (univariate, n=857)

Operation characteristics		Control (770)		Severe Lacerations (87)		P-value
		n (%) or mean (SD)		n (%) or mean (SD)		ue
Indication	NRFS	532	(69.3)	55	(63.2)	
	prolonged 2 nd stage	218	(28.4)	28	(32.2)	n.s.
	shortening of the 2 nd stage	18	(2.3)	4	(4.6)	n.s.
Station	+4,+5	566	(74.7)	50	(58.1)	
	+2,+3	192	(25.3)	36	(41.9)	<0.01
Malrotation	absence	725	(94.2)	74	(85.10)	
	presence	45	(5.8)	13	(14.9)	<0.01
Operator	specialized,	272	(36.3)	33	(39.3)	
	trainee	478	(63.7)	51	(60.7)	n.s.
Number of extractions (times)		1.12	(0.36)	1.28	(0.53)	<0.01

n.s., not significant.

Data are presented as absolute number (n) and relative frequency (%), standard deviation (SD).

Table 5 Logistic regression of characteristics as predictors of severe lacerations (multivariate, n= 857)

characteristics	OR (uni [†])	95% CI	P-value	Adjusted OR (multi [‡])	95% CI	Adjusted P-value	
Obstetric anesthesia (%)	0.53	(0.34-0.83)	<0.01	0.48	(0.29-0.79)	<0.01	
Birth weight (100g)	1.04	(1.03-1.16)	<0.01	1.06	(1.00-1.04)	0.06	
Station	+4,+5	1.00					
	+2,+3	2.12	(1.34-3.36)	<0.01	1.69	(1.02-2.83)	0.04
Malrotation	absence	1.00					
	presence	2.83	(1.47-5.49)	<0.01	2.74	(1.28-5.82)	<0.01
Number of extractions (times)	2.23	(1.40-3.55)	<0.01	1.97	(1.17-3.33)	0.01	

[†]univariate; [‡]multivariate; OR, odds ratio; CI, confidence interval.

Multivariate conditional backward model with input P=0.10, including the constant.

Fig. 1



Fig. 2

