Fetal Injury Associated With Cesarean Delivery

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OBJECTIVE: To describe the incidence and type of fetal injury identified in women undergoing cesarean delivery.

METHODS: Between January 1, 1999, and December 31, 2000, a prospective cohort study of all cesarean deliveries was conducted at 13 university centers. Information regarding maternal and infant outcomes was abstracted directly from hospital charts.

RESULTS: A total of 37,110 cesarean deliveries were included in the registry, and 418 (1.1%) had an identified fetal injury. The most common injury was skin laceration (n=272, 0.7%). Other injuries included cephalohematoma (n=88), clavicular fracture (n=11), brachial plexus (n=9), skull fracture (n=6), and facial nerve palsy (n=11). Among primary cesarean deliveries, deliveries with a failed forceps or vacuum attempt had the highest rate of injuries (6.9%). In women with a prior cesarean delivery, the highest rate of injury also occurred in the unsuccessful trial of forceps or vacuum (1.7%), and the lowest rate occurred in the elective repeat cesarean group (0.5%). The type of uterine incision was associated with fetal injury, 3.4% "T" or "J" incision, 1.4% for vertical incision, and 1.1% for a low transverse (P=.003), as was a skin incision–to–delivery time of 3 minutes or less. Fetal injury did not vary in frequency with the type of skin incision, preterm delivery, maternal body mass index, or infant birth weight greater than 4,000 g.

CONCLUSION: Fetal injuries complicate 1.1% of cesarean deliveries. The frequency of fetal injury at cesarean delivery varies with the indication for surgery as well as with the duration of the skin incision–to–delivery interval and the type of uterine incision.

(Obstet Gynecol 2006;108:885–90)

LEVEL OF EVIDENCE: II-3

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The incidence and type of fetal injury identified at cesarean delivery is not well characterized. The most commonly identified injury at cesarean delivery is fetal laceration, and its incidence has been reported to be as high as 3%.[1–4] Information on other types of injuries seen at cesarean delivery is limited to case reports or small case series and the overall rate of fetal injury at cesarean delivery is unknown.[5–9] One might hypothesize that the risk of fetal injury at cesarean delivery is low, especially considering that cesarean delivery is purported to limit birth trauma in certain scenarios (eg, breech presentation).[10,11] This supposition is supported by the observation that major birth

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Supported by grants From the National Institute of Child Health and Human Development (HD21410, HD21414, HD27860, HD27861, HD27869, HD27905, HD27915, HD27917, HD34116, HD34122, HD34136, HD34208, HD34210, and HD36801).

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ISSN: 0029-7844/06

trauma has decreased over the last several decades in response to rising cesarean rates.[12] Puza et al[13] report a decrease in fetal injury associated with rising cesarean rates but present data that suggest improved surgical technique, not cesarean delivery itself, explains the decrease in birth trauma over time. Others have observed that certain injuries such as clavicular fracture appear to be unrelated to the mode of delivery and can be seen with cesarean as well as vaginal delivery, making the point that fetal injuries commonly attributed to vaginal delivery can be seen with cesarean delivery as well.[5]

In 1999, the National Institutes of Health–sponsored Maternal–Fetal Medicine Units Network established a Cesarean Registry to prospectively address several contemporary issues related to cesarean delivery. This registry included all patients undergoing cesarean delivery at network centers during the study period, providing the opportunity to explore uncommon complications of cesarean delivery, including fetal injury. Using data obtained from this registry, we describe the incidence of fetal injury at cesarean delivery, classify the types of injury, and establish what risk factors if any can predict their occurrence.

MATERIALS AND METHODS

This is a prospective cohort study designed to assess several contemporary issues related to cesarean delivery. The study was performed by the Maternal-Fetal Medicine Units Network and details of the data collection have been published previously.[14] Between January 1, 1999, and December 31, 2000, all women undergoing a cesarean delivery at one of the 13 participating centers were prospectively ascertained. Each center's institutional review board approved the study protocol. The current analysis was approved by the institutional review board of the University of Texas Southwestern. For this study, all singleton, liveborn infants from the registry with information available on fetal injuries were examined.

We defined fetal injury using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM). Fetal injuries include skin lacerations, cephalohematoma, clavicular fracture, brachial plexus injury, skull fracture, and facial nerve palsy. In addition, we included long bone fractures as well as intracranial hemorrhage. These injuries were ascertained from the newborn infants discharge charts. Such injuries were then analyzed in relation to a variety of demographic characteristics and complications as well as surgical factors and the indication for cesarean delivery including dystocia, nonreassuring fetal heart rate, abnormal presentation, and cesarean delivery after an unsuccessful trial of forceps or vacuum. The indication for cesarean delivery was classified as dystocia if the indication for the procedure was failure to progress, cephalopelvic disproportion, or failed induction. Neonatal outcomes in terms of condition at birth (umbilical artery blood pH and Apgar score), neonatal seizures, intraventricular hemorrhage, and mortality were analyzed in relation to fetal injury.

Continuous variables were compared by using the Wilcoxon rank-sum test. Categorical variables were compared with the use of the χ^2 or Fischer exact, where appropriate. The Mantel-Haenszel test of trend was used to determine whether the rate of fetal injury increased when the time from incision to delivery decreased. $P<.05$ was considered significant. Statistical analysis was performed with SAS 8.2 (SAS Institute, Cary, NC). No adjustment was made for multiple comparisons.

RESULTS

Patients from the registry were included in this analysis if they had a singleton pregnancy that resulted in a liveborn infant with information available on fetal injuries. The cesarean registry had 47,112 records, of which 37,110 cesarean deliveries met the criteria, and 418 infants (1.1%) had identified fetal injuries. Two records were excluded for having no information about fetal injury recorded. A total of 427 injuries were reported because nine infants had two injuries each. These injuries are summarized in Table 1. The most common injury was skin laceration (n=272), and this occurred in 7 of 1,000 cesarean births. Shown in Table 2 are demographic characteristics and delivery outcomes in women with fetal injuries compared with those in women without such injuries. Characteristics including nulliparity and white maternal race were significantly associated with fetal injury. Mater-

Table 1. Incidence and Type of Fetal Injury Identified in 37,110 Cesarean Deliveries

	Number (Incidence per 1,000)
Total number of injuries*	418 (11.3)
Skin laceration	272 (7.3)
Cephalohematoma	88 (2.4)
Clavicle fracture	11 (0.3)
Facial nerve palsy	11 (0.3)
Brachial plexus injury	9 (0.2)
Skull fracture	6 (0.2)
Long bone fracture	8 (0.2)
Intracranial hemorrhage	2 (0.1)
Other†	20 (0.5)

* Nine patients had two fetal injuries.
† Includes abnormal bruising, subconjunctival hemorrhage, abrasion, and minor injuries not able to be classified.

Table 2. Demographic Characteristics and Delivery Outcome of Women Undergoing Cesarean Delivery Complicated by Fetal Injuries Compared With Cesarean Births Without Such Injuries

Characteristic	Cesarean Delivery With Fetal Injury (n=418)	Cesarean Delivery Without Fetal Injury (n=36,692)	*P*
Maternal age (y, mean±SD)	27.0±6.2	27.8±6.4	.03
Nulliparity	223 (54)	14,888 (41)	<.001
Race			<.001
White	210 (51)	14,451 (41)	
Black	100 (24)	11,192 (32)	
Hispanic	93 (23)	9,139 (26)	
Other	7 (2)	672 (2)	
Body mass index (mean±SD)	27.2±6.9	27.2±7.0	1.0
Birth weight more than 4,000 g	61 (15)	4,493 (12)	.14
Gestational age (wk, mean±SD)	38.3±3.5	38.2±3.3	.02
Less than 37 wk	85 (20)	7,332 (20)	.84

SD, standard deviation.
Data are presented as n (%), except where otherwise indicated.

nal size (prepregnancy body mass index), gestational age less than 37 weeks, and birth weight more than 4,000 g were not associated with fetal injury.

Shown in Table 3 are the indications for cesarean delivery in relation to fetal injury. The highest risk of fetal injury was in primary cesarean deliveries performed after an unsuccessful trial of operative vaginal delivery (69 per 1,000), and the lowest risk was in women undergoing repeat cesarean delivery without a vaginal birth after cesarean (VBAC) attempt (5 per 1,000). Information on cervical examination at the time of cesarean delivery was available in 64% of the cases (n=23,888). The cases in which data were missing were more likely to be electively scheduled repeat cesarean deliveries or cesarean deliveries for abnormal presentation. There was no relationship between cervical dilatation and fetal injury when the dilatation was 9 cm or less. There was, however, a relationship between fetal injury and the stage of labor, with fetal injury being more common when cesarean delivery was performed in the second stage of labor than when performed in the first stage (2.8% versus 1.1%, $P<.001$). Individual types of injury by indication for cesarean delivery appear in Table 4. More than half of the cases of cephalohematoma occurred in cesarean deliveries performed for abnormal labor. Of the nine cases of brachial plexus injury, four occurred in women who did not experience labor. Surgical factors potentially implicated in fetal injury at cesarean delivery are shown in Table 5. The rapidity with which the infant is delivered, using the skin incision–to–delivery interval, was a factor in fetal injury. Specifically, fetal injuries were most frequent when the infant was delivered within 3 minutes. The type of skin incision was unrelated to fetal injury, but injury was significantly increased in "T" or "J" uterine

Table 3. Indication for Cesarean Delivery and the Risk of Fetal Injury

Indication for Cesarean Delivery	Cesarean Delivery With Fetal Injury	Cesarean Deliveries (n)	*P**
Primary	318 (1.5)	21,798	
Dystocia	111 (1.4)	8,122	<.001
Nonreassuring fetal heart rate	79 (1.5)	5,404	
Abnormal presentation	61 (1.4)	4,321	
Other	24 (0.7)	3,323	
Unsuccessful trial of forceps or vacuum	43 (6.9)	628	
Repeat	100 (0.7)	15,312	
No VBAC attempt	66 (0.5)	12,565	<.001
Failed VBAC	33 (1.2)	2,687	
Unsuccessful trail of forceps or vacuum	1 (1.7)	60	

VBAC, vaginal birth after cesarean delivery.
Data are reported as n (%) or number.
* Chi-square analysis was used to determine whether the incidence of fetal injury varied by indication for cesarean delivery in both primary and repeat cesarean delivery.

Table 4. Specific Types of Fetal Injury in Relation to the Indication for Cesarean Delivery

	Primary					Repeat		
	Dystocia (n=8,122)	Nonreassuring Fetal Heart Rate Tracing (n=5,404)	Abnormal Presentation (n=4,321)	Other (n=3,323)	Unsuccessful Trial of Forceps or Vacuum (n=628)	Failed VBAC (n=2,687)	Unsuccessful Trial of Forceps or Vacuum, VBAC Attempt (n=60)	Elective Repeat Cesarean (No VBAC Attempt) (n=12,565)
Total (n=418)	111 (14)	79 (15)	61 (14)	24 (7)	43 (69)	33 (12)	1 (17)	66 (5)
Skin laceration (n=272)	53 (7)	58 (11)	53 (12)	20 (6)	18 (29)	23 (9)	0	47 (4)
Cephalohematoma (n=88)	48 (6)	14 (3)	2 (0.5)	0	8 (13)	7 (3)	1 (17)	8 (0.6)
Clavicular fracture (n=11)	3 (0.4)	1 (0.2)	1 (0.2)	2 (0.6)	0	0	0	4 (0.3)
Facial nerve palsy (n=11)	0	0	1 (0.2)	0	9 (14)	1 (0.4)	0	0
Brachial plexus (n=9)	4 (0.5)	1 (0.2)	0	0	0	0	0	4 (0.3)
Long bone fracture (n=8)	0	2 (0.4)	2 (0.5)	1 (0.3)	1 (1.6)	0	0	2 (0.2)
Skull fracture (n=6)	0	1 (0.2)	0	1 (0.3)	3 (5)	1(0.4)	0	0
Intracranial hemorrhage (n=2)	0	0	0	0	2 (3)	0	0	0
Other (n=20)	4 (0.5)	4 (0.7)	2 (0.5)	0	7 (11)	2 (0.7)	0	1 (0.1)

VBAC, vaginal birth after cesarean delivery.
Data are reported as n (per 1,000).

Table 5. Selected Surgical Factors at Cesarean Delivery in Relation to Fetal Injury

Indication for Cesarean Delivery	Cesarean Delivery With Fetal Injury (n=418)	Number of Cesarean Deliveries (n=37,110)	*P*
Incision to delivery time, min.			.002*
3 or less	61 (19)	3,266	
4–5	56 (14)	4,037	
6–10	146 (10)	14,405	
11–15	84 (9)	8,902	
More than 15	64 (10)	6,214	
Skin incision type			1.0
Pfannenstiel	328 (11)	29,072	
Midline	88 (11)	7,795	
Uterine incision type			.003
Transverse	385 (11)	35,040	
Vertical	24 (14)	1,779	
T or J	8 (34)	237	

Data are shown as n (per 1,000) or number.
* A test of trend was used to determine whether the incidence of fetal injury varied across incision lines.

incisions compared with transverse or vertical incisions.

Infant condition at birth was significantly associated with fetal injury identified at cesarean delivery. An umbilical artery pH less than 7.1 was more common in the fetal injury group (12.6% versus 7.8%, P=.007). The incidence of seizures (10 per 1,000 versus 5 per 1,000) and death (19 per 1,000 versus 11 per 1,000) were higher in the injury group, but at a significance of P>.05. Grade III or IV intraventricular hemorrhage was significantly higher in the injury group (12 per 1,000 versus 4 per 1,000, P=.04).

DISCUSSION

The incidence of fetal injury at cesarean delivery was 1.1%. The most common injury identified was skin

laceration, occurring in 7 of 1,000 cesarean deliveries and accounting for 64% of the injuries overall. Several factors were associated with fetal injury, including the indication for cesarean delivery, the length of the skin incision–to–delivery time, and the type of uterine incision. The fetuses at highest risk of injury were those born after an unsuccessful trial of forceps or vacuum delivery, and those at lowest risk were in women undergoing repeat cesarean delivery without an attempt at vaginal birth. Our interpretation of these associations between cesarean delivery and the injuries observed is that those procedures done under the most pressing clinical circumstances, for example, unsuccessful trial of operative vaginal delivery and cesarean deliveries for fetal distress, where short skin incision–to–delivery times are necessary, are the most likely to be associated with injury to the fetus. Maternal size, as well as infant macrosomia, although potential cofactors for more clinically difficult cesarean delivery, were not significantly associated with fetal injury. Fetuses with injury identified at cesarean delivery were not only at risk for sequelae from the injury itself, but these cases were also associated with compromised newborn condition as indicated by a cord pH less than 7.1 or diagnosis of intraventricular hemorrhage.

We were able to demonstrate that fetal injury identified at cesarean delivery can often be classified into two categories: those directly attributable to the surgery and those attributable to other obstetric conditions such as abnormal labor. Fetal skin laceration, for example, is a surgical injury found in clinical circumstances where a cesarean delivery is technically difficult. Emergent cesarean delivery, cesarean deliveries performed after an unsuccessful trial of forceps or vacuum, and abnormal presentation of the fetus are all circumstances that increased the risk of fetal laceration when compared with electively scheduled cesarean delivery. Our findings of an association between emergency cesarean delivery and fetal laceration are consistent with those reported by Dessole et al in 2004.[1] In their study of accidental fetal laceration, a strong association was shown between emergency cesarean birth and fetal injury. They found an overall rate of fetal laceration of 3.12%, with 78% of the lacerations occurring when the cesarean delivery was performed emergently. These authors point out that, in circumstances when there is a critically short time period to effect delivery to avoid fetal morbidity and death, the surgeon may pay little attention to potential fetal lacerations that may be created when making the uterine incision. Another type of fetal injury identified in our study that may be related to the cesarean delivery itself is long bone fracture. Although there were only eight cases of this injury, none of them occurred in cesarean delivery for dystocia, two occurred in malpresentations, two in cesarean delivery for fetal distress, two in women who underwent elective repeat cesarean delivery, one in a failed operative delivery, and one in the other category of primary cesarean delivery. Similar to fetal skin lacerations, long bone fractures seem more likely to occur in those circumstances where the cesarean delivery may be more technically difficult or when there is a need to effect delivery quickly.

Several injuries identified in this study were not attributable to the surgery, but to other clinical circumstances. Cephalohematoma for example was more commonly associated with cesarean deliveries performed in cases of abnormal labor and, as one might expect, quite uncommon in cesarean delivery for other indications. Although it can be debated whether cephalohematoma should be reported as an injury in this analysis, it is identified as such in the ICD-9 coding of birth trauma. Thus, we included it.[14] Intracranial hemorrhage, skull fracture, and facial nerve palsy were other injuries that were related to labor dystocia or an unsuccessful attempt at operative vaginal delivery and not directly attributable to cesarean birth. The impact of labor dystocia on neonatal cranial and other nerve injuries was recently addressed by Towner et al[15] Using birth certificate and hospital discharge data, they identified and extracted information about neonatal intracranial injury, including hemorrhage, facial nerve palsy, and brachial plexus injury. These injuries were more common in women undergoing operative vaginal delivery or cesarean delivery for abnormal labor and in women who had an attempt at operative vaginal delivery before their cesarean delivery than in women undergoing elective repeat cesarean delivery. Although these results suggest that operative delivery is a cause of fetal injury, the authors observed that women undergoing operative delivery commonly experience labor dystocia and that abnormal labor rather than the operative procedure or technique may be responsible for intracranial injury.

Brachial plexus injury is most commonly seen in cases of difficult vaginal delivery and shoulder dystocia. We were surprised to find that fewer than half of the cases of brachial plexus injury identified in this study were seen in cesarean delivery for dystocia and that four of the nine cases occurred in women who did not labor at all. In fact, several types of fetal injury commonly associated with difficult vaginal delivery occurred in women who did not labor and underwent

an elective repeat cesarean delivery. In addition to brachial plexus injury, these include cephalohematoma, clavicular fracture, and long bone fracture. This observation suggests that cesarean delivery does not, in and of itself, prevent major birth trauma. Although cesarean delivery may play a role in decreasing birth trauma in certain clinical circumstances, it does not eliminate its occurrence. Furthermore, the fact that cesarean delivery itself can cause injury such as laceration countermands some of the potential benefit of cesarean delivery in reducing birth trauma. Women should be counseled that, although fetal injury is uncommon, it is not absent in cesarean delivery.

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APPENDIX

Core committee members who participated in protocol development and coordination between clinical research centers were F. Johnson and J. McCampbell, while S. Gilbert provided protocol/data management and statistical analysis. In addition to the authors, other members of the National Institute of Child Health and Human Development Maternal–Fetal Medicine Units Network are as follows:

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