Associated Factors in 1611 Cases of Brachial Plexus Injury

WILLIAM M. GILBERT, MD, THOMAS S. NESBITT, MD, MPH, AND BEATE DANIELSEN, PhD

Objective: **To identify risk factors associated with brachial plexus injury in a large population.**

Methods: **A computerized data set containing records from hospital discharge summaries of mothers and infants and birth certificates was examined. The deliveries took place in more than 300 civilian acute care hospitals in California between January 1, 1994, and December 31, 1995. Cases of brachial plexus injury were evaluated for additional diagnoses and procedures of pregnancy, such as mode of delivery, gestational diabetes, and shoulder dystocia. Those complications were stratified by birth weight and analyzed, using bivariate and multivariate techniques to identify specific risk factors.**

Results: **Among 1,094,298 women who delivered during the 2 years, 1611 (0.15%) had diagnoses of brachial plexus injury. The frequency of diagnosis increased with the addition of gestational diabetes (odds ratio [OR] 1.9, 95% confidence interval [CI] 1.7, 2.1), forceps delivery (OR 3.4, 95% CI 2.7, 4.3), vacuum extraction (OR 2.7, 95% CI 2.4, 3.1), and shoulder dystocia (OR 76.1, 95% CI 69, 84). In cases of brachial plexus injury, the frequency of shoulder dystocia increased from 22%, when birth weight ranged between 2.5 and 3.5 kg, to 74%, when birth weight exceeded 4.5 kg. The frequency of diagnosis of other malpresentation (nonbreech) (OR 73.6, 95% CI 66, 83) was increased for all birth weight categories. Severe (OR 13.6, 95% CI 8.3, 22.5) and mild (OR 6.3, 95% CI 3.9, 10.1) birth asphyxia were increased. Prematurity (OR 0.8, 95% CI 0.67, 0.98) and fetal growth restriction (OR 0.1, 95% CI 0.03, 0.40) were protective against brachial plexus injury.**

Conclusion: **In macrosomic newborns, shoulder dystocia was associated with brachial plexus injury, but in low- and normal-weight infants, "other malpresentation" was diagnosed more frequently than shoulder dystocia. Our study findings suggest that brachial plexus injury has causes in addition to shoulder dystocia and might result from an abnormality during the antepartum or intrapartum period. (Obstet Gynecol 1999;93:536–40. © 1999 by The American College of Obstetricians and Gynecologists.)**

From the Department of Obstetrics and Gynecology, Center for Health Services Research in Primary Care, University of California, Davis, Davis; and Health Information Solutions, Redwood City, California.

Birth trauma is a major source of pregnancy-related medical litigation, especially when permanent injury results.[1] Permanent brachial plexus injury is a leading cause of litigation related to birth trauma. Permanent injury to the newborn's brachial plexus is rare and not always associated with a difficult delivery.[2,3] The etiology of brachial plexus injury is believed to be excessive downward traction on the fetal head during the attempt to deliver the anterior shoulder in a vaginal delivery.[4,5] This downward traction strains the brachial plexus in the neck, resulting in transient or permanent injury, and is believed to be caused by shoulder dystocia.[4,5] Most studies partially support this belief. In their retrospective review, Jennett et al[2] found that more than half of the cases (22 of 39) of brachial plexus injury were not associated with shoulder dystocia. They concluded that brachial plexus injury might be the result of intrauterine maladaption and should not be taken as prima facie evidence of a birth-process injury. The current literature on brachial plexus injury is a collection of case reports or series, that cover multiyear periods.[2,3,6–9] Management and diagnostic modalities change with time, and those studies do not reflect those changes.

Brachial plexus injury has a reported occurrence rate of 0.05–0.26% of all deliveries.[9–14] Most injuries are transient, with full return of function occurring in 70–95% of cases.[9–14] In this study, we examined brachial plexus injury, associated risk factors such as shoulder dystocia, and maternal-fetal complications in all births at civilian hospitals in California during a 2-year period.

Materials and Methods

A database that linked maternal and neonatal hospital discharge records to birth certificate vital statistics records was used. The linkage of vital statistics was established for all civilian hospitals that reported to the California Office of Statewide Health Planning and

Table 1. Frequency of Brachial Plexus Injury Associated With Mode of Delivery

Delivery mode	No. of patients	%	OR (95% CI)
All deliveries	1611 of 1,094,298	0.15	1
All vaginal deliveries	1551 of 877,884	0.18	1.2 (1.1, 1.3)
NSVD	1147 of 781,077	0.15	1.0 (0.9, 1.1)
Vacuum extractor	322 of 80,412	0.40	2.7 (2.4, 3.1)
Forceps	82 of 16,395	0.50	3.4 (2.7, 4.3)
Cesarean	60 of 216,414	0.03	0.2 (0.15, 0.25)

OR = odds ratio; CI = confidence interval; NSVD = normal spontaneous delivery.

Development from January 1, 1994, to December 31, 1995. That database did not include births at military facilities, home deliveries, out-of-state deliveries, or births at birthing centers not reporting to the California office. The method was able to link 98.9% of maternal and 98.6% of neonatal hospital discharge records with the birth record vital statistics, an overall linkage of 97.9%. This generated a database of 1,094,298 deliveries. With the use of statistical software, the database was searched using International Classification of Diseases, 9th revision[15] (ICD-9), codes, which resulted in specific data for statistical analysis.

The database was sampled for the diagnosis of brachial plexus injury and those records were examined for ICD-9 codes relating to pregnancy outcomes and maternal complications. The linked database was searched for demographic, antepartum, intrapartum, and postpartum diagnoses, including diabetes and operative vaginal delivery. Modes of delivery and stratified birth weights were compared with the frequency of brachial plexus injury. Unadjusted odds ratios (ORs) were calculated comparing for presence of brachial plexus injury. The frequency of the following birth outcomes were determined: birth trauma (ICD-9 767), birth asphyxia (ICD-9 768), fetal growth restriction (FGR, ICD-9 764), intraventricular hemorrhage (ICD-9 772.1), subarachnoid hemorrhage (ICD-9 772.2), and infant length of stay. Incidences of the following complications were determined from the maternal records: other malpresentation (ICD-9 763.1), shoulder dystocia (ICD-9 660.4), gestational diabetes (ICD-9 648.8), and prematurity. The terms were from ICD-9[15] and were not defined further.

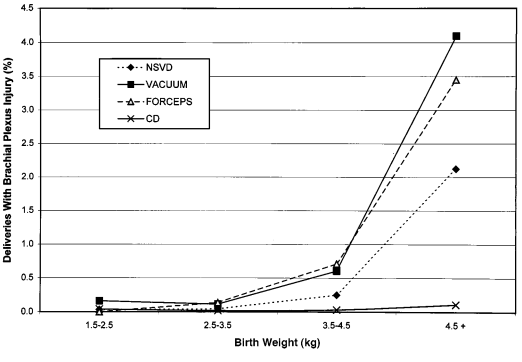

Figure 1. Frequency of brachial plexus injury, stratified by birth weight and displayed as mode of delivery. NSVD = normal spontaneous delivery; CD = cesarean delivery.

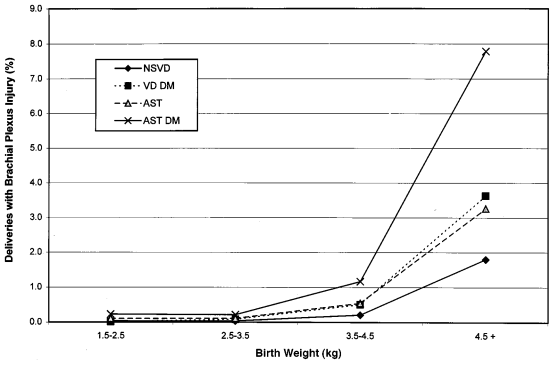

Figure 2. Frequency of brachial plexus injury associated with gestational diabetes and mode of delivery, stratified by birth weight. NSVD = normal spontaneous delivery; VD DM = normal delivery and gestational diabetes. AST = assisted vaginal delivery (forceps and vacuum extractor); AST DM = assisted vaginal delivery and gestational diabetes.

Results

Among 1,094,298 women who delivered during the 2 years, 1611 (0.15%) had diagnoses of brachial plexus injury recorded. The individual percentage risks of brachial plexus injury and associated ORs, separated by mode of delivery, are shown in Table 1. The risk of brachial plexus injury is greater in deliveries assisted by forceps or vacuum extractor. There were 60 cases (0.03%) of brachial plexus injury among women who delivered by cesarean; the frequency of brachial plexus injury among women who delivered vaginally was greater (Table 1). The risk of brachial plexus injury increased with increasing birth weight and particular modes of delivery (Figure 1). Forceps, vacuum extractor, and cesarean deliveries were associated with similar increases in brachial plexus injury with increasing birth weight.

The effect of gestational diabetes (OR 1.9, 95% confidence interval [CI] 1.7, 2.1) on brachial plexus injury is shown in Figure 2. Assisted vaginal deliveries (forceps and vacuum extractor) in nondiabetic women was equivalent to spontaneous vaginal deliveries in diabetic women in terms of frequency of brachial plexus injury (Figure 2). The macrosomic (> 4500 g) newborns of diabetic women who had assisted vaginal deliveries had the highest brachial plexus injury rate (7.8%). The

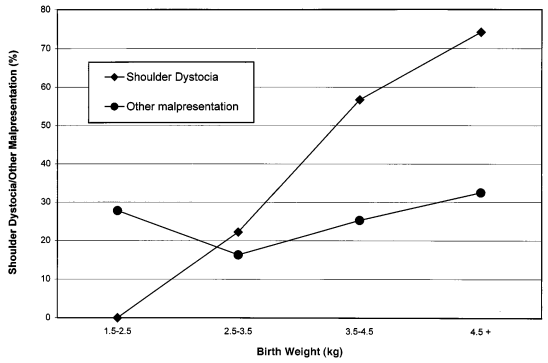

Figure 3. Frequency of shoulder dystocia and the diagnosis of other malpresentation (nonbreech) in all cases of brachial plexus injury, stratified by birth weight.

frequency of shoulder dystocia and brachial plexus injury increased with increasing birth weight, with 22% of newborns weighing 2.5–3.5 kg with brachial plexus injury also having shoulder dystocia. This increased to 74% in newborns weighing more than 4.5 kg (Figure 3). Overall, 53% of brachial plexus injury cases involved diagnoses of shoulder dystocia. However, the frequency of diagnosis of other malpresentation (ICD-9 763.1) was increased in all birth weight categories (Figure 3), exceeding shoulder dystocia in the low birth weight category. Other maternal and neonatal outcomes are displayed in Table 2. All types of birth asphyxia were increased with brachial plexus injury. Prematurity and FGR appeared to be protective against brachial plexus injury.

Table 2. Maternal and Neonatal Discharge Diagnoses in Patients With and Without Brachial Plexus Injury

Diagnosis	ICD-9 Code	Odds ratio (95% CI)	% of cases
Shoulder dystocia	660.4	76.1 (69, 84)	53.4
Severe birth asphyxia	768.5	13.6 (8.3, 22.5)	1.0
Mild birth asphyxia	768.6	6.3 (3.9, 10.1)	1.2
Hypoxia, any birth asphyxia	768	3.7 (3.1, 4.5)	7.5
Other malpresentation	763.1	73.6 (66, 83)	25.1
FGR	764	0.1 (0.03, 0.40)	0.1
Prematurity		0.8 (0.67, 0.98)	7.7
IVH	772.1	1.8 (0.6, 5.5)*	0.2
SAH	772.2	23.8 (8.8, 64.5)	0.3
NLOS >3 days		3.2 (2.8, 3.6)	19.0
NLOS >5 days		2.5 (2.2, 2.8)	11.5
Neonatal death†		0	0
Neonatal transfer		1.3 (0.9, 1.9)*	1.7
Home health services referral		2.2 (1.7, 2.8)	4

ICD-9 = International Classification of Diseases, 9th revision; CI = confidence interval; FGR = fetal growth restriction; IVH = intraventricular hemorrhage; SAH = subarachnoid hemorrhage; NLOS = neonatal length of stay.

* P = nonsignificant.

† Neonatal deaths during initial hospitalization except for transfers.

Discussion

We found individual and collective risk factors associated with diagnoses of brachial plexus injury in our population of more than 1 million deliveries. This large population allowed for a detailed analysis and reflects a true population frequency (0.15%) for the state of California.[9–14] Brachial plexus injury increased with increasing birth weight, shoulder dystocia, assisted vaginal deliveries, and gestational diabetes. The highest risk group for having newborns with brachial plexus injury (7.8%) was diabetic women who underwent forceps or vacuum-assisted deliveries and whose infants weighed more than 4.5 kg at birth (Figure 2). The frequency of diagnosis of other malpresentation was increased (OR 73.6, 95% CI 66, 83) in our population, suggesting non-shoulder dystocia causes of brachial plexus injury. Vacuum extractor and forceps deliveries increased the risk of brachial plexus injury. Cesarean delivery decreased the risk of but did not prevent brachial plexus injury (Figure 1). Neonatal morbidity was increased in newborns in our population (Table 2). The majority of newborns were discharged home, a small percentage were transferred to other institutions or referred for home health services.

One finding in our study was that more than half (53%) of all cases of brachial plexus injury were associated with diagnoses of shoulder dystocia. Among macrosomic infants, shoulder dystocia was absent in 26% of cases of brachial plexus injury. Graham et al[3] found that 53% of cases of brachial plexus injury also involved diagnoses of shoulder dystocia, whereas Jennett et al[2] found even fewer (43%) cases of brachial plexus injury to be associated with shoulder dystocia. Not all cases of brachial plexus injury are the result of difficult deliveries or traction on the anterior shoulder.[4,16,17] Ouzounian et al[4] reported on eight infants without shoulder dystocia, four of whom had a brachial plexus injury in the posterior arm that did not undergo downward traction during delivery. Shoulder dystocia might be important in brachial plexus injury, especially in macrosomic infants, but it cannot explain completely brachial plexus injury in low- and normal-weight infants.

We were surprised to find an increase in the frequency of diagnosis of other malpresentation (ICD-9, 763.1), associated (OR 73.6, CI 66, 83) with brachial plexus injury less frequently only than shoulder dystocia (Table 2). The increase in frequency of diagnosis of other malpresentation was equivalent across birth weight categories, compared with shoulder dystocia, whose frequency of diagnosis increased with increasing birth weight (Figure 3). The other malpresentation diagnosis was coded when a fetus presented abnormally (other than breech) in labor or delivery, and this

diagnosis was coded in 0.5% of the entire population. Exact fetal presentations cannot be determined from our data set because the ICD-9 coding for other malpresentation is recorded in the discharge summaries. Whether the increase in that diagnosis was due to a reporting or coding error cannot be determined from our data set. If the increase in frequency of other malpresentation is accurate, it might show a cause of brachial plexus injury. Our findings suggest two possibilities: 1) shoulder dystocia, resulting in excessive traction on the brachial plexus, is the cause of a certain percentage of cases of brachial plexus injury; and, 2) fetal malpresentation, before or during labor and delivery, results in brachial plexus injury. A small percentage (15%, Figure 3) of macrosomic infants with brachial plexus injury were not associated with shoulder dystocia or other malpresentation, suggesting other possible causes of brachial plexus injury.

A difficult problem when one is confronted with a newborn with brachial plexus injury, is whether the injury was preventable. If identifiable risk factors can be found, an elective cesarean delivery might prevent brachial plexus injury. The majority (92%) of patients in the highest risk group (diabetic women who underwent assisted vaginal delivery and whose infants weighed more than 4.5 kg at birth) did not have brachial plexus injury and cesarean delivery would have been unnecessary. If inaccuracy in estimating fetal weight is added to this equation, our success rate for identifying the high-risk group would be worse. Many associations were found between obstetric conditions (macrosomia, diabetes, forceps and vacuum extractor deliveries, obesity, prolonged labor) and brachial plexus injury, but predicting which newborns will have brachial plexus injuries is unreliable.[6,7] Infants who are delivered by cesarean have decreased risks of brachial plexus injury.[10,18] However, routine use of cesarean delivery in certain patients at increased risk was not warranted. Macrosomia is commonly associated with brachial plexus injury; however, Ecker et al[6] could not recommend routine use of cesarean delivery in the case of macrosomia. Rouse et al[19] found no benefit to elective cesarean delivery in women with estimated fetal weights of more than 4.5 kg, unless the patients also had diabetes in which case the policy (of elective cesarean) became tenable. Perlow et al[20] used multiple logistic regression to determine whether brachial plexus injury could be predicted. Only 19% of cases of brachial plexus injury were able to be identified before delivery and thus possibly were prevented.[20]

The majority of cases of brachial plexus injury diagnosed at birth resolve shortly thereafter. Nocon et al[7] found that 96% of 28 cases of brachial plexus injury diagnosed at birth resolved within 6 months after delivery. Morrison et al,[8] in a 10-year review, reported that 91% of 82 cases of brachial plexus injury resolved with no sequelae. Others[13,14,21] report similar resolution rates. The best correlation with permanent brachial plexus injury is transient brachial plexus injury, which, as we discussed earlier, cannot be identified reliably. Permanent brachial plexus injury itself cannot be identified reliably before birth. An important question about patient management involves women who present with histories of brachial plexus injury in previous pregnancies. Literature reporting on recurrent brachial plexus injury is limited. al-Qattan and al-Kharfy[22] hand surgeons who treat patients with permanent brachial plexus injury, reported a high recurrence of brachial plexus injury in their patients. Of eight women whose children had prior permanent brachial plexus injury, who delivered a total of 16 more offspring, two-thirds had infants with permanent brachial plexus injury, and the injury was worse in newborns who were also macrosomic. al-Qattan and al-Kharfy[22] concluded that elective cesarean delivery might be indicated in cases of macrosomia and a history of brachial plexus injury. Their population included a large percentage of patients with permanent brachial plexus injury, and whether the conclusion applies to patients with resolved brachial plexus injury (the majority of patients) is unclear. Gordon et al[13] found that 14% of their 59 subjects with brachial plexus injury had histories of brachial plexus injury in previous pregnancies. That information, if acted on through performance of elective cesarean delivery could have prevented brachial plexus injury in those newborns. Offering elective cesarean delivery to women with children with permanent brachial plexus injury is indicated. In cases in which prior brachial plexus injury resolved after birth, cesarean delivery should be discussed and considered as an option. We were unable to determine whether the brachial plexus injuries reported were permanent or temporary. Only information on discharges from the hospital was available, not information on follow-up visits.

Neonatal morbidities were increased in the brachial plexus injury population, with an increase in mild and severe birth asphyxia and subarachnoid hemorrhage (Table 2), confirming previous publications.[10,13,23] Evidence of increased morbidity was demonstrated indirectly by a three-fold increase in newborn lengths of stay, compared with newborns without brachial plexus injury (Table 2). Additional evidence of increased morbidity was shown by the increase in referrals to other hospitals and referrals for home health services. There were no reported neonatal deaths in the 1583 infants who were discharged from delivering hospitals. The outcomes of the 28 neonates who were referred to other

hospitals are unknown. Prematurity and FGR were protective against brachial plexus injury, probably relating to lower birth weight in those infants. The data presented here show that there are potentially multiple causes of brachial plexus injury, including shoulder dystocia, malpresentation, diabetes, and operative vaginal delivery.

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Address reprint requests to:
William M. Gilbert, MD
4860 Y Street, Suite 2500
Sacramento, CA 95817
E-mail: wmgilbert@ucdavis.edu

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