Risk Factors for Obstetric Brachial Plexus Palsy Among Neonates Delivered by Vacuum Extraction

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OBJECTIVE: The risk of obstetric brachial plexus palsy (OBPP) is increased in infants delivered instrumentally. The aim of this study was to identify risk factors for OBPP and to evaluate the association between possible risk factors linked to the duration of the vacuum extraction procedure and the subsequent risk.

METHODS: A population-based retrospective design was adopted. Using a national registry of operative vaginal deliveries linked to the Medical Birth Registry in Sweden, we evaluated by univariate and multiple logistic regression analyses the risk factors for OBPP in 13,716 women delivered by vacuum extraction. The variables assessed in the multiple logistic regression analysis were shoulder dystocia, fetal birth weight of 3,999 g or greater, fundal pressure, number of tractions, vacuum application time, parity, vacuum silicone cup, epidural anesthesia, and fetal head at the level of the ischial spines at vacuum application time.

RESULTS: Obstetric brachial plexus palsy was recorded in 153 (1.1%) infants. The following variables increased significantly the risk of OBPP in the newborn: shoulder dystocia (odds ratio 16.0; 95% confidence interval 8.9–28.7), fetal birth weight of 3,999 g or greater (7.1; 4.8–10.5), and administration of fundal pressure (1.6; 1.1–2.3). The probability of the risk of OBPP in vacuum-assisted deliveries increased in relation to vacuum extraction time (minutes).

CONCLUSION: Shoulder dystocia in the setting of vacuum extraction is a prominent risk factor for OBPP in the newborn. The risk of OBPP increases with the time required for vacuum extraction.
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LEVEL OF EVIDENCE: II-3

Obstetric brachial plexus palsy (OBPP) results from injury to the cervical roots C5–8 and Th1,[1,2]and the risk of permanent injury is high.[3] The reported incidence of OBPP is 0.5–2.7% of all births.[1,4] The main obstetric cause of OBPP is suspected to be difficulties in delivery of the shoulders.[2,5–8] In cases of shoulder dystocia, the risk of OBPP has been estimated to be as high as 53%.[9] Deliveries complicated by arrest of descent occur more often in vacuum deliveries.[10,11] This mode of delivery is associated with a higher incidence of shoulder dystocia than nonoperative vaginal delivery.[5,12,13] Recent studies have demonstrated a higher risk of OBPP in the newborn in the range of odds ratios (ORs) 2.3–17.2 in vacuum-assisted deliveries, compared with infants delivered spontaneously.[9,14–16] Each year, approximately 7% of pregnant woman are delivered by vacuum extraction in Sweden. Therefore, is it important to analyze the risk factors for OBPP by this mode of delivery.

It is generally recommended that the total vacuum extraction time not exceed 20 minutes.[12,17] However, none of these previous studies have addressed the question of how the duration of vacuum application or other factors related to vacuum extraction influence the risk of OBPP in the newborn. The aim of the present study was to identify risk factors for OBPP specifically in women delivered by vacuum extraction and to evaluate the association between OBPP and other factors linked with vacuum extraction.

MATERIALS AND METHODS

Since 1973, all deliveries in Sweden must be registered in the Medical Birth Registry of the National

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Board of Health and Welfare, Stockholm, Sweden. Data from antenatal care, delivery, and the pediatric examinations of the newborn are recorded in the registry. The reliability of information in the register has previously been studied.[18] Copies of the original medical records were obtained from the hospitals and the data compared with those in the Medical Birth Registry. Scores, ranging from 1 to 3, were subjectively rated as follows: 1 = poor; 2 = acceptable, can be used with care; and 3 = good, with a low rate of error. Compared with the original medical records, the diagnoses based on International Classification of Diseases (ICD) codes used in the present study referring to delivery were reliable (score = 3).

In the Swedish Medical Birth Registry, information on virtually all pregnancies, deliveries, and newborns has been stored since 1973. Data in the register contains 120 variables, but during the 3 years from January 1, 1995, to December 31, 1997, a national evaluation protocol with an additional 25 variables related to vaginal instrumental delivery was used in Sweden. Data were collected in a national registry for operative vaginal deliveries and linked to the Medical Birth Registry to add missing data. Only vaginal deliveries with a completed instrumental delivery protocol were included. Vaginal deliveries (n = 6,570) in which the protocol was not used or those infants delivered by forceps (n = 140) were excluded.

According to the registry 281,575 women were delivered during the period. Among these, 7.3% (n = 20,426) of infants were born by vaginal delivery assisted by vacuum extraction. We analyzed data from 13,716 deliveries of singleton neonates in Sweden during the period. Inclusion criteria were, as previously mentioned, singleton vaginal vacuum deliveries in which the instrumental delivery protocol was used. Among these, 1.1% (n = 153) of infants were identified in the register with a code for OBPP (ICD-9 code 767 G, ICD-10 codes 14.0 and 14.1). Vacuum extractions resulting in infants with OBPP were compared with all other vacuum deliveries not complicated by OBPP. The following variables were derived from the database: parity, maternal age, gestational age at delivery, induction of labor, augmentation of labor, obstetric analgesia, status of the operating obstetrician (the obstetricians in Sweden are specialists in obstetrics and gynecology after 5 years of obstetric practice), and indications for intervention by vacuum extraction: fetal distress or prolonged second stage of labor (defined as > 60 minutes for parous women and > 120 minutes for nulliparous women), vertex at or below the level of the ischial spine at the time of vacuum application, use of vacuum silicone or vacuum metal cup, fundal pressure, number of cup detachments, duration of vacuum extraction (from start of extraction to delivery of the infant), number of vacuum tractions, occurrence of shoulder dystocia, and fetal birth weight. Ethical approval for the study was obtained from the local ethics committee in Göteborg.

The association between the above factors and the occurrence of OBPP in neonates was tested with univariate logistic regression to estimate ORs with 95% confidence intervals (CIs). In the second analysis, multivariable logistic regression analysis was used to suggest predictor variables (shoulder dystocia, fetal birth weight, fundal pressure, number of tractions, vacuum application time, parity, vacuum silicone cup, epidural anesthesia, and fetal head at the level of the ischial spines at vacuum application time), which consisted of apparently independent and significant predictors of OBPP. Statistical software (SAS 8.20; SAS Institute, Cary, NC) was used for the analyses. In the next step, logistic regression was combined with spline functions. The analyses resulted in a curve of probability of the risk of OBPP related to vacuum extraction time. Continuous data were tested for significance with Wilcoxon rank-sum test. Proportions were compared by Fisher exact test, and differences were considered significant at the $P < .05$ level.

RESULTS

A total of 13,716 women were included, corresponding to 67.1% of all those delivered by vacuum extraction during the time period. There were 153 newborns with OBPP found in the group of 13,716 vacuum deliveries, corresponding to an incidence of 1.1% (153/13,716). All infants were born after 36 completed weeks of gestation. The group of excluded cases (6,570 vaginal deliveries in which the complete vacuum protocol was not used and 140 cases delivered by forceps) was comparable to the study group with regard to OBPP, maternal age, gestational age, gender, and fetal birth weight.

No differences in maternal age, gestational age at delivery, induced labor, and diabetes disease (manifest or pregnancy-induced) were found, whereas mean birth weight and parity differed between the 2 groups. The infant mean birth weight was lower in nulliparous (3,579.9 ± 507) than in parous women (3,756.2 ± 529) ($P < .001$). Among 13,716 women delivered by vacuum extraction, 10,681 were nulliparous women. However, of the total number of cases (n = 153) with OBPP, 105 infants were born by nulliparous (68.6%) and 48 by parous women (Table 1). Thus, the relative risk of OBPP was higher for parous than nulliparous women (Table 2).

Table 1. Comparison of Maternal Characteristics Between Vacuum-Assisted Deliveries That Resulted in Obstetric Brachial Plexus Palsy in Newborns and Infants Not Suffering From the Injury

	Infants With Obstetric Brachial Plexus Palsy (n = 153)	Infants Without Obstetric Brachial Plexus Palsy (n = 13,563)	*P*
Maternal age (y)	28.7 ± 4.6	29.7 ± 5.0	.7
Nulliparous women (%)	68.6	77.9	.01
Gestational age at delivery (wk)	40.1 ± 1.5	39.9 ± 1.4	.2
Diabetes, manifest or pregnancy-induced (n)	2	120	.4
Induced labor (%)	16.3	12.6	0.2
Birth weight (g)	4,172 ± 469	3,612 ± 515	< .001

Values are expressed as mean ± standard deviation unless otherwise indicated.

Table 2. Univariate Analysis of the Association Between Intrapartum Variables and Obstetric Brachial Plexus Palsy

	Obstetric Brachial Plexus Palsy (%)	OR (95% CI)	*P*
Parity			.01
Nulliparity	105/10,681 (0.98)	1.0	
Parous	48/3,035 (1.58)	1.6 (1.2–2.4)	
Augmentation of labor			.19
No oxytocin used	11/1,490 (0.74)	1.0	
Oxytocin used	142/12,226 (1.16)	1.6 (0.9–2.9)	
Epidural analgesia			.87
Yes	83/7,551 (1.10)	1.0	
No	70/6,165 (1.14)	1.0 (0.8–1.4)	
Vacuum extractor cups			.06
Silicone cup	27/3,472 (0.78)	1.0	
Metal cup	120/9,804 (1.22)	1.6 (1.0–2.4)	
Position of fetal head at vacuum application time			.01
Vertex below the ischial spines	137/12,898 (1.06)	1.0	
Vertex at the ischial spines	16/818 (1.96)	1.9 (1.1–3.1)	
Cup detachment			.22
No	128/11,925 (1.07)	1.0	
Yes	25/1,791 (1.41)	1.3 (0.8–2.0)	
Indications for assisted delivery			.02
Fetal distress	61/6,764 (0.90)	1.0	
Delay of second stage of labor	92/6,952 (1.32)	1.5 (1.1–2.0)	
Fundal pressure			< .001
No	64/8,480 (0.75)	1.0	
Yes	89/5,236 (1.70)	2.3 (1.7–3.1)	
Shoulder dystocia			< .001
No	124/13,622 (0.91)	1.0	
Yes	29/94 (30.9)	48.6 (30.1–77.9)	
Number of vacuum tractions			< .001
≤ 5	121/12,172 (0.99)	1.0	
≥ 6	32/979 (3.26)	2.8 (1.9–4.3)	
Vacuum extraction time from start of extraction to birth (min)			< .001
≤ 9	109/11,880 (0.9)	1.0	
≥ 10	44/1,764 (2.5)	2.6 (1.9–3.9)	
Birth weight (g)			< .001
≤ 3,999	53/10,616 (0.5)	1.0	
4,000–4,499	61/2,514 (2.4)	5.1 (3.6–7.3)	
≥ 4,500	39/586 (6.7)	14.5 (9.5–22.2)	
Operator status specialist registrar			.11
Yes	116/9,583 (1.21)	1.0	
No	7/4,133 (0.90)	0.7 (0.5–1.1)	

OR, odds ratio; CI, confidence interval.
Values are expressed as n/n_{total} (%) unless otherwise indicated.

The results of the univariate analysis of the association between intrapartum variables and OBPP are given in Table 2. The estimated risk of OBPP was increased by multiparity, vertex at the level of the ischial spine (versus below the ischial spine) at time of application, indication due to delay of the second stage of labor (versus fetal distress), use of fundal pressure, shoulder dystocia, 6 or more vacuum tractions (versus < 6 tractions) to complete delivery, vacuum extraction time of 10 minutes or more (versus < 10 minutes) from start of traction to birth, and fetal birth weight of 3,999 g or more. Intrapartum factors not associated with OBPP in the newborn included augmentation of labor, epidural analgesia, use of vacuum silicone cup, cup detachment, and operator experience (Table 2).

A correlation was found between vacuum extraction time from start of extraction to birth (minutes) and OBPP (Table 2). Analysis with univariate logistic regression (Table 2) showed that the probability of OBPP increased by OR 2.6 for vacuum extraction time of 10 minutes or more. Analysis by a combination of spline functions and logistic regression revealed that the probability of the risk of OBPP in vaginal vacuum deliveries increased continuously in relation to extraction time. At 5 minutes of extraction time, the estimated risk of OBPP was 0.8%, whereas at 25 minutes of extraction time, it was close to 4% (Fig. 1).

To adjust for potential confounders, all factors in the univariate model were processed by multivariate logistic regression analysis. Parity, indication for assisted delivery, delay in the second stage of labor, fetal head at the level of the ischial spine at vacuum application time, 5 or more vacuum tractions, vacuum application time, use of vacuum silicone cup, and epidural anesthesia were not significantly related to OBPP, whereas shoulder dystocia, fetal birth weight of 3,999 g or more, and fundal pressure all independently increased the risk, even after statistical adjustment. When birth weight was included as a continuous variable, the risk of OBPP was more than 7 times higher in infants of birth weight greater than 3,999 g, compared with newborns of lower weight (Table 3).

Of all cases of OBPP, 20.5% (n = 21) of the infants to nulliparous women had a birth weight of 4,500 g or more, and 24.6% of these deliveries were complicated by shoulder dystocia. A similar analysis of multiparous women resulted in 7.1% infants with a birth weight of 4,500 g or more, and 7% of these deliveries were complicated by shoulder dystocia.

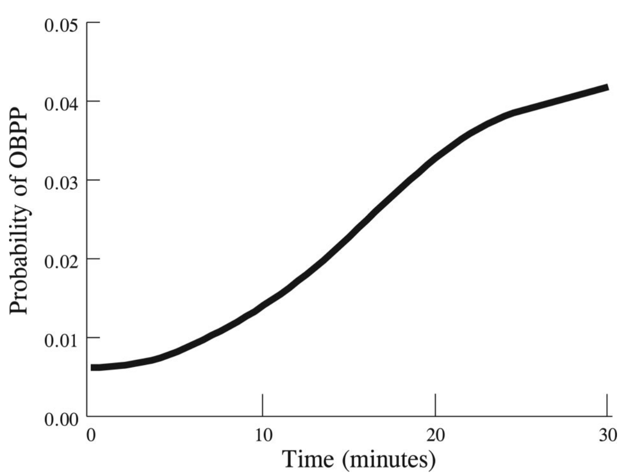

Fig. 1. Probability of the risk of obstetric brachial plexus palsy (OBPP) in vacuum-assisted deliveries in relation to vacuum extraction time (minutes) with logistic regression analysis and spline functions.

Mollberg. Obstetric Brachial Plexus Palsy. Obstet Gynecol 2005.

DISCUSSION

This retrospective study aimed to identify the risk factors of OBPP relative to the duration of vacuum application. Such detailed data are usually not easily obtained from standard birth records but were able to be retrieved from the national evaluation protocol combined with the Medical Birth Registry in Sweden.

One factor that initiated the present study was the increasing incidence of OBPP during the last decade in Sweden.[16] Vacuum extraction is an important part of obstetric practice, and this mode of delivery has recently been linked to an increased risk of OBPP in the infant.[1,9] There is an ongoing debate, as to whether OBPP is caused by a prolonged second stage of labor or is related to the vacuum extraction itself. In this study we do not focus primarily on fetal birth weight because the infant's weight is unknown at the time of vacuum application. Furthermore, the increased risk of OBPP related to high birth weight is well known from previous studies.[1,9,16] Three factors remained as independent risk factors: shoulder dystocia, fetal birth weight of 3,999 g or greater, and the use of fundal pressure during the second stage of labor. Multiple logistic regression analysis revealed that shoulder dystocia was the predominant obstetric risk factor for OBPP in vacuum-assisted deliveries. In the present study, the incidence of OBPP in vacuum-assisted deliveries was 1.1%, which is 5.5-fold higher than in the total population of vaginal deliveries[16] (Table 2). This result agrees with most previous studies, in which the incidence ranged from 0.4%[9] to 3.7%.[15] However, an incidence up to 17.6% was reported by others.[14] The reason for these discrepant findings is unclear, but the fact that most studies were not population-based could be a contributory explanation.

Table 3. **Multivariate Logistic Regression Analysis of Risk Factors Associated With Obstetric Brachial Plexus Palsy***

	Obstetric Brachial Plexus Palsy AOR (95% CI)
Shoulder dystocia	16.0 (8.9–28.7)
Fetal birth weight ≥ 3,999 g	7.1 (4.8–10.5)
Fundal pressure	1.6 (1.1–2.3)
Parous women	1.1 (0.7–1.8)
Indications for assisted delivery delay in the second stage of labor	1.3 (0.9–1.9)
Fetal head at the level of the ischial spines at vacuum application time	1.1 (0.5–2.6)
Number of vacuum tractions ≥ 5	1.1 (1.0–1.2)
Vacuum application time	1.0 (1.0–1.1)
Silicone cup	0.8 (0.5–1.3)
Epidural anaesthesia	1.1 (0.5–2.1)

AOR, odds ratios adjusted for all the other variables in this table; CI, confidence interval.

* A comparison of 153 deliveries where the infant had obstetric brachial plexus palsy and 13,563 deliveries without the injury from the Swedish Medical Birth Registry.

Nulliparous women are subjected to vacuum deliveries more often than parous women (Table 1), which is in agreement with previous studies.[10,15] On the contrary, the relative risk of OBPP is higher among parous than nulliparous women undergoing vacuum deliveries (Table 2). We have no definite explanation for this finding, but it could relate to the fact that multiparous women are giving birth to larger infants.[2] In several previous studies, the increased risk of OBPP among parous women has been associated to high infant birth weight.[6] It is also well known that infants who weigh 3,999 g or more, irrespective of parity, are at greater risk of arrest of descent of the fetal head, vacuum-assisted delivery, shoulder dystocia, and OBPP.[1,5,9,11,17] The reason for the lower percentage of infants weighing 4,500 g or more among parous women, compared with nulliparous women, may be the fact that a higher proportion of large babies are delivered spontaneously by parous women, whereas nulliparous women more often need vacuum extraction assistance.

There are data to suggest that infants born to nulliparous women are at greater risk of OBPP because of shoulder dystocia in vacuum-assisted deliveries. Of all infants with this mode of delivery, 4.3% (586/13,716) had a birth weight of 4,500 g or more. Shoulder dystocia is clearly a problem associated with large babies, especially in nulliparous women. Vacuum duration of 10 minutes or more was associated with an increased risk of OBPP in the univariate analysis (Table 2), and the risk of OBPP in the infant increased continuously as a function of the duration of extraction (Fig. 1). We found no data available in the literature for comparison, but it has been suggested that extraction should be interrupted if 3 consecutive pulls do not result in noticeable progress.[11] On the other hand, prolonged extraction per se is perhaps not the cause of OBPP. More likely, cephalopelvic proportion or insufficient contractions cause prolonged labor associated with a higher of risk of instrumental delivery, shoulder dystocia, and OBPP. Such an explanation is supported by Beall et al,[7] demonstrating that the duration of the second stage of labor was associated with shoulder dystocia but that there was no association with operative vaginal delivery.

The association between external fundal pressure and OBPP was an interesting result (Tables 2 and 3). One explanation for such a relationship could be that fundal pressure could impact the anterior shoulder behind the pubic symphysis and indirectly cause shoulder dystocia. The effect of fundal pressure during the second stage of labor has been studied previously only to a limited extent.[5,11,17] These studies suggest an association between fundal pressure and a difficult vacuum procedure[17] and that the need for fundal pressure could act as a warning sign for shoulder dystocia.[5] In the study by Gherman et al,[11] the authors found that 12% of deliveries in which fundal pressure was applied result in permanent OBPP, which is much higher than the 1.7% found in the present study. It is not clear exactly how fundal pressure is associated with a risk of OBPP. However, there is an association between fundal pressure and both prolonged second stage and high birth weight, indicating that the need for fundal pressure may serve as an indicator of a disproportionately large fetus in relation to the birth canal.

Shoulder dystocia was found to be the most significant risk factor for OBPP in our study (Tables 2 and 3). Most children with OBPP are large, with the majority (65.4%) weighing more than 3,999 g at birth (Table 2). It is known that infants of 3,999 g or more are at greater risk of complications during delivery.[1,9,11] In deliveries complicated by shoulder dystocia, the risk of OBPP was 30%, and the association with OBPP was very strong, both in the univariate and in the multivariate analysis (Tables 2 and 3). A high risk has been observed also in other studies, and a frequency as high as 53% was reported by Gilbert et al.[9] The different results obtained probably relate to the fact that there is no universal definition of shoulder dystocia and that few studies are population-based. The mechanism whereby shoulder dystocia causes OBPP is unknown. It probably relates to application of force, compression or traction on the brachial plexus, and the need to use ancillary maneuvers to deliver the shoulders.[7,13] Even if a close relationship exists, most deliveries (81%) resulting in OBPP were not complicated by shoulder dystocia (Table 2). However, we suspect that less severe difficulties in delivery of the shoulders, with the application of some traction and force to the cervical roots, could contribute in the etiology of OBPP, and still these cases may not be classified as shoulder dystocia.

In conclusion, this study indicates that, in the present population of vacuum-assisted deliveries, shoulder dystocia, fetal birth weight of 3,999 g or more, the use of fundal pressure, and prolonged vacuum extraction time were all significant risk factors for OBPP. An important decrease in OBPP could be achieved if a patient population at risk for shoulder dystocia could be identified. A cesarean delivery would be indicated in these cases to prevent the poor outcome in the infant. Unfortunately, there is no effective strategy for predicting shoulder dystocia, and still the majority of deliveries resulting in infants with OBPP were not complicated by shoulder dystocia. So the question remains: how could OBPP be prevented? We suggest that prospectively performed studies are warranted to better understand those critical factors in obstetric procedures that are associated with OBPP. Such knowledge may form the basis for modification of obstetric management so as to reduce the risk of OBPP in the infant.

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