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Obstetric brachial plexus palsy: a prospective study on risk factors related to manual assistance during the second stage of labor

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Abstract

Background. To evaluate the association between obstetric brachial plexus palsy and obstetrical maneuvers during the second stage of delivery. *Methods*. Prospective population-based case control study. Cases of obstetric brachial plexus palsy were compared with a randomly selected control group with regard to obstetric management. *Results*. Five or more obstetrical maneuvers were used to deliver the infants in 82% in the obstetric brachial plexus palsy group versus 1.8% in the controls. Risk factors independently associated with obstetric brachial plexus palsy were force applied when downward traction was imposed on the fetal head (odds ratio 15.2; 95% confidence interval 8.4–27.7). The incidence of obstetric brachial plexus palsy in the infants in the population was 3.3‰. At 18 months of age 16.1% (incidence of 0.05%) of children had residual functional deficits and downward traction with substantial force was applied in all these cases. *Conclusions*. Forceful downward traction applied to the head after the fetal third rotation represents an important risk factor of obstetric brachial plexus palsy in vaginal deliveries in cephalic presentation.

Key words: *Obstetric brachial plexus palsy, shoulder dystocia, obstetrical maneuvers*

Abbreviations: *CI: confidence intervals, OBPP: obstetric brachial plexus palsy, OR: odds ratio, VAS: visual analog scale*

Obstetric brachial plexus palsy (OBPP) is caused by injury to the cervical roots C5–8 and Th1 and is a serious form of neonatal neurologic injury (1,2). Most published data (1,3–7) imply that impaction of the shoulder is the most important predictor of OBPP. There is, however, very little information on the impact of obstetrical management and its relationship to development of OBPP (1,3–7). We hypothesized that such information could provide clinical guidance with regard to the use of various maneuvers utilized in the second stage of labor and specific obstetric procedures may be identified that later could be addressed in randomized controlled trials.

The aim was to prospectively evaluate which events and obstetrical maneuvers during the second stage of labor were associated with subsequent OBPP diagnosed after birth and which of these factors correlated to severe OBPP with remaining motor disability at 18 months of age.

Methods

The prospective population-based case control study was carried out in the western health care region of Sweden from 1999 to 2001. The local ethics committee approved the study (No. 491-98) and participating parents gave informed consent.

A flow diagram of participants is presented in Figure 1. In order to avoid systematic bias, all delivery protocols (see Table I and below) for the 31,605 deliveries were completed prior to identification of the 112 cases with OBPP and randomization of the controls. Thus, the medical staff, without

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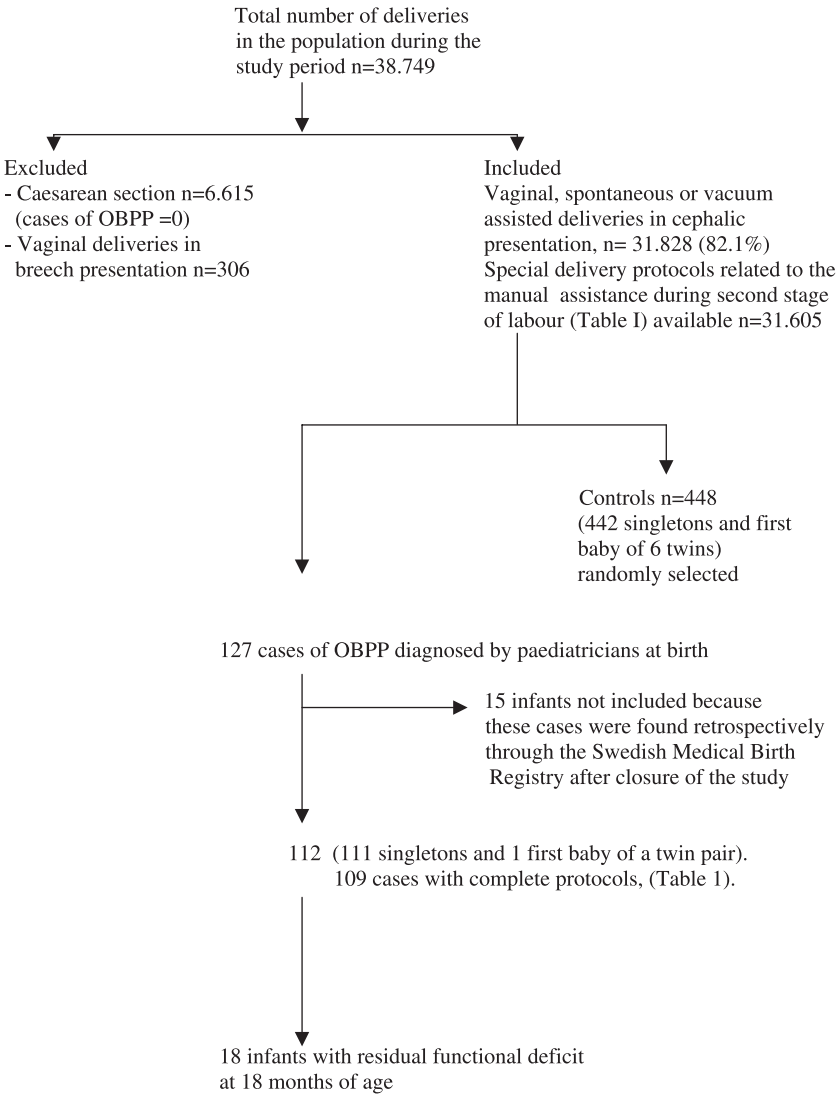

Figure 1. Study design of participants in the prospective study of OBPP and infants with residual functional deficit at 18 months of age.

knowledge of the outcome, gave detailed information about obstetric management. Included infants were those with OBPP diagnosed by the pediatrician in the postpartum ward. Women delivered by cesarean section or vaginally in breech presentation were included in the calculation of the incidence rate of OBPP in the total population, but these women were otherwise excluded. All patients/newborns delivered vaginally during the study period without diagnosis of OBPP were potential control cases. The 448 controls were selected by a random number table, practically possible as all delivery protocols (Table I) were numbered in consecutive order.

Delivery care is provided at seven units within the region and all departments have protocols for handling shoulder dystocia. The instructions include flexion of hips, application of suprapubic pressure, internal maneuvers which attempt to manipulate the infant to rotate the anterior shoulder into an oblique plane or remove the posterior arm, deliberate fracture of the clavicle, and the Zavanelli maneuver.

A delivery protocol (Table I) related to manual assistance during the second stage of labor in vaginal mode of delivery was applied, in order to obtain detailed information about obstetric management. Midwives and obstetricians evaluated the questions in the protocol in a pilot study prior to the start of the study.

Primary outcome was the need for specialized obstetrical maneuvers and the degree of manual force applied in the second stage of labor (Table I). The responsible midwife or doctor filled out the protocol after birth of the baby but without knowledge of and before diagnosis of OBPP was made. They also subjectively ranked the degree of manual force applied on an ungraded 100-mm visual analog

Table I. Delivery protocol related to manual assistance during the second stage of labor in vaginal mode of delivery

1.	Was downward traction exerted on the head in order to facilitate delivery of the anterior shoulder? Yes or no.
2.	How many active, bearing-down contractions were required, from delivery of the head to complete delivery of the infant. One, two vs. three ore more?
3.	Were the shoulders delivered during a uterine contraction? Yes or no.
4.	Was fundal pressure applied before delivery of the head? Yes or no.
5.	If the answer to question 4 is "yes": what degree of manual force was required when exerting fundal pressure? No force _____Maximal force
6.	Was fundal pressure applied after the head was delivered but before delivery of the shoulders? Yes or no.
7.	If the answer to question 6 is "yes": what degree of manual force was required when exerting fundal pressure after the head was delivered? No force _____Maximal force
8.	What was the presentation of the fetal head at delivery: right or left?
9.	Diameter of the fetal shoulder girdle, cm?
10.	Was the "turtle sign" observed, i.e. did the head retract onto the perineum after delivery? Yes or no.
11.	Was downward traction applied on the head with the sagittal suture in an essentially anteroposterior axis after the third rotation? Yes or no.
12.	If the answer to question 11 is "yes": what degree of manual force was required in this downward traction? No force_____Maximal force
13.	Was delivery of the anterior shoulder difficult? Yes or no.
14.	If the answer to question 13 is "yes": mark the degree of difficulty on the line. No difficulty _____Maximal difficulty
15.	Was the head raised in an attempt to deliver the posterior shoulder before the anterior shoulder? Yes or no.
16.	If the answer to question 15 is "yes": what degree of manual force was required in raising the fetal head? No force _____Maximal force
17.	Was the head pulled in the birth canal's axis in an attempt to deliver the shoulders? Yes or no.
18.	If the answer to question 17 is "yes": what degree of manual force was required in pulling the head? No force _____Maximal force
19.	Were the maternal hips hyperflexed (McRoberts maneuver)? Yes or no.
20.	Was suprapubic pressure applied? Yes or no?
21.	Identification of the posterior shoulder and subsequent rotation of the shoulders into an oblique/transverse plane? Yes or no.
22.	Extraction or attempted extraction by pulling the fetal armpit? Yes or no.
23.	Flexion of the posterior arm, and sweeping of the hand and upper arm over the chest and out onto the perineum? Yes or no.
24.	Interval from delivery of the fetal head to complete delivery of the infant, in seconds.

scale (VAS) scale. The scale ranged from 'no force' to 'worst conceivable force'. It was also evaluated if the primary outcome correlated to residual OBPP in the infant at 18 months of age.

All data in Table II were extracted from standard birth records and from data in Table I.

For evaluation of functional outcome related to OBPP at vaginal mode of delivery, physiotherapists evaluated all infants regularly. End-stage assessment of residual deficits related to functions on cervical roots C5–8 and Th1 in the infant were regularly evaluated by a physiotherapist (using a standardized protocol) at the age of 18 months. This time was chosen because it represented a period during which most infants are able to make functional recovery (2).

Power calculation

When planning the study we assumed that the occurrence of specialized obstetrical maneuvers (Table I) was 5% in the control group (cf. the actual occurrence in Table III). Test of statistical significance was based on the hypothesis that there was a difference in the manual assistance and use of specialized obstetrical maneuvers between cases and controls. With 70 cases of OBPP and 280 controls a minimum power of 80% and a significance of $<0.05\%$ was obtained if the true relative risk is at least 3.9.

Statistical methods

Continuous data in Table I were tested for significance with Wilcoxon's rank sum test. In Table III continuous data were tested with univariate analysis with Fisher's permutation test to estimate associations to OBPP. Statistical significance of differences in VAS is presented as mean $\pm$ standard deviation. All p-values were two-sided and $p<0.05$ was considered as statistically significant. To evaluate the independent impact of risk factors on outcome, multivariable logistic regression to estimate OR with 95% CI was performed. The results are summarized in Table IV. The independent variables analyzed were downward traction imposed on the fetal head after the fetal third rotation, fetal head raised with intention to deliver the posterior shoulder before the

Table II. Comparison between maternal and infant characteristics in cases (infants suffering from OBPP after delivery) and controls. Continuous variables are expressed as mean (standard deviation) and the other variables are expressed as %

	Cases ($n=112$)	Controls ($n=448$)	p-value
Age, mean (SD) (years)	30.5 (4.6)	29.7 (4.9)	NS
Maternal height, mean (SD) (cm)	165.3 (6.0)	166.3 (6.3)	NS
Parous women (%)	62.5	52.0	0.04
Parous women with previous history of an infant birth weight $\geq$4,000 g (%)	27.7	12.7	$<$0.001
Smoking habits (%)	12.5	15.0	NS
Body mass index, mean (SD) (kg/m^2)*	25.5 (4.4)	24.1 (3.8)	NS
Weight gain during pregnancy, mean (SD) (kg)†	13.2 (5.1)	12.7 (5.2)	NS
Fundal height, mean (SD) (cm)‡‡	37.7 (2.1)	36.5 (2.1)	NS
Gestational age at delivery, mean (SD) (weeks)	39.8 (1.5)	39.2 (1.8)	NS
Fetal presentation at time of delivery, occipito anterior position (%)	99.1	98.8	NS
Diameter of the shoulder girdle, mean (SD) (cm)	40.2 (6.4)	36.7 (6.5)	0.0001
Birth weight, mean (SD) (g)	4,357 (551.3)	3,566 (559.2)	0.0001
Large for date (%)	51.4	4	0.0001

NS, not statistically significant.
*Maternal body mass index at first visit at the antenatal care unit.
†Weight gain from first visit at the antenatal care unit to actual weight at delivery.
‡‡Fundal height measured at the last visit at the antenatal care unit.

Table III. Univariate analyses of ancillary maneuvers executed in the second stage of labor in vaginal deliveries in the OBPP and the control group. Values are given as n or %. Results of the degree of force required according to the VAS (expressed in mm) are expressed as means (SD)

	Cases ($n=109$*)	Controls ($n=448$)	Fisher's permutations test p-value
External fundal pressure applied before delivery of the head (%)	41	10	$<$0.001
Degree of force applied when fundal pressure were used before delivery of the head, mean (SD)	24.1 (32.8)	4.6 (14.8)	$<$0.001
Use of fundal pressure after delivery of the fetal head to complete delivery (%)	49	6.0	$<$0.001
Degree of force applied when fundal pressure was used after delivery of the fetal head, mean (SD)	31.2 (35.9)	2.9 (12.7)	$<$0.001
Gentle downward traction of the fetal head after the third rotation (%)	97.3	80.6	$<$0.001
Downward traction imposed on the fetal head after the fetal third rotation (%)	85	23	$<$0.001
Degree of force used in the downward traction of the fetal head after the third rotation, mean (SD)	54.8 (30.1)	8.1 (7.3)	$<$0.001
Maternal hip flexion (%)	51	13	$<$0.001
Suprapubic pressure (%)	23	2	$<$0.001
Rotation of the shoulders into oblique pelvic diameter (%)	18	1	$<$0.001
Delivery of the posterior arm by flexing the elbow and sweep the forearm over the chest to deliver the hand (%)	3	0	$<$0.001
The fetal head was raised with intention to deliver the posterior shoulder before the anterior shoulder (%)	29	7	$<$0.001
Degree of force used when the fetal head was raised with intention to deliver the posterior shoulder before the anterior shoulder, mean (SD)	20.1 (33.7)	2.3 (9.1)	$<$0.001
Extraction by pulling in the armpit of the infant (%)	11	1	$<$0.001
Try to deliver the fetal shoulders by pulling the fetal head straight on in the birth canal (%)	15	2	$<$0.001
Number of bearing down contractions from delivery of the head to complete delivery of the infant, mean (SD)	2.0 (0.8)	1.3 (0.5)	$<$0.001
Time between delivery of the head and complete delivery of the infant, mean (SD) (seconds)	80.9 (110.4)	7.4 (27.5)	$<$0.001
More than 60 seconds from delivery of the head, to completion of delivery (%)	54.1	2.7	$<$0.001
Difficulties to deliver the shoulder (%)	97.2	0.04	$<$0.001
The diagnosis code for "shoulder dystocia" was given in the mothers' record (%)	36.7	0.4	$<$0.001

*109 cases with complete protocols related to manual assistance during the second stage of labor in vaginal mode of delivery.

Table IV. Multivariable analysis of the association between obstetrical maneuvers and the risk of OBPP

	OBPP OR (95% CI)*
Downward traction imposed on the fetal head after the fetal third rotation	15.2 (8.4–27.7)
The fetal head was raised with intention to deliver the posterior shoulder before the anterior shoulder	1.3 (0.6–2.7)
Try to deliver the fetal shoulders by pulling the fetal head straight on in the birth canal	1.1 (0.4–3.2)
Rotation of the shoulders into oblique pelvic diameter	5.5 (1.6–18.9)
Extraction by pulling in the armpit of the infant	2.5 (0.6–9.4)
Delivery of the posterior arm by flexing the elbow and sweep the forearm over the chest to deliver the hand	5.2 (0.2–135.3)

*OR, odds ratio; 95% CI, 95% confidence interval.

anterior shoulder, attempt to deliver the fetal shoulders by pulling the fetal head straight on in the birth canal, rotation of the shoulders into oblique pelvic diameter, extraction by pulling in the armpit of the infant, and delivery of the posterior arm by flexing the elbow and sweep the forearm over the chest to deliver the hand. In the next step (Figure 2) logistic regression was combined with spline functions. The analyses resulted in a curve of probability of the risk of OBPP related to VAS value when downward traction was imposed.

Results

In total 127 infants suffered from OBPP corresponding to an incidence in the population of 3.3‰.

Table II shows a comparison between maternal and infant characteristics in cases of OBPP and controls. There was a higher occurrence of parous women, parous women with a previous delivery of an infant $\geq$4,000 g, and delivery of large infants in the OBPP group versus controls.

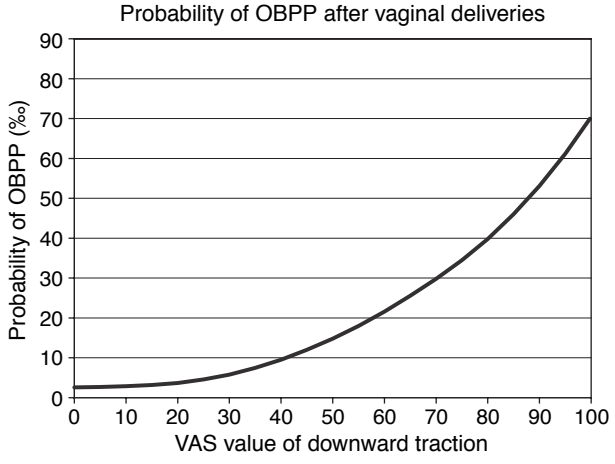

Figure 2. By use of spline functions applied in logistic regression the probability of OBPP was estimated. The constant of the logistic regression was adjusted so it corresponded to the proportion 127/(31,828–127) instead of ¼ (number of OBPP/number of non-OBPP). The VAS values in the present study were determined before the assessment of OBPP.

Use of ancillary maneuvers indicating difficulty in delivering the infant during the second stage of labor was significantly associated with increase in risk rate of OBPP (Table III). Five or more manual maneuvers in Table I (question numbers 1, 4, 6, 11, 15, 17 and 19–23) were applied in 82% of the OBPP cases compared to 1.8% of controls.

According to answers in Table I, 97.2% (106/109) of the deliveries were clinically complicated by some degree of shoulder impaction but only 36.7% of the deliveries obtained the diagnosis code for shoulder dystocia (Table III). Multivariable analysis of the association between obstetrical maneuvers and the risk of OBPP are presented in Table IV. Downward traction imposed on the fetal head after the fetal third rotation was strongly associated with OBPP and the risk increased significantly with the VAS score reflecting the force applied when downward traction was imposed (Figure 2). Rotation of the shoulders into oblique pelvic diameter was also associated with risk of OBPP in the infant.

Most infants (83.9%) suffering from OBPP at birth exhibited complete recovery of the OBPP at 18 months of age and a residual functional deficit was documented in only 18 cases (Figure 1), corresponding to a total incidence of 0.05%. Downward traction to the fetal head after the third rotation was imposed in *all* cases of residual OBPP at 18 months and in 83.3% a stronger force than 50 points on a 100-point VAS was applied, as compared to 4% in controls.

Discussion

The main finding was that downward traction directed on the head in an anteroposterior axis was strongly associated with OBPP in the infant in vaginal deliveries in cephalic presentation.

Our study has several strengths. It is prospective, population-based, and includes all 38,749 births occurring in women in the western part of Sweden from 1999 to 2001 and infants suffering from OBPP. The prospective design was important as most of the

cases requiring ancillary maneuvers to deliver the baby were not recorded as complicated by shoulder dystocia in the birth records. Secondly, obstetrical maneuvers during the second stage of labor were identified with the help of an especially designed protocol, which was a necessity to obtain the relevant information, as medical records do not always include detailed information on assistance during the second stage of labor. Thirdly, all cases with OBPP at birth underwent regular follow-up by a physiotherapist who used a standardized protocol and remaining motor disability was recorded at 18 months of age.

This study was initiated by the continuing debate on how the etiology of OBPP is related to vaginal delivery and modes of manual assistance. Two principle theories exist in the literature regarding the etiology of OBPP in newborns: the intrauterine origin and traction applied during delivery of the infants (1,2). In the present study, there was not one infant suffering from OBPP among the 6,615 cases delivered by cesarean section. Our study suggests that there are substantial differences in manual assistance in vaginal deliveries in cases of OBPP as compared to the controls. Ideally, the association between manual maneuvers like downward traction of the head and OBPP should be tested in a randomized controlled trial. However, considering the low incidence of OBPP and thereby the need for a very high number of deliveries and the problem of defining criteria for inclusion, we do not think that such a study will be performed in the near future.

Several studies (1,2) indicate that OBPP is caused by traction to the brachial plexus during labor. However, there are to our knowledge no prospective studies focused on whether some maneuver used to relieve a shoulder dystocia might constitute a higher risk to OBPP than others. From this point of view it is hard to compare our results to previous studies. We found that downward traction was imposed in the majority of OBPP cases, contrary to the situation in controls. In the most severe cases with persistent motor disability at 18 months of age, downward traction was applied in *all* OBPP cases and in most of them a considerable force (>50 points on a 100 point VAS) was applied. This finding is novel and there are no prospective studies that have been able to address this specific issue before due to the retrospective design and the lack of detailed information (1,4). In spite of the strength of this association, we are certainly aware that the present study does not allow any firm conclusions with regard to the cause–effect relationship between downward traction and OBPP. However, it seems mechanistically plausible that such a relationship exists. Firstly, forceful downward traction of the head in a situation when the shoulder is impacted under the pubic bone would be expected to lead to overstretching of the brachial plexus with a risk of damage. Secondly, if the shoulders are impacted and therefore unable to rotate into the transverse plane it is not very likely that forceful downward traction would help, but may on the contrary interfere with the mechanisms of labor and hinder the birth of the shoulders.

The data also suggest that clinicians often underestimate the seriousness of the situation as downward traction with application of a substantial force was done in the majority of OBPP cases but the delivery was still not (in most cases) considered to be complicated by shoulder dystocia. This interpretation is in agreement with Beall et al. (6), who found that shoulder dystocia is often under-reported. Hypothetically, if downward traction of the head with force was avoided and replaced by manual assistance directed more specifically at freeing the impacted shoulder (maternal hip flexion, suprapubic pressure, rotating the shoulders into an oblique plane), then we may be able to avoid some cases with OBPP. Rotating the fetal shoulders into an oblique plane was associated with more than a 5-fold increase in risk of OBPP. Once again the causality is uncertain as rotation of the shoulders is only executed in situations of severe shoulder dystocia, which in turn is associated with an increased risk of OBPP. Indeed, this procedure involving rotation of the shoulders to release the impacted anterior shoulder is a mechanically logical maneuver.

Fundal pressure was frequently administered to shorten the length of the second stage of labor in the OBPP group. It is not known if this procedure is causally related to OBPP or if this association is merely because the more severe the impaction of the shoulder the higher the likelihood that fundal pressure is applied as an effort to promote delivery. Alternatively, fundal pressure may actually be ineffective or even worsen shoulder dystocia unless simultaneous actions are taken to free the impacted shoulder. In the study by Gross et al. (7) it is suggested that the use of traction combined with fundal pressure is associated with neurological complications.

We found an OBPP incidence of 3.3‰, which is higher than the rate recently found in Sweden (5) and also higher than previous prospective estimates (3), but lower compared to some retrospective studies (1). It is, however, important to point out that after 18 months the incidence of infants suffering from OBPP at birth with remaining motor disability was only 0.05% of all births, which is

lower than previously reported (2). The follow-up period of the infants in our study was shorter than the time period presented in the review by Pondaag et al. (2). They recommend a period of follow-up of at least three years in infants suffering from OBPP at birth.

Conclusions

The results support a prevention strategy for the clinician in the management of shoulder dystocia. Instead of forceful downward traction of the head, measures should be taken to relieve the impacted shoulder. Further prospective studies are needed to provide more detailed information concerning practical management of shoulder dystocia.

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