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ORIGINAL ARTICLE

High birthweight and shoulder dystocia: the strongest risk factors for obstetrical brachial plexus palsy in a Swedish population-based study

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Background. Obstetrical brachial plexus palsy (OBPP) is a serious form of neonatal morbidity.
Objective. The aim of this work was to study the incidence of OBPP and to analyze its risk factors.
Methods. This is a population-based retrospective case–control study. All deliveries recorded in the Swedish Medical Birth Registry between 1987 and 1997 ($n = 1\,213\,987$) were investigated. Cases ($n = 2399$) with OBPP were compared to all other cases.
Results. The incidence of OBPP increased from 0.17 in 1987 to 0.27% in 1997 ($p = 0.002$). During the same time period, the mean birthweight increased from 3483 to 3525 g. Birthweight increasing from 4000 g was associated with a progressive rise in OBPP risk. Other significant risk factors associated with the injury were shoulder dystocia, breech presentation in vaginal delivery, operative vaginal delivery, diabetes mellitus, induction of labor, protracted active phase, secondary arrest of dilatation, and epidural anesthesia. Cesarean section was associated with a decreased risk of OBPP. If 5000 g is chosen as cut-off for cesarean section, 85% of the infants in this weight class are underestimated using ultrasonography. Approximately, 331 abdominal deliveries have to be performed to avoid one case of OBPP.
Conclusions. Shoulder dystocia and infant birthweight of 4500 g and more are the strongest risk factors for OBPP in a Swedish population.

Key words: fetal macrosomia; labor management; obstetrical brachial plexus palsy; shoulder dystocia

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Obstetrical brachial plexus palsy (OBPP) results from injury to the cervical roots, C5-8 and Th1 (1,2). According to some reports, most injuries are transient, with full return of function occurring in 70–92% of cases (3–5). Other studies (6–8) have shown a high incidence of permanent injury (25–78%) resulting in various degrees in life-long handicaps. Sjöberg et al. (5) suggested that these late effects of OBPP have not been taken into full consideration in the obstetric management. Difficulties in delivering the shoulders is suspected to be the main obstetrical cause of OBPP (9–13). The injury has a reported incidence of 0.5–2.6 per 1000 live births (5,6,14,15). Such a wide range could be due to differences in investigated

Abbreviations:
AOR: adjusted odds ratio; CI: confidence intervals; ICD-codes: international classification code for diseases; OBPP: obstetrical brachial plexus palsy; OR: odds ratio.

populations, reporting bias and other limitations of studies performed in a retrospective manner. Most of the studies were not population-based. The risk of an OBPP is lower after cesarean section, compared to that of a vaginal delivery (9). A recently published population-based Swedish study focusing on neonatal outcome of OBPP demonstrated a gradual increase of the incidence of the injury between 1981 and 1989 (6).

The aim of the present study was to examine the incidence of OBPP and to identify risk factors for OBPP in a population-based study.

Materials and methods

Since 1973, all deliveries in Sweden must have been registered in the Swedish Medical Birth Registry. Data from antenatal care, delivery, and the pediatric examinations of the newborn are registered in the Swedish Medical Birth Registry. The reliability of information in the registry has previously been studied (16). Copies of the original medical records were obtained from the hospitals and the data, compared to those held in the Swedish Medical Birth Registry. They found a good quality regarding the variables birth weight and diagnoses based on international classification code for diseases (ICD-codes) (16). Diagnoses were given as ICD-9 codes and ICD-10 codes. We analyzed data from the Medical Birth Registry for the year 1987–1997 ($n = 1\,213\,987$) and identified all infants ($n = 2399$), whose mothers had a code for Erb's or Klumpke's paralysis (ICD-9 code 767 G, ICD-10 codes 14.0 and 14.1) in the register. There was no change in the criteria for diagnosing Erb's or Klumpke's paralysis, but only a change in code number; accordingly, this did not cause any bias in the analysis. All cases of OBPP were compared to all other deliveries in the database. The following variables were included in the analysis: parity, smoking habits, pregestational or pregnancy-induced diabetes mellitus, induction of labor, epidural anesthesias, protracted active phase (cervical dilatation was less than 1 cm/h), secondary arrest of dilatation (no progress in 2 h after initially normal progress of labor), mode of delivery, fetal presentation, Apgar score (at 1, 5, and 10 min), birthweight divided into eight weight groups (≤1999, 2000–2499, 2500–2999, 3000–3499, 3500–3999, 4000–4499, 4500–4999, and ≥5000 g), neonates classified as large for date (>90th percentile), and gestational age (based on routine ultrasound before the completion of 17 gestational weeks) and divided into four groups (28–36 weeks + 6 days, 37–39 weeks + 6 days, 40–41 +6 days and ≥42 + 0 days).

A calculation was made to evaluate the outcome if ultrasound weight estimations were used to detect newborns with a suspected birthweight of ≥5000 g from 37 completed weeks of gestation. In addition, a calculation was made to evaluate the effect on reducing the incidence of OBPP by selecting women for cesarean section with the help of ultrasonography if the fetus was expected to be ≥5000 g. These calculations were based on the information from the 1 135 404 deliveries where information about gestational age and birthweight was available and the gestational age was ≥37 weeks.

Data analysis

The association between the above factors and the occurrence of OBPP was tested with univariate logistic regression. In the second analysis, multivariate logistic regression analysis was used and adjusted odds ratios (AOR) were calculated, as the possible risk factors were adjusted for potential confounders. Odds ratios (OR) with 95% confidence intervals (CI) were calculated. Statistical software (SAS Version 8.20) was used for the analysis.

Results

In the Swedish Medical Birth Registry, 1 213 987 births were documented between 1987 and 1997. Of these, 2399 infants had OBPP (0.19%). The incidence of OBPP in Sweden increased significantly during the period 1987–1997 ($p = 0.002$) from 0.17 in 1987 to 0.27% in 1997, as well as the mean birthweight (Fig. 1).

Univariate analyses (Table I) demonstrated that the estimated risk of OBPP was increased by maternal body mass index over 25 during the first visit at the maternal care center, diabetes mellitus, gestational age ≥40 weeks, induction of labor, epidural anesthesia, protracted active phase, secondary arrest of dilatation, operative vaginal delivery, breech presentation, shoulder dystocia, Apgar score <7 at 1, 5, and 10 min, birthweight ≥4000 g, and infants large for gestational age. The proportion of women, who smoked during their first visit to the antenatal care unit, was 26.2 in 1987 and 13.7% in 1997. Apgar score <7 at 5 min was found in 8.3% of OBPP cases, compared to that in 1.1% of the neonates without OBPP. The risk of OBPP increased with increasing birthweight; of the 2399 infants with OBPP, 66.6% had a neonatal birthweight of ≥ 4000 g (Table I).

In order to adjust to potential confounders, a multivariate logistic regression analysis was performed. If birthweight was included as a

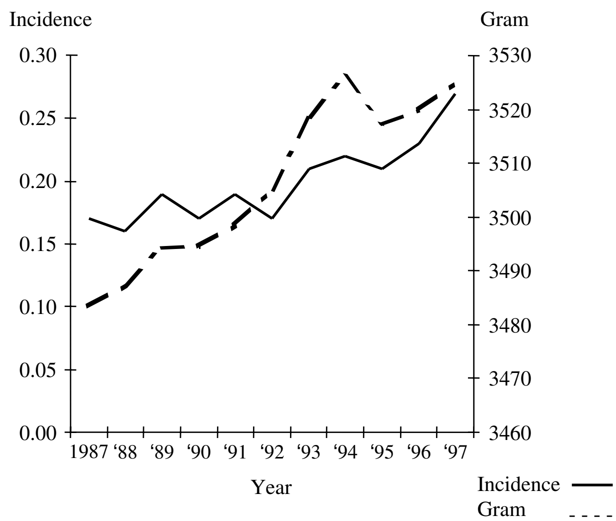

Fig. 1. Annual incidence of obstetrical brachial plexus palsy (OBPP) and mean birthweight.

Table I. Univariate analyses of the association between pregnancy and delivery variables and obstetrical brachial plexus palsy (OBPP); values given as *n/n* (%), unless otherwise indicated

	Incidence of OBPP (%)	OR (95% CI)
Multiparous	1473/713 350 (0.2)	1.0
Primiparous	926/500 637 (0.2)	0.9 (0.8–1.0)
Non-smoker at first visit at the maternal care center	2041/962 444 (0.2)	1.0
Smoker at first visit at the maternal care center	358/251 543 (0.1)	0.7 (0.6–0.8)
Body mass index at first visit at the maternal care center		
<19	27/27 686 (0.1)	0.5 (0.4–0.8)
19–25	690/382 005 (0.2)	1.0
26–30	223/74 155 (0.3)	1.6 (1.4–1.8)
>30	171/38 171 (0.5)	2.4 (2.1–2.9)
Diabetes mellitus manifest or pregnancy-induced		
No	2360/1 209 595 (0.2)	1.0
Yes	39/4392 (0.9)	4.6 (3.3–6.3)
Gestational age (weeks)		
<28	4/5519 (0.1)	0.5 (0.1–1.3)
>28 and <37	49/73 064 (0.1)	0.5 (0.3–0.6)
37 and <40	730/505 472 (0.1)	1.0
≥40 and <42	1324/546 002 (0.2)	1.68 (1.5–1.8)
>42 + 0	292/83 930 (0.3)	2.4 (2.1–2.8)
Induction of labor		
No	2165/1 148 667 (0.2)	1.0
Yes	234/65 320 (0.4)	1.9 (1.7–2.2)
Epidural anesthesia		
No	1745/1 011 416 (0.2)	1.0
Yes	654/202 571 (0.3)	1.9 (1.7–2.1)
Protracted active phase		
No	2279/1 180 271 (0.2)	1.0
Yes	120/33 716 (0.4)	1.9 (1.6–2.2)
Secondary arrest of dilatation		
No	1872/1 132 863 (0.2)	1.0
Yes	527/81 124 (0.7)	4.0 (3.6–4.4)
Mode of delivery		
Spontaneous vaginal delivery	1700/999 860 (0.2)	1.0
Cesarean section	52/141 108 (0.04)	0.2 (0.2–0.3)
Operative vaginal delivery Vacuum or forceps	648/75 030 (0.9)	5.2 (4.8–5.7)
Fetal presentation		
Vertex	1570/739 612 (0.2)	1.0
Breech	87/30 429 (0.1)	1.5 (1.2–1.8)
Shoulder dystocia		
No	1988/1 212 410 (0.2)	1.0
Yes	411/1577 (26.1)	214.6 (190.2–242.2)
Apgar score		
≥7 at 1 min	1536/1 161 819 (0.1)	1.0
<7 at 1 min	863/52 168 (1.7)	12.7 (11.7–13.8)
≥7 at 5 min	2200/1 200 449 (0.2)	1.0
<7 at 5 min	199/13 538 (1.4)	8.1 (7.0–9.4)
≥7 at 10 min	2338/1 206 986 (0.2)	1.0
<7 at 10 min	61/7001 (0.9)	4.5 (3.5–5.6)
Birthweight (g)		
≤1999	4/21 341 (0.02)	0.3 (0.1–0.5)
2000–2499	14/33 729 (0.04)	0.3 (0.2–0.5)
2500–2999	42/132 288 (0.03)	0.2 (0.1–0.3)
3000–3499	187/382 795 (0.05)	0.4 (0.3–0.4)
3500–3999	549/418 276 (0.1)	1.0
4000–4499	824/180 792 (0.5)	3.5 (3.1–3.9)
4500–4999	566/37 005 (1.5)	11.8 (10.5–13.2)
≥5000	208/4834 (4.3)	34.2 (29.1–40.2)
Large for gestational age		
No	1695/1 138 138 (0.2)	1.0
Yes	378/39 671 (1.7)	11.7 (10.7–12.6)

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

Table II. Multivariate logistic regression analysis of risk factors associated with obstetrical brachial plexus palsy (OBPP)

	OBPP AOR (95% CI)*
Shoulder dystocia	38.5 (33.5–44.2)
Breech delivery	8.8 (7.0–11.0)
Birthweight of ≥4500 g	8.7 (7.9–9.6)
Operative vaginal delivery	3.4 (3.1–3.8)
Diabetes mellitus, manifest or pregnancy-induced	2.4 (1.7–3.5)
Protracted active phase	1.5 (1.2–1.8)
Secondary arrest of dilatation	1.3 (1.2–1.5)
Epidural anesthesia	1.2 (1.1–1.3)
Induction of labor	1.1 (1.0–1.3)
Cesarean section	0.1 (0.1–0.2)

*Odds ratios are adjusted for all the other variables in this table.
AOR; adjusted odds ratios.
95% CI: 95% confidence interval.

continuous variable, the risk of OBPP was more than eight times higher in infants of birthweight of ≥4500 g, compared to that in newborns of lower weight (Table II). Shoulder dystocia, breech presentation in women delivered vaginally, high fetal birthweight (≥4500 g), operative vaginal delivery, prepregnancy- or pregnancy-induced diabetes mellitus, protracted active phase of delivery, secondary arrest of dilatation, epidural anesthesias, and induction of labor – all increased the risk of OBPP in the newborn even after statistical adjustment (Table II).

In 1987, the percentage of cases of OBPP was highest in infants with birthweight of <3999 g, whereas in 1997, the prevalence of OBPP was highest in the category of newborns weighing ≥4500 g. A birthweight of ≥5000 g was found in 0.36% of the neonates in 1987 and in 0.45% of the neonates in 1997, and a birthweight of 4000–4999 g was found in 16.9% of the neonates in 1987 and in 19.0% of the neonates in 1997. A calculation was made to estimate the impact of the increase in fetuses with a higher birthweight in 1997, compared to that in 1987. A rise in the frequency of OBPP of 0.002% could be explained by the higher frequency of higher birthweights in 1997 (Table III).

In 26% (411/1577) of the cases with OBPP, the delivery was complicated by shoulder dystocia (Table I). In cases of shoulder dystocia, the odds of OBPP increases with birthweight of ≥4000 g (Table IV). A close association is evident between OBPP and birthweight in vaginal deliveries and in shoulder dystocia. The highest OR for shoulder dystocia in vaginal delivery is in the weight group of ≥5000 g (Table IV).

Of all cases of OBPP, 98% occurred in deliveries after 37 completed weeks of gestation (Table I). A calculation was made to evaluate the outcome if ultrasound weight estimations were used to detect newborns with a suspected birthweight of ≥5000 g from 37 completed weeks. We made the assumption that the sensitivity of identifying fetuses of ≥5000 g using ultrasonography was expected to be 60% and the specificity 90%. Studies have shown that the sensitivity and specificity for finding fetuses of ≥4000 g is 60 and 90% (9,17) and we used these figures to extrapolate that the same sensitivity and specificity were applicable also to the diagnosis of fetuses of ≥5000 g. According to information from the Swedish Medical Birth Registry, there were 4811 neonates with a birthweight of ≥5000 g in a population of 1 135 404 infants. In sensitivity levels of 60% of 4811 infants (0.6×4811), 2887 of the newborns could be detected using ultrasound and classified as true positive. In the specificity levels of 90% of 1 135 404 infants in the weight class of <4999 g approximately ($0.1 \times 1\,135\,404$), 113 540 infants would be false positive.

The prevalence of OBPP was 4.3% (Table I) among neonates of ≥5000 g. Because ultrasound would detect 2887 of these infants, 124 cases (0.043×2887) of OBPP could be avoided. Cesarean section would be performed in 113 540 women with a newborn with expected birthweight of <5000 g. The prevalence of OBPP in this weight group is 0.2% and delivery by cesarean sections in all these women could avoid 227 cases ($0.02 \times 113\,540$) of OBPP. Three hundred fifty-one ($124 + 227$) cases of OBPP could be avoided by detected fetuses of over 5000 g on using ultrasound and performing 116 427 ($113\,540 + 2887$) cesarean sections. Approximately, 331 (116 427/351) abdominal deliveries

Table III. Proportions of newborns and prevalence of obstetrical brachial plexus palsy (OBPP) in different groups according to birthweight in 1987 and in 1997. Calculations were made to evaluate the impact of higher birthweights in 1987, compared to that in 1997

Weight groups (g)	Percentage of deliveries	Prevalence of OBPP in 1987, *n* (%)	Percentage of deliveries	Prevalence of OBPP in 1997, *n* (%)
<3999	82.8	67 (50.8)	80.5	67 (49.2)
4000–4499	14.2	65 (47.4)	15.5	72 (52.6)
4500–4999	2.7	42 (44.2)	3.5	53 (55.8)
>5000	0.36	15 (44.1)	0.45	19 (55.9)
Total	100	189	100	209

Table IV. The risk of obstetrical brachial plexus palsy (OBPP) in relation to birthweight in vaginal deliveries complicated by shoulder dystocia

Birthweight (g)	Incidence of shoulder dystocia (%)	Incidence of OBPP in neonates born after shoulder dystocia (%)	OBPP after shoulder dystocia, odds ratio (95% CI)*
≤3999	295/991 061 (0.03)	46/295 (15.6)	1.0
4000–4499	611/180 792 (0.3)	156/611 (25.5)	1.9 (1.3–2.7)
4500–4999	484/37 005 (1.3)	143/484 (29.5)	2.3 (1.6–3.3)
≥5000	187/4834 (3.9)	66/187 (35.3)	3.0 (1.9–4.6)

*Numbers and odds ratio with 95% confidence interval (95% CI).

had to be performed to avoid one case of OBPP, but there would still be about 2000 infants suffering from OBPP in the population.

Discussion

The incidence of OBPP increased in Sweden between 1987 and 1997. In this population-based study of more than one million deliveries, OBPP increased with shoulder dystocia, breech presentation in women delivered vaginally, high fetal birthweight (≥4500 g), operative vaginal delivery, prepregnancy- or pregnancy-induced diabetes, protracted active phase of delivery, secondary arrest of dilatation, epidural anesthesias, and induction of labor.

The incidence of OBPP in the Swedish population is in the range of international non-population-based reports (9,19). The increasing incidence of OBPP is alarming, because the causes of this increase are unknown and the risk of permanent OBPP is 25–78% (5,6,8). Over the past decade, the mean birthweight of live singletons born in Sweden has also increased steadily, which could explain on increase in OBPP from 0.17 to 0.19%, but other factors must explain the additional rise in OBPP. Our study confirms other studies (15,20) that diabetes mellitus is a significant risk factor for OBPP. In women with diabetes mellitus, a policy of using ultrasonography to identify macrosomia is justified. Rouse et al. (21) found the same in their analysis.

The observed rise in mean birthweights in Sweden is difficult to explain especially for women without diabetes. May be, the decrease in the proportion of women smoking over the 10-year period explains some of the trend to higher birthweights. Numerous other factors, such as paternal and maternal heredity, maternal prepregnancy weight, nutrition, and lifestyle, must be investigated, and a prospective study would be required. In our study, neonates with birthweight of ≥4500 g are at risk of both shoulder dystocia and OBPP (Table IV). Neonates with birthweight of ≥5000 g are rare 0.4% (4834/1 213 987) of all deliveries and represent 8.7% of all cases (208/2399) of OBPP. Gilbert et al. (15) suggest that all cases of OBPP are not related to excessive tractions of the brachial plexus at the time of delivery. It has been speculated that this complication may even be congenital, with the actual injury occurring prior to delivery. An obvious finding is that birth by caesarean section obviously offers no complete protection from OBPP (0.04%) (Table I) and the highest frequency of OBPP among infants delivered by caesarean section was found in the weight class of ≤3499 g. Some authors suggested that OBPP after cesarean delivery may result from excessive lateral traction at the time of delivery through the abdominal incision or may represent intrapartum forces on the brachial plexus before delivery (14). Rouse et al. (21) constructed a decision analytic model and used OBPP as the main outcome measure. For each permanent OBPP to be prevented, 3695 cesarean sections in cases with estimated birthweight of exceeding 4500 g would be needed, at an additional cost of USD 8.7 million. Their calculation was based on data from the literature supplemented with information from 30 333 deliveries to calculate the prevalence of macrosomia.

The risk of OBPP for infants with a birthweight of between 4000 and 4500 g (Table I) is greater than that for the general population and the risk of OBPP increases sharply beyond 4500 g (Table II) in agreement with previous studies (11,14,17,18). Should ultrasonography be used to assess high fetal weight in pregnancies of ≥37 completed weeks of gestation for the purpose of performing prophylactic cesarean delivery? A problem in this context is the poor sensitivity and specificity of identifying the large fetus antenatally. A policy of weight estimation using ultrasonography to detect infants weighing over 5000 g and perform cesarean sections would reduce the prevalence of OBPP, but far too many cesarean sections have to be performed to avoid one case of OBPP. According to our calculation, it is not cost-effective to perform prophylactic ultrasonography in all pregnant women in gestational age of $\geq$37 weeks, because the method underestimates about 85% (2004/2346) of infants with birthweight of $\geq$5000 g. The strongest predictor of OBPP is neonatal birthweight, but the inability to accurately predict birthweight before delivery limits its use in selection of patients for cesarean section.

The question remains unanswered: How could OBPP be prevented? Many of the known risk factors for OBPP interacting in the last phase of delivery and shoulder dystocia as well as the fetal weight are usually difficult to predict. The association between a prolonged second stage and shoulder dystocia has been reported (12). Our results also indicate that labor abnormalities are independent risk factors for OBPP. Prospective studies have to be performed to study the association between management in labor and the risk of OBPP. Today, there is also a problem in the evaluation of shoulder dystocia, because there is no universal definition of the complication. In our study, 26% of cases of OBPP were associated with diagnoses of shoulder dystocia, which is considerably lower, compared to the frequency of 53%, presented by Gilbert et al. (15). Such a wide range of this complication is presumably due to the unclear definition and thereby a result of underreporting.

The retrospective design of the study was based on reports to the Swedish Medical Birth Registry, which has good reliability in many respects, but has also been critically reviewed. Individual errors could occur in registering the correct diagnosis in the Swedish Medical Birth Registry, but because our population is very big, there would not be any difference of importance between cases and controls. Shoulder dystocia and infant birthweight of 4500 g and more are the strongest risk factors for OBPP in a Swedish population. Because methods of diagnosing fetal weight are limited, prospective studies of clinician managements in infants suffering from OBPP have to be studied to end the increasing prevalence of OBPP.

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