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Posted Date: 16 May 2024

doi: 10.20944/preprints202405.1104.v1

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Neurodevelopment of Children Born with Forceps Delivery

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Abstract: Background/Objectives: Forceps delivery is a crucial obstetrical technique that has been increasingly underutilized in favor of cesarean delivery, despite numerous complications related to cesarean section. The major concerns in assisted vaginal birth (AVB) are the safety and long-term consequences. Thus, we aimed to investigate the neurodevelopmental outcome of children born with forceps delivery up to the age of seven. **Methods:** A prospective descriptive study was conducted from January 2011 to December 2016 among 49 women from our department in the Clinic for Gynecology and Obstetrics, University Clinical Center of Serbia. The study included women with term singleton cephalic pregnancies. Descriptive statistics were calculated for the baseline demographic and clinical features, whereas the logistic regression analysis was used to explore the association between various perinatal parameters and neurological status of newborns. The Sarnat and Sarnat classification was used to evaluate neurological status of newborns, while long-term neurodevelopmental outcome was assesed with Griffiths Mental Development Scale and additional questions based on the neurologist's clinical practice and experience. **Results:** Pathological neurological status of the newborn was found in 16.3%, with pathological ultrasound of CNS in 3%. A statistically significant association was observed with Apgar score, odds ratio of 0.575 (95% CI: 0.407–0.813, $p = 0.002$) and perinatal asphyxia, odds ratio of 9.882 (95% CI: 1.111–87.902, $p = 0.04$). However, this was unlikely to be related to the mode of delivery. Long-term adverse neurological outcome was seen in three cases, which accounts for 6.4%. These included mild disorders, such as delayed milestone, speech delay and motor clumsiness. **Conclusion:** The present study highlights the safety of forceps delivery regarding children's neurological outcomes at 7 years of age. This is an importatnt contribution to the modern management of labor, especially in light of increasing rates of cesarean deliveries worldwide.

Keywords: forceps; assisted vaginal birth; cesarean delivery; neurodevelopment

Introduction

Assisted vaginal birth (AVB) rates have fallen globally in the last three decades, especially with rising cesarean section (CS) rates, which have significantly increased from around 7% in 1990 to 21% today, surpassing the ideal acceptable CS rate, that is around 10%–15% according to the WHO [1]. Contrary to vacuum, forceps is associated with reduced fetal trauma such as an intracranial bleeding and a greater likelihood of a successful vaginal birth, but also with increased likelihood of an obstetric anal sphincter injury. When comparing low-cavity forceps to any vacuum extractions, the protective effect of vacuum extraction was diminished [2–5]. Another study reported that overall fetal risks are higher with delivery via ventouse than via forceps [6]. On the other hand, cesarean delivery at full dilatation is associated with a higher maternal morbidity and neonatal special care unit admission

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rate than after AVB [7]. Epidemiological studies have also reported that cesarean delivery is correlated with higher risk of developing asthma, food allergy, type 1 diabetes and obesity in offspring, which leads to other non-communicable diseases [8]. It also has implications for future pregnancies. There is an increased risk for preterm birth and an increased risk for unexplained fetal death in subsequent pregnancies [9,10]. The risk for an invasively adherent placenta is greater with an increasing number of cesarean deliveries, increasing from 4% with no history of a cesarean delivery to 50% - 67% when there have been three or more cesarean deliveries [11–13]. Another condition associated with the increased risk of maternal and neonatal complications is impacted fetal head with a cesarean delivery [14,15]. The risk for impacted fetal head is increased in the second stage of labor and can be minimized with AVB [16].

According to systematic reviews of long-term follow-ups, cesarean deliveries do protect against long-term pelvic floor dysfunction, but there was no significant difference in this outcome between assisted and unassisted vaginal births [17–19].

In a recent systematic review of women and their partners views, emergency cesarean delivery was rated lowest by women in high-income countries and AVB was an acceptable alternative [20].

One study that compared outcomes of vacuum and forceps concluded that the use of forceps was associated with fewer adverse outcomes, increased quality-adjusted life years, and was more cost-effective than vacuum extraction [21].

Several potential reasons are responsible for the underuse of AVB, especially in the middle- and low-income countries. These include lack of equipment, sufficiently trained staff and adequate supervision, as well as the fear of adverse outcome [22].

In order to perform an AVB there are maternal and fetal indications, as well as contraindications that must be followed. The fetal indication is potential fetal compromise when the vertex is well below the ischial spines. Maternal indications include maternal exhaustion and prolonged second stage of labor (nulliparous: 3 hours with epidural anesthesia and 2 hours without, multiparous: 2 hours with epidural anesthesia and 1hours without). Also, criteria that are necessary before proceeding with AVB are: fully dilated cervix, rupture of membranes, engaged fetal head, knowledge of the fetal position and estimated fetal weight, maternal pelvis adequate for vaginal delivery, empty maternal bladder and a back-up plan if the operative vaginal delivery method fails [23]. Prior to any procedure, risks and benefits have to be thoroughly explained and maternal consent obtained. It is of utmost importance that operator has the appropriate knowledge, skills and experience and that a neonatologist is present in case of neonatal resuscitation [24].

Although a large number of studies have demostrated the short-term safety and beneficence of using forceps in the second stage of labor when indicated, the data of long-term effects on neurodevelopment in infants is still sparse. Thus, the aim of the present study was to evaluate neurodevelopment of children up to the age of seven.

Materials and Methods

A prospective descriptive study was conducted from January 2011 to December 2016 among 49 women from our department in the Clinic for Gynecology and Obstetrics, University Clinical Center of Serbia. The study included womenwith term singleton cephalic pregnancies. All deliveries were performed by an experienced obstetrician after the written valid and informed consent from mothers was obtained.

Data were collected using medical records and survey with the parents. Evaluated parameters included maternal demographic data such as the age, parity and gestational age at delivery, overall duration of labor, as well as the secondstage,maternal comorbidities, presence of epidural anesthesia and birth injuries to the mother. Fetal parameters comprised of birthweight, predictors of fetal distress, which is non-reassuring or abnormal cardiotocography and meconium stained amniotic fluid, signs of perinatal asphyxia, i.e., at least one of the following:laboratory parameters, pH<=7 or BE ≤-12 mmol/L in the umbilical artery or in the neonate's blood in the first hour of life, resuscitation measures applied due to slow postnatal adaptation and/or AS<=5 in the 5th minute, as well as bilirubin levels in the newborn, i.e., application of phototherapy.

Neonatal neurological status was classified as normal or pathological based on the newborn medical records - presence of cephalohematoma, neurological examination and ultrasound of the central nervous system (CNS). A pathological neurological finding meant altered muscle tone (hypotonia, hypertonia), reduced spontaneous motility, altered primitive reflexes, changes in the state of consciousness - somnolence, convulsive crises and irritability. Regarding ultrasound, ischemic encephalopathy (HIE) and intraventricular hemorrhage (IVH) grades II and III were considered a pathological finding. The Sarnat and Sarnat classification was used to evaluate neurological status and the degree of HIE [25].

The neurodevelopment of children up to 7 years of age was analyzed by a neurologist by survey with the parents. A pathological finding meant the later acquisition of milestones of early psychomotor development, behavior disorder, clumsiness in motor activity and fine motor coordination of hands - graphomotorics, slight asymmetry in muscle tone and speech delay. This assessment was based on the Griffiths Mental Development Scale and additional questions based on the neurologist's clinical practice and experience [26].

Participation in the research was voluntary for all participants and each of them was given the detailed information about the goals and methods of the research. Parents gave a written consent for the use of data for scientific and research purposes.

Ethical approval was obtained from the Ethics Committee of University Clinical Center of Serbia.

Statistical Method

Descriptive statistics were calculated for the baseline demographic and clinical features. Continuous variables were presented as means with standard deviations, while categorical variables are presented with numbers and percentages. Normality of distribution for continuous variables was tested with mathematical and graphical methods. This study employed logistic regression analysis to explore the association between various perinatal parameters and neurological status of newborns, as the plausible confounding factors. The dependent variable was neurological status, and independent variables included gender, birth weight, Apgar score, parity, duration of labor, duration of the second phase of labor, episiotomy, rupture of the cervix, perineum and/or vagina, intrapartum CTG, cephalhematoma and signs of perinatal asphyxia. Results are reported as unadjusted odds ratio and 95% CI. The level of significance was set at 0.05. Statistical analysis was performed using the IBM SPSS 21 (Chicago, IL, 2012) package.

Results

The average maternal age in the study was 30 ± 5.5 years. The majority of pregnant women (81.6%) did not have any pre-existing maternal diseases. A small percentage (6.1%) had a diagnosis of gestational hypertension. Approximately 8.2% of women were diagnosed with gestational diabetes. A minority (4.1%) had hypothyroidism as a pre-existing condition. Maternal exhaustion was the main indication (79.6%) for forceps delivery, whereas the rest (20.4%) was due to the fetal distress, according to cardiotocography and characteristics of amniotic fluid.

The mean duration of labor was 467.4 minutes, with the second phase lasting 69.7 minutes on average. Episiotomy was performed in 77.6% of cases, and rupture of the cervix, perineum, and/or vagina occurred in 40.8% of women. Epidural anaesthesia was given to 34.7% of pregnant women, whreas the rest got perineal analgesia.

Male newborns accounted for 79.6%, while females for 20.4%. The majority of babies were firstborns (83.7%), all born at term, in the 40th gestational week predominantly (95.9%). Non-reassuring intrapartum CTG and meconium stained amniotic fluid were found in 12.2% and 8.2% of cases, respectively.

Signs of perinatal asphyxia were observed in 51% of newborns, with pathological ultrasound of CNS in 3% of cases. Adverse neurological status was identified in 16.3% of newborns, with cephalhematoma observed in 40.8% and hyperbilirubinemia in 34.7% of cases. Later neurological development up to 7 years of age, classified as abnormal, was found in three cases (6.4%). One child

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was reported with delayed milestone, another one had a speech delay, whereas the third one expressed motor clumsiness, speech delay and aggressiveness. Results are presented in Table 1.

Table 1. Newborn and maternal baseline characteristics.

		n (%)
Maternal age		30 ± 5.5
Maternal comorbidity	Without	40 (81.6)
	Gestational hypertension	3 (6.1)
	Gestational diabetes	4 (8.2)
	Hypothyreosis	2 (4.1)
Parity	1	41 (83.7)
	2	5 (10.2)
	3	2 (4.1)
	4	1 (2)
Gestational age of delivery (weeks)	39	2 (4.1)
	40	47 (95.9)
Episiotomy		38 (77.6)
Rupture of the cervix, perineum and/or vagina		20 (40.8)
Epidural anaesthesia		17 (34.7)
Duration of labor (min)	467.4 ± 164.1	
Duration of the 2nd stage of labor (min)	69.7 ± 35.2	
Newborn gender	Male	39 (79.6)
	Female	10 (20.4)
Birthweight (grams)		3523.3 ± 465.1
5th min Apgar score (AS)		7.2 ± 2.4
Non-reassuring intrapartum CTG		6 (12.2)
Meconium stained amniotic fluid		4 (8.2)
Signs of perinatal asphyxia		25 (51)
Pathological ultrasound of CNS		1 (3)
Pathological neurological status of the newborn		8 (16.3)
Cephalhematoma		20 (40.8)
Hyperbilirubinemia		17 (34.7)
Adverse long-term neurological outcome		3 (6.4)

Logistic regression analysis was used to examine the association between various perinatal parameters and adverse neurological status of newborns.

The odds ratio for gender was 0.508 (95% CI: 0.055–4.686, p = 0.55), indicating no statistically significant association between gender and neurological status. Birthweight showed no significant association with neurological status (OR = 1, 95% CI: 0.998–1.001, p = 0.708). A statistically significant association was observed with Apgar score OR 0.575 (95% CI: 0.407–0.813, p = 0.002), suggesting that lower Apgar scores are associated with an increased likelihood of adverse neurological outcomes. The odds ratio for parity was 0.605 (95% CI: 0.109–3.347, p = 0.565), indicating no significant association with neurological status. There was no significant association between neither the duration of labor, nor the duration of the second phase of labor and neurological status, (OR = 1.001, 95% CI: 0.996–1.005, p = 0.757) (OR = 1.002, 95% CI: 0.981–1.023, p = 0.847), respectively. The odds ratiofor episotomy was 0.206 (95% CI: 0.041–1.027, p = 0.054), and for the rupture of cervix, perineum and/or vagina 0.426 (95% CI: 0.077–2.367, p = 0.329), suggesting no association between these parameters and short-term adverse neurological outcome.

The odds ratio for intrapartum CTG was 3.083 (95% CI: 0.459–20.697, p = 0.246), without significant relationship. The same was observed with cephalhematoma (OR = 1.562, 95% CI: 0.341–7.154, p = 0.565). A statistically significant association was found with signs of perinatal asphyxia,

 doi:10.20944/preprints202405.1104.v1

with odds ratio of 9.882 (95% CI: 1.111–87.902, p = 0.04), indicating a strong correlation between signs of perinatal asphyxia and adverse neurological outcomes in newborns. It was shown that epidural anaesthesia did not influence the neurological outcome of the newborns (OR = 1.157, 95% CI: 0.213–5.443, p = 0.88). Results are presented in Table 2.

Table 2. Logistic regression - association between perinatal factors and the neurological status of newborns.

	OR	95% CI for OR		p
Gender of the child	0.508	0.055	4.686	0.55
Birthweight	1	0.998	1.001	0.708
Apgar score	0.575	0.407	0.813	0.002
Parity	0.605	0.109	3.347	0.565
Duration of labor	1.001	0.996	1.005	0.757
Duration of the 2nd stage of labor	1.002	0.981	1.023	0.847
Episiotomy	0.206	0.041	1.027	0.054
Rupture of the cervix, perineum and/or vagina	0.426	0.077	2.367	0.329
Intrapartum CTG	3.083	0.459	20.697	0.246
Cephalhematoma	1.562	0.341	7.154	0.565
Signs of perinatal asphyxia	9.882	1.111	87.902	0.04
Epidural anaesthesia	1.157	0.213	5.443	0.88

Lower Apgar score and signs of perinatal aphyxia are the only parameters correlated with the short-term adverse neurological outcome, however, this was unlikely to be related to the mode of delivery. In view of the small number of long-term adverse outcomes, data relating to these outcomes are descriptive in nature.

Discussion

In the present study we examined the short and long term neurological outcomes of children born with forceps deliveries, since their number has decreased globally. Actually, they account for only 1.1% of vaginal deliveries, according to a retrospective cohort involving more than 22 million vaginal deliveries [27], whereas overall instrument vaginal delivery rates range between 10% and 12% [28]. Data from the Clinic for Gynecology and Obstetrics, University Clinical Center of Serbiashows a similar trend. In the period of 1987 - 2016 the lowest CS rate was observed in year 1987 (7.36%), and the highest in year 2015 (36,85%), while the highest forceps delivery rate was noted in year 1997 (2.09%), and the lowest in year 2015 (0.12%) [29].

Two different studies examining effects of AVB reported slightly lower maternal average age than the one observed here [30,31]. The previous study has shown the same percentage for gestational hypertension, but lower percentage of 3% for gestational diabetes. There was no prolonged labors, which is in accordance with another study where less than 1% of prolonged labors (>18 h) was noted [30].

Previous studies also showed higher number of male children born with forceps [30–32]. The average birthweight was similar to the findings from previous studies [30,31]. Average AS was 7.2 in the 5th minute, while 24% of newborns had AS lower than 7. One cohort study showed that 17% of children born with AVB had 5th min AS < 7 [32], whereas another one reported average 5th min AS of 8.83 among children born with AVB [31].

Adverse neurological status was identified in 16.3% of newborns, with pathological ultrasound of CNS in 3% of cases. A randomised controlled trial (RCT) comparison of ventouse, forceps and caesarean deliveries favoured forceps delivery as being least likely to cause short-term adverse neonatal neurologic outcomes [33]. According to one cohort study intraventricular hemorrhages were noted in 0.05% of forceps deliveries, in 0.07% of vacuum extractions, and in 0.08% of cesarean deliveries. The incidence of subdural hemorrhages in this cohort were 0.14%, 0.19%, and 0.09%, respectively [34]. Another study reported that Cesarean delivery in labor led to intracranial hemorrhage in 1 of 907 births, which was significantly more than for cesarean deliveries not in labor (1 of 2750) [35].

 doi:10.20944/preprints202405.1104.v1

Abnormal later neurological development up to 7 years of age was found in 6.4% of cases (4% had speech delay, 2% had motor clumsiness and 2% was reported with delayed milestone). Bahl et al. published similar results in a cohort study: 8.7% of children born with AVB had problems with speech, 2.4% with coordination and 3.9% with development [32]. Our results are in line with other studies which showed no correlation between long-term morbidity and neurodevelopment of the children up to the age of 5 and the mode of delivery [36–38]. Ayala et al. examined differences in later childhood educational outcomes after AVB and cesarean section by comparing children's third grade reading and math proficiencies and reported no differences [31].

Johanson et al. noticed that developmental outcome at age 5 was similar for both forceps and ventouse births [39]. It has also been shown that children born of Caesarean section and normal vaginal delivery have comparable school performance at age 8 [40].

A whole-of-population study done in Australia, examining children's school achievement after AVB, concluded that instrumental delivery did not have an adverse effect on neurodevelopment as measured by NAPLAN performance at age 8. However, literacy and numeracy performances were slightly better after forceps delivery, compared to ventouse and cesarean delivery [30].

Conclusions

The present study aimed to highlight the safety of forceps delivery, with the focus on long-term children's neurodevelopment up to the age of seven. We reported only three cases of mild neurodevelopmental disorders, which accounts for six percent of our sample. Although this is a tertiary center study, the relatively small sample size can be the possible limitation. Alongside another data in literature showing similar results, this paper represents an important contribution for informed decision making and appropriate management of labor for both mothers and obstetricians.

Author Contributions: Conceptualization, Sanja Kostic, Milos Petronijevic, Natasa Cerovac and Svetlana Vrzic Petronijevic; Investigation, Sanja Kostic, Katarina Ivanovic and Ivana Jovanovic; Methodology, Natasa Cerovac and Jelena Milin-Lazovic; Project administration, Miroslava Gojnic Dugalic and Svetlana Vrzic Petronijevic; Software, Jelena Milin-Lazovic; Supervision, Milos Petronijevic, Aleksandar Stefanovic and Svetlana Vrzic Petronijevic; Validation, Danijela Bratic; Visualization, Stefan Dugalic; Writing—original draft, Sanja Kostic, Katarina Ivanovic and Ivana Jovanovic; Writing—review & editing, Milos Petronijevic and Natasa Cerovac. All authors have read and agreed to the published version of the manuscript.

Funding Information: This research received no external funding.

Ethics Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the University Clinical Center of Serbia (no. 305/7) on June 29, 2023.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest Statement: The authors declare no conflicts of interest.

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