Original Article

Risk Factors for Brachial Plexus Injury and Permanent Sequelae due to Shoulder Dystocia

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Abstract

Aim: The primary aim of this study was to determine the risk factors for the occurrence of brachial plexus injury in cases of shoulder dystocia. Secondly, it was aimed to determine the factors affecting the occurrence of permanent sequelae in cases with brachial plexus injury. **Subjects and Methods:** ICD-10 codes were scanned from the records of patients who gave birth between 2012 and 2018, and the records of patients with brachial plexus injury and shoulder dystocia were reached. Shoulder dystocia cases with brachial plexus damage were accepted as the study group, and shoulder dystocia cases without brachial plexus damage were considered the control group. Shoulder dystocia patients with brachial plexus injury and without injury were compared for 2-year orthopedics clinic follow-up reports, surgical intervention, permanent sequelae status as well as birth data, maternal characteristics, and maneuvers applied to the management of shoulder dystocia. **Results:** Five hundred sixty births with shoulder dystocia were detected. Brachial plexus injury was observed in 88 of them, and permanent sequelae were detected in 12 of these patients. Maneuvers other than McRobert's (advanced maneuvers) were used more and clavicle fracture was seen more in the group with plexus injury ($P < 0.05$, $P < 0.05$, respectively). Logistic regression analysis was performed to determine the risk factors of brachial plexus injury. Brachial plexus injury was observed 4.746 times more in infants who were delivered with advanced maneuvers and 3.58 times more in infants with clavicle fractures at birth. **Conclusion:** In patients with shoulder dystocia, the risk of brachial plexus injury increased in deliveries in which advanced maneuvers were used and clavicle fracture occurred.

Keywords: *Brachial plexus injury, maneuvers, obstetric palsy, sequelae, shoulder dystocia, vaginal delivery*

Introduction

Shoulder dystocia is defined as vaginal delivery in which the delivery of the shoulders by traction fails after the delivery of the head, and additional obstetric maneuvers are needed.[1] It is an obstetric emergency observed in 0.2–3% of all deliveries.[2,3] It leads to significant perinatal mortality and morbidity. Most cases occur without a particular risk factor.[2]

Neonatal brachial plexus palsy results from injury to one or more cervical and thoracic nerve roots (C5-T1) before, during, or after the birth process.[4] Researchers in various countries have previously reported that the incidence of this injury varies between 0.38 and 5.1 per 1,000 live births.[4,5] It has been stated that 80–95% of all injuries are mild and children recover in the

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first 2 months of life.[6,7] However, according to the data obtained in recent studies, spontaneous recovery has been demonstrated to be as low as 60%, contrary to popular belief.[4] There are still questions about the etiology of neonatal brachial plexus palsy that need to be answered. In studies, fetal macrosomia, operative delivery, prolonged delivery, shoulder dystocia, multiparity, breech delivery, and gestational diabetes have been found to be associated with brachial plexus injury.[8,9] However, although some infants with neonatal brachial plexus palsy have one or more risk factors, some infants do not have any risk factors.

The primary aim of this study was to compare the antepartum and intrapartum characteristics of infants with brachial plexus injury as a result of shoulder dystocia at birth and infants with shoulder dystocia but without brachial plexus injury at birth and to reveal the risk factors of the occurrence of brachial plexus injury in cases of shoulder dystocia. Secondly, it was aimed to determine the factors affecting the occurrence of permanent sequelae in cases with brachial plexus injury.

Materials and Methods

After obtaining ethical approval from the Institutional Review Board (No. 90057706-799-11, the date of approval: 04/07/2019), which is a tertiary reference center in the field of obstetrics and gynecology, the records of births between 2012 and 2018 were obtained from the hospital data. The data of 82,307 patients who gave birth, 55,362 of which were vaginal deliveries, were scanned, and the data of 560 births with shoulder dystocia were detected. The births in which the delivery of the shoulders by traction fails after the delivery of the fetal head and additional obstetric maneuvers were required to deliver the shoulders were considered shoulder dystocia.[10] The cases were reached using the "follow-up form for infants with shoulder dystocia" available in the files of births conforming to this description. All infants with shoulder dystocia were examined by a pediatrician. Patients whose ICD-10 codes were entered as "Brachial plexus injury with diagnosis code S14.3" or "Clavicle fracture due to birth trauma with diagnosis code P13.4" after the pediatrician examination were considered infants with plexus injury. Ninety cases of brachial plexus injury were reached by scanning these ICD-10 codes. However, 2 of these 90 patients were excluded from the study because their follow-up records could not be reached. In the remaining 470 births, information on infants with shoulder dystocia without brachial plexus injury was also recorded.

Demographic data such as age, parity, gestational week, pregnancy follow-up records, the presence of gestational diabetes, oral glucose tolerance test (OGTT) results, comorbidities if any, weight gain during pregnancy, a history of shoulder dystocia in a previous pregnancy, a history of stillbirth in a previous pregnancy, a history of gestational diabetes mellitus (GDM) in a previous pregnancy, the duration of the second stage of labor, and maneuvers used in shoulder dystocia management were obtained from files.

Gestational age was calculated according to the last menstrual period (LMP) and was confirmed by first and second-trimester ultrasound examinations. According to the LMP, pregnant women were divided into three groups less than 37 weeks, between 37 and 41 weeks, and ≥ 41 weeks. Concerning parity, pregnant women were divided into four groups, namely, those who have never given birth, those who have given birth once, those who have given birth twice, and those who have given birth three or more times.[11] GDM was scanned with 50 g OGTT at 24–28 weeks of gestation. A positive 50 g OGTT was accepted as a blood glucose level of 140 mg/dL and above at the postprandial first hour. Also, 100 g OGTT was applied to pregnant women with positive 50 g OGTT. GDM was diagnosed for 100 g OGTT results. If any of the two or more measurements of glucose levels exceeded 95, 180, 155, and 140 mg/dL, under fasting and 1, 2, and 3 h after 100 g glucose intake (respectively), the diagnosis was confirmed.[12] In the study, a weight gain of more than 16 kg during pregnancy was considered excessive weight gain, and the parameter of weight gain during pregnancy was examined in two groups, under 16 kilograms and ≥16 kilograms.[13] The body mass index (BMI) parameter was divided into two as below and above 30 kg/m^2.[13]

If an obstetrician cannot deliver the shoulder with simple traction during vaginal delivery, a rescue maneuver is applied. These maneuvers include McRobert's maneuver, suprapubic pressure, delivery of the posterior arm, Wood's screw maneuver, and Rubin's maneuver.[14] If there is a recognizable risk factor for shoulder dystocia in our clinic, McRobert's maneuver is often used prophylactically. According to the data obtained from the records, McRobert's maneuver was the first maneuver applied when shoulder dystocia was encountered in all 558 cases. In cases when McRobert's maneuver was applied first and no results were obtained, infants were delivered by applying other maneuvers. The patients who were delivered with McRobert's maneuver ± suprapubic pressure were discussed as a group. The patients who could not be delivered despite McRobert's maneuver and delivered with any of Wood's maneuvers, Rubin's maneuver, delivery of the posterior arm, and Gaskin's maneuvers were accepted as advanced maneuvers. And,

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they were discussed as another group. The duration of the second stage of labor was also grouped as less than 1 h, between 1 and 2 h, and 2 h and more.[11]

Information on infants such as gender, birth weight, the presence of brachial plexus injury, and clavicle fracture was obtained from the files. The birth weight of infants was examined by dividing them into two groups <4000 g and ≥4000 g.[15]

Oligohydramnios was defined as a single deepest pocket (SDP) <2 cm or amniotic fluid index (AFI) ≤5 cm.[16] Polyhydramnios was accepted as SDP ≥8 cm and AFI ≥24 cm.[17]

Infants diagnosed with plexus injury were referred to a tertiary orthopedic clinic for follow-up. The follow-up data of the referred patients were obtained from patients' records. Data such as the nerve levels of infants with brachial plexus injury, the type of injury, the need for surgery, the sequelae of plexus injury, and the 2-year follow-up results were obtained from these records. The follow-up of infants was recorded for up to 2 years because the spontaneous functional recovery period can be considered to be at least 1 year.[18]

Brachial plexus injury can be classified as preganglionic and postganglionic and is also divided into five types according to the Sunderland classification:

Type 1: It conforms to neurapraxia in the Seddon classification. They are simple extension injuries without the disintegration of the brachial plexus and heal spontaneously.

Type 2: It conforms to axonotmesis in the Seddon classification. They are injuries in which axonal injury is present; however, the nerve sheath is intact. Spontaneous recovery is possible.

Type 3: There is also injury to the endoneurium along with axonal injury. The epineurium and perineurium are intact. It can heal spontaneously.

Type 4: There is also injury to the endoneurium and perineurium along with axonal injury. The epineurium is intact. It must be treated surgically.

Type 5: It conforms to neurotmesis in the Seddon classification. Complete nerve rupture is present. Spontaneous recovery is not expected. It must be treated surgically.[19]

The patients were divided into three groups according to this classification. Type 1 injury was considered as a group because there was spontaneous recovery. Types 2 and 3 with possible spontaneous recovery were considered as a group. Types 4 and 5 that might require surgery were considered a group. Furthermore, while evaluating the affected nerve levels, C 5-6 level, which is the most common upper trunk injury, was considered as a group, and nerve injuries at other levels (C 7-8 and T 1) were evaluated under another group.[19]

Statistical analysis

The data were analyzed using the SPSS 26.0 program. Categorical data are shown in numbers (*n*) and percentages (%). Whereas normally distributed data are shown as mean ± standard deviation (SD), non-normally distributed data are shown as median (min–max). In the study, the Chi-square test was used for categorical variables, and the Mann–Whitney *U*/independent samples *t*-test was used for numerical variables. Logistic regression analysis was used to determine risk factors. Statistical significance was considered as $P < 0.05$.

Results

In Table 1, cases with and without brachial plexus injury as a result of shoulder dystocia were compared in terms of demographic and clinical characteristics. McRobert's maneuver (with ± suprapubic pressure) was found to be applied more in the group without brachial plexus injury. Among advanced maneuvers, the delivery of the posterior arm maneuver was applied to 5.1% of patients, Wood's screw maneuver was applied to 3.6%, and the Rubin maneuver was applied to 2.4%. However, in patients with brachial plexus injury, the delivery of the posterior arm maneuver was applied to 18.4% of patients, Wood's screw maneuver was applied to 10.3%, and the Rubin maneuver was applied to 9.2%. Upon comparing the groups in terms of the maneuvers used, it was observed that advanced maneuvers were used more in the group with injury (38.6%); however, patients in the group without injury were mostly delivered with McRobert's ± suprapubic pressure maneuver (88.5%) ($P < 0.05$). Furthermore, the incidence of clavicle fracture was higher in the patient group with brachial plexus injury ($P < 0.05$). There was no statistically significant difference between the two groups for age, obstetric history, gestational diabetes, infant gender, BMI, and duration of the second stage of labor (All $P > 0.05$).

Logistic regression analysis was performed to determine the risk factors of brachial plexus injury. According to the results in Table 2, the maneuver type and clavicle fracture status were found to be statistically significant independent risk factors for brachial plexus injury ($P < 0.05$). Brachial plexus injury was observed 4.746 times more in infants who were delivered with advanced maneuvers and 3.58 times more in infants with clavicle fractures at birth [Table 2].

Although no sequelae were seen during the follow-up and treatment in 76 of 88 infants with brachial plexus

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Table 1: Comparison of demographic and clinical chracteristics of groups

	Brachial plexus injury (+)		Brachial plexus injury (-)		*P*
Age (years)	44-18 (28)	28.28±6	44-18 (28)	28.24±5.72	0.945[t]
LMD (weeks)	41-32 (38)	38.27±1.92	41-32 (38)	38.3±1.93	0.910[t]
<37 weeks	14 (15.9)		74 (15.7)		0.997[X2]
37-40 weeks	63 (71.6)		336 (71.5)		
<40 weeks	11 (12.5)		60 (12.8)		
Parity	5-0 (1)	1.16±1.14	5-0 (1)	1.19±1.14	0.807[t]
0	30 (34.1)		153 (32.6)		0.991[X2]
1	30 (34.1)		161 (34.3)		
2	16 (18.2)		91 (19.4)		
≥3	12 (13.6)		65 (13.8)		
Primiparous/multiparous					
Primiparous	30 (34.1)		153 (32.6)		0.778[X2]
Multiparous	58 (65.9)		317 (67.4)		
GDM history					
No	86 (97.7)		458 (97.4)		0.999[X2]
Yes	2 (2.3)		12 (2.6)		
Shoulder dystocia history					
No	84 (95.5)		449 (95.5)		0.999[X2]
Yes	4 (4.5)		21 (4.5)		
Stillbirth history					
No	85 (96.6)		464 (98.7)		0.156[X2]
Yes	3 (3.4)		6 (1.3)		
Amnion fluid pathology					
Polyhydramnios	5 (5.7)		27 (5.7)		0.999[X2]
Oligohydramnios	6 (6.8)		32 (6.8)		
GDM					
No	81 (92)		435 (92.6)		0.999[X2]
Yes	7 (8)		35 (7.4)		
Gender					
Male	44 (50)		237 (50.4)		0.999[X2]
Female	44 (50)		233 (49.6)		
Maneuvers					
Delivery of the posterior arm	16 (18.4)		24 (5.1)		0,000*[X2]
McRobert's	36 (41.4)		174 (37.2)		
McRobert's+Suprapubik pressure	18 (20.7)		242 (51.7)		
Rubin	8 (9.2)		11 (2.4)		
Wood's screw	9 (10.3)		17 (3.6)		
McRobert's±suprapubic pressure	54 (61.4)		416 (88.5)		0.000*[X2]
Other maneuvers	34 (38.6)		54 (11.5)		
Clavicle fracture					
No	55 (62.5)		430 (91.5)		0.000*[X2]
Yes	33 (37.5)		40 (8.5)		
Duration of second stage of labor (min)	120-10 (45)	48.07±26.13	120-10 (45)	47.98±25.29	0.976[t]
<60 mn	50 (56.8)		266 (56.6)		0.999[X2]
60-120 mn	38 (43.2)		204 (43.4)		
BMI (kg/m^2)	42-21 (30)	29.76±4.32	42-21 (30)	29.66±4.29	0.832[t]
<30 kg/m^2	41 (46.6)		225 (47.9)		0.908[X2]
≥30 kg/m^2	47 (53.4)		245 (52.1)		
Weight gain during pregnancy (kg)	36-5 (15)	16.24±6.39	36-4 (15)	16.12±6.23	0.872[t]
<16 kg	48 (54.5)		259 (55.1)		0.999[X2]
≥16 kg	40 (45.5)		211 (44.9)		
Birth weight (g)	4970-2500 (3830)	3834.77±472.29	4900-2500 (3800)	3839.11±465.6	0.936[t]
<4000 g	57 (64.8)		308 (65.5)		0.891[X2]
≥4000 g	31 (35.2)		162 (34.5)		

LMD: Gestational age according to the last menstrual period, GDM: Gestational Diabetes Mellitus, BMI: Body Mass Index. Pearson's Chi-square Test (X^2) and independent samples *t*-test (*t*) were used. *P<0.05 was accepted as significant

Table 2: Logistic regression analysis, determination of risk factors for brachial plexus injury

	B	SD	*P*	Odds	95% CI lower	95% CI upper
Advanced maneuvers	1.557	0.280	0.000*	4.746	2.742	8.215
Clavicle fracture	1.844	0.290	0.000*	6.320	3.580	11.157

B: Regression coefficent, SD: Standart deviation, *P*: Probability value, CI: Confidence interval. **P*<0.05 was accepted as significant, logistic regression analysis

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Table 3: Comparison of demographic/clinical characteristics of ınfants with and without sequelae due to brachial plexus ınjury

	Sequelae (+)		Sequelae (-)		*P*
Age (years)	44-19 (29)	28.92±6.79	40-18 (28)	28.18±5.91	0.719[U]
LMD (weeks)	41-37 (40)	39.17±1.4	41-32 (38)	38.13±1.96	0.087[U]
<37 weeks	0 (0.0)		14 (18.4)		0.252[X2]
37-40 weeks	10 (83.3)		53 (69.7)		
<40 weeks	2 (16.7)		9 (11.8)		
Parity	4-0 (1)	1.33±1.5	5-0 (1)	1.13±1.09	0.904[U]
0	4 (33.3)		26 (34,2)		0.196[X2]
1	5 (41.7)		25 (32.9)		
2	0 (0.0)		16 (21.1)		
≥3	3 (25.0)		9 (11.8)		
Primiparous/multiparous					
Primiparous	4 (33.3)		26 (34.2)		0.999[X2]
Multiparous	8 (66.7)		50 (65.8)		
GDM history					
No	12 (100)		74 (97.4)		0.999[X2]
Yes	0 (0)		2 (2.6)		
Shoulder dystocia history					
No	12 (100)		72 (94.7)		0.999[X2]
Yes	0 (0)		4 (5.3)		
Stillbirth history					
No	11 (91.7)		74 (97.4)		0.359[X2]
Yes	1 (8.3)		2 (2.6)		
Amnion fluid pathology					
Polyhydramnios	2 (16.7)		3 (3.9)		0.164[X2]
Oligohydramnios	0 (0)		6 (7.9)		
GDM					
No	11 (91.7)		70 (92.1)		0.999[X2]
Yes	1 (8.3)		6 (7.9)		
Gender					
Male	6 (50)		38 (50)		0.999[X2]
Female	6 (50)		38 (50)		
Maneuvers					
Other maneuvers	3 (25)		31 (40.8)		0.356[X2]
Mc Robert's±Suprapubik pressure	9 (75)		45 (59.2)		
Clavicle fracture					
No	8 (66.7)		47 (61.8)		0.999[X2]
Yes	4 (33.3)		29 (38.2)		
Duration of second stage of labor (minutes)	120-15 (45)	54.17±36.17	120-10 (48)	47.11±24.36	0.794[U]
<60 mn	7 (58.3)		43 (56.6)		0.999[X2]
60-120 mn	5 (41.7)		33 (43.4)		
BMI (kg/m^2)	36-22 (32)	30.67±4.31	42-21 (30)	29.62±4.33	0.277[U]
<30 kg/m^2	4 (33.3)		37 (48.7)	37 (48.7)	0.597[X2]
≥30 kg/m^2	8 (66.7)		39 (51.3)	39 (51.3)	

Contd...

Table 3: Contd...

	Sequelae (+)		Sequelae (-)		*P*
Weight gain during pregnancy (kg)	24-4 (12)	13.08±6.32	36-7 (15)	16.74±6.3	0.071[U]
<16 kg	9 (75.0)		39 (51.3)		0.223[X2]
≥16 kg	3 (25.0)		37 (48.7)		
Birth weight (gr)	4300-2750 (3835)	3798.33±415.64	4970-2500 (3825)	3840.53±482.86	0.908[U]
<4000 gr	8 (66.7)		49 (64.5)		0.999[X2]
≥4000 gr	4 (33.3)		27 (35.5)		
Plexus injury classification					
Type 1	1 (8,3)		39 (51.3)		0.000*[X2]
Type 2-3	2 (16.7)		28 (36.8)		
Type 4-5	9 (75)		9 (11.8)		
Affected nerves					
C 5-6	3 (25)		46 (60.5)		0.047*[X2]
C 5-6-7+C8-T1	9 (75)		30 (39.5)		
Surgical Intervention					
No	3 (25)		68 (89.5)		0.000*[X2]
Yes	9 (75)		8 (10.5)		

LMD: Gestational age according to the last menstrual period, GDM: Gestational Diabetes Mellitus, BMI: Body Mass Index. Pearson's Chi-square Test (X^2) and Mann-Whitney U Test (u) were used. *P<0.05 was accepted as significant

Table 4:Determination of risk factors for permanent sequelae, logistic regression Analysis

	B	SD	*P*	Odds	95% CI lower	95% CI upper
Plexus injury classification (Type 2-3)	0.815	1.370	0.552	2.260	0.154	33.115
Plexus injury classification (Type 4-5)	1.834	1.917	0.339	6.260	0.146	267.984
Affected nerves (C 5-6-7+C8-T1)	0.136	0.945	0.886	1.145	0.180	7.303
Surgical Intervention (Yes)	1.911	1.525	0.210	6.760	0.341	134.167

B: Regression coefficient, SD: Standard deviation, P: Probability value, CI: Confidence interval. *P<0.05 was accepted as significant, logistic regression analysis

injury, permanent sequelae were seen in 12 infants after 2 years of follow-up. Twelve infants with sequelae and 76 infants without sequelae were compared in terms of demographic and clinical characteristics. Type 4-5 nerve injury (75%), affected nerve group C 5-7 and C8-T1 (75%), and surgery (75%) rates were higher in patients with sequelae (P < 0.05). There was no statistically significant difference between the groups in terms of other demographic and clinical characteristics (P > 0.05) [Table 3].

Logistic regression analysis was performed to determine the risk factors for the occurrence of sequelae after brachial plexus with variables that showed significant differences according to the groups as a result of analyses. However, no statistically significant risk factor for the occurrence of sequelae was found (P > 0.05) [Table 4].

Discussion

Brachial plexus injury is one of the most troublous fetal complications during delivery. In this study, the use of advanced maneuvers in shoulder dystocia and clavicle fracture were found as independent risk factors for brachial plexus injury.

In the American Congress of Obstetricians and Gynecologists (ACOG) bulletin, the overall incidence of neonatal brachial plexus palsy was reported as 1.5 per 1,000 total births in 2014.[20] In this study, the incidence of neonatal brachial plexus was found to be 1.06 per 1,000 births. Due to the change in health policies in Turkey, there have been significant increases in the rates of cesarean sections. We think that the main determinant of this low incidence of injury in our population is the increase in cesarean section rates. However, the role of expert healthcare professionals in the management of shoulder dystocia should not be ignored.

Shoulder dystocia is the most clearly established risk factor for obstetric brachial plexus injury.[21] Because this study consisted of cases with shoulder dystocia in both groups, it can be thought that cases with the highest risk were included in the study. Thus, the bias created by this parameter is eliminated. However, high birth weight is one of the known risk factors for both brachial plexus injury and shoulder dystocia.[22,23] However, birth weight was not found to be a risk factor in this study. The fact that the birth weights of both groups were shown to be similar in this study should cause skepticism to be associated with brachial plexus injury of this factor,

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which has been reported to be the most correlated. As a matter of fact, in a large population study from the USA on brachial plexus injury, birth weight was not reported as a risk factor, similar to our study.[21] As emphasized in this study, it should be kept in mind that other risk factors may be factors in brachial plexus injury.

Although the Cochrane review concluded that prophylactic maneuvers should not be used to prevent shoulder dystocia, prophylactic McRobert's maneuver is mostly used in our clinic if there is a recognizable risk factor for shoulder dystocias such as fetal macrosomia and GDM.[24] In this study, McRobert's maneuver was found to be the most frequently used and effective maneuver. A study concluded that Mc Robert's maneuver was associated with significant success in coping with shoulder dystocia and might be associated with lower morbidity compared to other maneuvers.[25] In this study, advanced maneuvers were performed in 38.7% of infants with brachial plexus injury, and it was observed that the likelihood of brachial plexus increased significantly in deliveries with advanced maneuvers. However, in their study conducted with 285 cases of shoulder dystocia, Gherman *et al*.[26] reported that maneuver techniques used for shoulder dystocia were not associated with an increased rate of brachial plexus injury. However, this study was conducted with a small number of cases, and the Rubin maneuver was not included in the study.

Brachial plexus injury may be due to uncontrolled traction.[27] In this study, less brachial plexus injury in McRobert's and suprapubic pressure maneuvers suggested that uncontrolled traction was avoided. However, there was a significantly increased risk of brachial plexus injury in other maneuvers that may be considered more invasive. This increased risk may be due to the fact that clinicians mostly attempted to apply more traction in deliveries with advanced maneuvers.

It was reported that 25% of infants with shoulder dystocia at birth also had clavicle fractures.[28] A clavicle fracture is considered a poor prognostic factor in cases of brachial plexus injury.[29] In this study, the presence of a clavicle fracture was found as an independent risk factor for brachial plexus injury; however, it could not be shown as a significant factor for sequelae. Infants with clavicle fractures at birth should be carefully examined for brachial plexus injury and followed up appropriately.

In this study, the rates of Type 4-5 nerve damage (75%), affected nerve group C 5-7 and C8-T1 (75%), and need for surgery (75%) were found to be higher than expected in patients with permanent sequelae. Mainly, the prognosis of brachial plexus injury is closely associated with the type of the initial injury (neurapraxia, rupture, or avulsion) and the affected roots (upper, lower, middle, and total brachial plexus palsy). Concomitant Horner's syndrome and lower and total brachial plexus palsy are also considered poor prognostic factors.[30] In a study, although early surgery was recommended for patients with injury to C5-T1 nerve groups, follow-up was recommended for infants with C5-6 nerve involvement.[31] In this study, although the infants with C5-6 nerve involvement were followed up, early surgical treatment was applied to patients with C5-T1 nerve injury. In the present research, the rate of sequelae due to brachial plexus injury was also found to be 0.14 per 1,000 live births. It was determined that 13.6% of patients had sequelae. In current studies, it has been stated that 66% of cases resulted in complete recovery, a permanent deficiency remained in 20–30% of them, and significant loss of function occurred in 10–15% of them.[4] However, in this study, no independent risk factor associated with permanent sequelae was found in patients with brachial plexus injury. Unlike this study, risk factors such as high BMI and GDM were reported in the literature.[32] In the present study, a clavicle fracture was found to be a factor that did not affect the rate of permanent sequelae, although it increased the risk of brachial plexus injury. However, it is recommended to provide immediate orthopedic and physical therapy both in case of nerve injury and clavicle fracture. Although there is no predictable risk factor, it is considered that a better recovery can be achieved with quick treatment and appropriate follow-up. Therefore, in a suspected case of brachial plexus injury, treatment should be immediately initiated with a passive range of motion of the affected upper extremity.[33] It is necessary to continue focusing on early diagnosis and treatment to minimize complications. It should be kept in mind that an appropriate approach can significantly contribute to the prognosis, although no risk factor was found.

One of the strengths of the study is its application to a large cohort. The risk factors for brachial plexus injury, which is a birth complication, and permanent sequelae were reviewed, and data for Turkey were obtained. Other maneuvers other than McRobert's and suprapubic pressure were classified as advanced maneuvers and the complication rates were given separately. However, it is one of the limitations of the study to collect them under the same class, as each maneuver may not contribute to complications at the same rate. Another important limitation is the retrospective nature of the study.

In conclusion, the risk of brachial plexus injury increased in deliveries in which advanced maneuvers were used and clavicle fracture occurred. However, no risk factor has been found that increases the rate of sequelae

in infants with brachial plexus injury. Appropriate orthopedic and physical therapy and follow-ups should be arranged without delay for infants who had shoulder dystocia with the specified risk factors.

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Conflicts of interest

There are no conflicts of interest.

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