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## Obstetrical Brachial Plexus Palsy: Electrodiagnostical Study and Functional Outcome

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**Abstract:** Obstetrical Brachial Plexus Palsy (OBPP) is a complication of difficult delivery and resulted from excessive traction on the brachial plexus during delivery. Erb palsy, klumpke paralysis and panplexus palsy reported in 46, 0.6 and 20% of patients, respectively. Unilateral injury is more common than bilateral injury. Risk factors include macrosomia, multiparity, prior delivery of a child with OBPP, breech delivery shoulder dystocia, vacuum and forceps assisted delivery and excessive maternal weight gain. The recovery rate is usually reported to be between 80 and 90%. We evaluated 42 children with OBPP. Out of them, we could follow only 28 cases during two years. Poor to moderate recovery occurred in 13 cases. Good to complete (expected) recovery occurred in 15 cases. Most of the patients were females. Right side palsy was more prevalent than left side palsy. Vaginal delivery without forceps was the most mode of delivery. Vertex was the most common presentation. Most of the patients were term. The mean weight of the birth was 3.8 kg. Erb palsy and pan-plexus palsy consisted of 71.4 and 28.6% of lesions. In patients with Erb palsy, there were preganglionic palsy in 3 (15.8%) and postganglionic palsy in 16 (84.2%) cases, while all the patients with panplexus palsy had postganglionic palsy. All patients with complete recovery (9 of 15) had Erb palsy and postganglionic lesion. Erb palsy was present in 71.4% and panplexus palsy was present in 28.6% of cases. Also, 23.8% of cases had preganglionic and 76.2% of cases had postganglionic injuries.

**Key words:** Obstetrical, Brachial Plexus, Palsy, electrodiagnosis, Outcome

### INTRODUCTION

Obstetrical brachial plexus palsy (OBPP) is a complication of a difficult delivery (Vekris *et al.*, 2008) and resulted from excessive traction on the brachial plexus during delivery (Hoeksma *et al.*, 2000). The incidence of OBPP is between 0.9 and 2.3 per 1000 live births (Bager, 1997; Gorden *et al.*, 1973; Hardy, 1981; Sjobery *et al.*, 1988). According to other reports, it has a frequency of 0.38 to 1.56 per 1000 live births (Kay, 1998; Levine *et al.*, 1984). The difference seen in incidence may depend on the type of obstetric care and the average birth weight of neonates in different geographic regions (Waters, 2005).

The C5 and C6 nerve roots form the upper trunk; C7 alone forms the middle trunk and the C8 and T1 nerve roots form the lower trunk. Injury to C5-C6 (Erb palsy) found in 46% of patients with OBPP (Ruchelsman *et al.*, 2009). Upper and lower trunks involvement found in 29% of patients with OBPP (Brandt and Mackinnon, 1993). Lesion to C8-T1 (klumpke paralysis) is a very rare

condition (0.6% of all reported OBPP) (Al-Qattan *et al.*, 1995). Panplexus palsy (C5-T1 injuries) is devastating condition and found in 20% of patients (Shenaq *et al.*, 1998). In a meta-analysis, the incidence of OBPP categorized according to birth weight. The median incidence rates per 1000 live births were 0.9 (in newborns weighing less than 4000 g), 1.8 (in newborns weighing 4000-4500 g) and 2.6 (in newborns weighing more than 4500 g), respectively (Rouse *et al.*, 1996). The incidence of bilateral OBPP is 10% and seen almost exclusively in breech presentation (Joyner *et al.*, 2006). Moreover, the incidence of OBPP in newborn by cesarean section has been reported 1% (Al-Qattan and Al-Kharfy, 1996). The incidence of OBPP in vertex and breech presentations has been reported 94-97 and 1-2%, respectively.

Perinatal risk factors for OBPP include macrosomia (McFarland *et al.*, 1986; Geutjens *et al.*, 1996), multiparity, prior delivery of a child with OBPP (Al-Qattan and Al-Kharfy, 1996; Gherman *et al.*, 1999), breech delivery, prolonged labor especially second stage, shoulder

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dystocia, excessive maternal weight gain and vacuum or forceps assisted delivery (Medlock and Hanigan, 1997; Ubachs *et al.*, 1995; Gonen *et al.*, 1996; Gilbert *et al.*, 1980; Nehme *et al.*, 2002; Ghorashi *et al.*, 2008). The natural course of OBPP depends on the extent and severity of the site and type of nerve lesions. The recovery rate is usually reported to be between 80 and 90% (Hoeksma *et al.*, 2004). Management of OBPP includes nonsurgical and surgical interventions. Optimal rehabilitation of OBPP requires a multidisciplinary team of specialists including pediatrician, expert physical therapist, a pediatric surgeon, an orthopedic surgeon, an electro physiologist, an occupational therapist and a psychosocial therapist. In all cases of OBPP initial management is conservative. Goals of therapy include maintaining passive range of motion and supple joints and muscle strengthening. Specific therapy includes stretching potentially contracting muscle groups. There are indications for surgical management of OBPP including failure of recovery of elbow flexion and shoulder abduction from the 3rd to the 6th month of life (Dodds and Wolf, 2000).

The present study was designed to evaluate the long-term outcome of OBPP by physical examination and electrophysiological assessment. Also study aimed to determine:

- The frequency of OBPP causes in east Azerbaijan
- Objective and subjective functional results after physiotherapy of patients
- The function of the hands of OBPP patients managed by physiotherapy
- The frequency of various types of OBPP

## MATERIALS AND METHODS

**Participants:** Between September 2006 and September 2007 among babies with suspected OBPP that had been referred to rehabilitation ward of Tabriz Children Hospital, 42 cases having inclusion criteria entered to the study.

The study was approved by the Medical Ethical Committee of Tabriz Medical University and all parents were asked to give informed consent.

Patients followed up for at least 2 years (i.e., until 2 years of age). Seven cases could not be traced. The parents of ten children were unable to bring them to the hospital in order to the treatment and monitoring for personal reasons. The parents of remaining (fourteen cases) didn't continue treatment because of remote distant. Therefore, the final study population consisted of 28 children (17 females, 11 males), all of them were examined and observed during two years. All cases were

seen at first by rehabilitation practitioner and then by physiotherapist. Electromyography (EMG) was performed and conservative treatment had consisted of immediate initiation of physiotherapy. Physiotherapy was being carried out three sessions every week for 50 min at every session. Patients visited and evaluated by the same rehabilitation practitioner before beginning of treatment. Gentle and frequent exercise activities, putting all affected joints through a full range of motion, massage of affected limbs and frequent motivation of parents were principal measures in the prevention of contractures.

All of diagnostic measures and physiotherapy process as well as evaluation of clinical course and functional condition and finally completion of a specific questionnaire carried out and supervised by the same rehabilitation practitioner. The number of children decreased because follow-up ended when complete neurological recovery was achieved. During all these visits, neurological and orthopedic examinations were performed and carefully documented on a specific questionnaire. Every change in active or passive range of motion was discussed with the physiotherapist in order to adjust or change therapy whenever necessary.

**Diagnostic tests and clinical examination:** In all of cases, electrodiagnostical study including needle electromyography and Nerve Conduction Velocity (NCV) Studies (F-Wave, Amplitude and Latency) performed in order to evaluation of upper limb nerves. The motor strength identified and classified according to two systems: British Medical Research Council Scale (Sundholm *et al.*, 1998; Curtis *et al.*, 2002) and Mallet (Fig. 1) scale (Dodds and Wolf, 2000; Bae *et al.*, 2003). These motor function grading systems are shown in Table 1. In all of children, neurological examination of the upper limb was performed by the same examiner and by the same method.

**Inclusion criteria:** Inclusion criteria were as follows:

- Patients without history of OBPP treatment by surgery
- Patients without associated systemic diseases
- Patients without neurological findings in other limbs
- Patients without history of re-injury in affected limb due to any reason
- Patients with positive electrodiagnostical study results

**Maternal and infantile parameters:** Parameters that evaluated in this study were as follows: Patients sex,






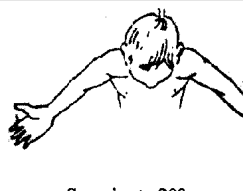









	II	III	IV
Active abduction	 Inferior to 30°	 30° to 90°	 Superior to 90°
External rotation	 0°	 Inferior to 20°	 Superior to 20°
Hand to nape of neck	 Impossible	 Difficult	 Easy
Hand to back	 Impossible	 S1	 T12
Hand to mouth	 Clonion	 Small clonion	

Fig. 1: Mallet's classification of function in brachial plexus birth palsy

injury side, mode of delivery, maternal age on delivery, fetal presentation, forceps use during vaginal delivery, gestational age on delivery, maternal weight, parity and infant age at first visit. EMG and NCV parameters were ulnar Compound Muscle Action Potential (CMAP) amplitude, median CMAP amplitude, median Sensory

Nerve Action Potential (SNAP) amplitude, thenar muscle denervation, thenar muscle recruitment, Extensor Digitorum Communis (EDC) denervation, EDC recruitment, deltoid muscle denervation, deltoid muscle recruitment, biceps denervation, biceps recruitment and type of OBPP.

Table 1: Motor Function grading systems

Grade	MRC	Mallet
0	NO constriction	
1	Visible muscle activity without movement	Absence of function
2	Active movement with gravity eliminated	Global external rotation :<0 degrees hand to mouth: trumpet sign Hand to neck :not possible Hand on spine :not possible
3	Active movement against gravity	Global abduction :30-90 degrees Global external rotation:0-20 degrees Hand to mouth :partial trumpet sign Hand to neck :difficult Hand on spine :hand to first sacral vertebra
4	Active movement against gravity and resistance	Global abduction :>90 degrees Global external rotation:>20 degrees Hand to mouth :<40 degrees of shoulder abduction Hand to neck :easy Hand on spine :hand to 12th thoracic vertebra
5	Normal Power	Normal function

MRC: Medical Research Council

**Residual deformities classification (recovery degree classification):** Criteria of OBPP deformities classification were as follows:

- Mild residual deformity (good recovery): minimal scapular winging, shoulder abduction of 90° or more, minimal limitation of shoulder rotation and forearm supination, normal hand function and normal sweat and sensation
- Moderate residual deformity (moderate recovery): moderate winging of the scapula, shoulder abduction less than 90° with substitution of the trapezius and serratus anterior in shoulder elevation, flexion contracture of the elbow, no forearm supination, weak wrist and finger extensors, good hand intrinsic muscles and some loss of sweat and sensation
- Severe residual deformity (poor recovery): marked winging of the scapula, total loss of scapulohumeral rhythm, shoulder abduction less than 45°, severe elbow flexion contracture, no forearms supination, poor or no hand function, severe loss of sweat and sensation resulting in a small atrophic extremity (Campbell *et al.*, 2005)

In this study, we considered good recovery and complete recovery as an expected recovery.

**Statistical analysis:** All data were collected and analyzed by SPSS software package for windows (version 16, SPSS Inc., IL, USA). Tests used for comparing quantitative parameters were independent samples T-test and Mann-Whitney test. Tests used for comparing qualitative parameters were Chi-square test and Fisher's exact test. Statistical significance was set at  $p < 0.05$ .

## RESULTS

We studied 42 children with OBPP during 2 years. There were 17 (40.5%) males and 25 (59.5%) females. Regarding the side of injury, there were 30 (71.4%) in the right side and 12 (28.6%) in the left side. There were 41 (97.6%) vaginal delivery and 1 (2.4%) cesarean section. There were 41 (97.6%) term and 1 (2.4%) preterm cases. Fetal presentation was vertex in 34 (81%), shoulder in 6 (14.3%), hand in 1 (2.4%) and breech in 1 (2.4%). Forceps was used in 4 (9.5%) cases. The mean weight of neonates at birth was  $3.8 \pm 0.6$  kg. The mean age of mothers on delivery was  $28.5 \pm 5.6$  years. The mean weight of mothers on delivery was  $73.5 \pm 10.8$  kg. The mean number of previous deliveries was  $2.3 \pm 1.1$ . The mean age of children at first visit was  $2.6 \pm 1.7$  weeks. There were 37 (88.1%) cases under 1 months of age and 5 (21.9%) cases more than 2 months of age. The mean CMAP amplitude values of ulnar nerve at first visit were  $3.6 \pm 2.3$  mv. There were 17 (40.5%) cases with reduced values of ulnar nerve CMAP amplitude compared with the opposite side. The mean CMAP amplitude values of median nerve at first visit were  $3.0 \pm 2.0$  mv. There were 18 (42.9%) cases with reduced values of median nerve CMAP amplitude compared with the opposite side. The mean SNAP amplitude values of median nerve were  $16.2 \pm 16.2$  mv at first visit. There were 27 (63.4%) cases with reduced values of median nerve SNAP amplitude compared with the opposite side. Thenar denervation results were zero degree in 34 (81%), 1 degree in 2 (4.8%) 2 degrees in 1 (4.8%) and 3 degrees in 5 (11.9%) cases. Thenar recruitment results were normal in 28 (66.7%), reduced in 6 (14.8%) and absent in 8 (19%) cases. EDC denervation results were zero degree in 28 (66.7%),

1 degree in 5 (11.9%), 2 degrees in 4 (9.5%) and 3 degrees in 5 (11.9%) cases. EDC recruitment results were normal in 16 (38.1%), reduced in 11 (26.2%), discrete in 6 (14.3%), single in 1 (2.4%) and absent in 8 (19%). Deltoid denervation results were zero degree in 13 (31%), 1 degree in 4 (9.5%), 2 degrees in 8 (19%), 3 degrees in 17 (40.5%). Deltoid recruitment results were reduced in 8 (19%), discrete in 5 (11.9%), single in 3 (7.1%) and absent in 26 (61.9%). Biceps denervation results were zero degree in 10 (23.8%), 1 degree in 5 (11.9%), 2 degrees in 11 (26.2%) and 3 degrees in 16 (38.1%). Biceps recruitment results were reduced in 10 (23.8%), discrete in 6 (14.3%), single in 5 (11.9%) and absent in 21 (50%). There were 30 (71.4%) cases with Erb palsy and 12 (28.6%) cases with panplexus injury. There were 10 (23.8%) cases with preganglionic injury and 32 (76.2%) cases with postganglionic injury in electrodiagnosical study. Twenty eight (66.7%) cases were followed-up. Among them, there were expected recovery in 15 (53.6%), moderate recovery in 10 (35.7%) and poor recovery in 3 (10.7%) cases. Among 15 (53.6%) cases of expected recovery, there were 9 (21.4%) cases with complete recovery without any deformity. Data obtained from the patients with expected recovery and poor to moderated recovery was compared with each other.

**Demographic and characteristic data of neonates and their mothers:** Demographic and characteristic data of neonates and their mothers classified in two groups based

on recovery status (Table 2). At the end of 2 years follow-up, electrodiagnosical study and clinical examination showed that previous history of physiotherapy was significantly higher in patients with poor to moderate recovery compared to those with expected recovery (11 vs. 7). There were expected recovery in 8 (53.3%) and poor to moderate recovery in 2 (15.4%) without any physiotherapy during two years (i.e., they had spontaneous recovery). There was not any significant difference between two groups in any other of studied variables.

**Primary electrodiagnosical findings of patients:**

Electrodiagnosical findings of patients are presented in Table 3. The number of patients with panplexus palsy was significantly higher in patients with poor to moderate recovery compared to those with expected recovery. The mean CMAP amplitude values of ulnar nerve were significantly lower in patients with poor to moderate recovery compared with those in expected recovery group. Frequency of patients with reduced values of ulnar CMAP amplitude compared to the opposite side was significantly higher in patients with poor to moderate recovery. The mean CMAP amplitude values of median nerve were significantly reduced in patients with poor to moderate recovery compared to the expected recovery group. Frequency of patients with reduced median CMAP amplitude values compared to the opposite side was significantly higher in patients with poor to moderate

Table 2: Comparison between maternal and infant characteristics in cases according to degree of recovery; continuous variables are expressed as mean ± standard deviation and the other variable are expressed as frequency (%)

Parameter	Expected recovery (non or mild deformity) (n = 15)	Poor and moderate recovery (moderate to severe deformity) (n = 13)	p-value
Sex			
M	5 (33.3)	6 (64.2)	0.488
F	10 (66.7)	7 (53.8)	
Birth weight(kg)	3.6±0.6	3.9±0.6	0.363*
Maternal age(years)	28.3±5.6	28.7±6.0	0.928*
Maternal weight(kg)	72.2±10.6	71.2±9.0	0.928*
Injury side			
R	9 (60)	9 (69.2)	0.705*
L	6 (40)	4 (30.8)	
Parity	2.3±1.0	1.9±1.3	0.185*
Mode of delivery			
V	14 (93.3)	13 (100)	0.536
CS	1 (6.7)	0 (0)	
Presentation			
Ve	12 (80)	11 (84.6)	-
S	2 (13.3)	2 (15.4)	
H	1 (6.7)	0 (0)	
Forceps use	1 (6.7)	2 (15.4)	0.583
Infant's age at firs visit (weeks)	2.5±3.9	2.3±4.3	0.413*
Physiotherapy			
Re	3 (20)	8 (61.5)	0.043
Ur	4 (26.7)	3 (23.1)	
N	8 (53.3)	2 (15.4)	
Physiotherapy period (months)	18.9±17.0	30.3±18.90.179*	

\*Non-Parametric test, CS: Cesarean section; F: Female; H: Hand; L: Left; M: Male; N: Never; R: Right; Re: Regular; S: Shoulder; Ur: Un regular; V: Vaginal; Ve: Vertex

recovery. The mean values of median SNAP amplitude in patients with poor to moderate recovery were significantly reduced. Frequency of patients with reduced median SNAP amplitude values compared to the opposite side was significantly higher in patients with poor to moderate recovery. Frequency of patients with abnormal thenar recruitment and abnormal EDC recruitment was significantly higher in patients with poor to moderate recovery. There was not any significant difference between two groups in other variables. Among 28 cases

followed-up, in patients with Erb palsy, there were preganglionic lesion in 3 and postganglionic lesion in 16 cases, while all the patients with panplexus palsy (9 cases) had postganglionic lesion.

**Outcomes of patients' follow-up:** Outcomes in two groups of patients according to recovery status are compared and presented in Table 4. Frequency of patients with shoulder contracture and elbow contracture was significantly higher in poor to moderate recovery group. The mean

Table 3: Primary electrodiagnostical findings according to degree of recovery; continuous variables are expressed as mean  $\pm$  standard deviation and the other variable are expressed as frequency (%)

Findings	Expected recovery (non) or mild deformity (n = 15)	Poor to moderate recovery (moderate to severe deformity) (n = 13)	p-value
Injury (paralysis) type			
Erb	14 (93.3)	5 (38.5)	0.004
Panplexus	1 (6.7)	8 (61.5)	
Lesion according to ganglion site			
Preganglion	2 (13.3)	1 (7.7)	0.556
Postganglion	13 (86.7)	12 (92.3)	
Ulnar CMAP amplitude (mv)	5.1 $\pm$ 1.8	2.8 $\pm$ 2.7	0.004*
Decreased ulnar amplitude CMAP amplitude (mv) <sup>o</sup>	4 (26.7)	9 (69.2)	0.024
Median CMAP amplitude (mv)	4.4 $\pm$ 2.2	1.9 $\pm$ 1.4	0.002*
Decreased median CMAP amplitude (mv) <sup>o</sup>	4 (26.7)	9 (69.2)	0.024
Median SNAP amplitude ( $\mu$ v)	28.0 $\pm$ 19.8	7.1 $\pm$ 7.5	<0.001*
Decreased median SNAP amplitude ( $\mu$ v) <sup>o</sup>	8 (53.3)	12 (92.3)	0.038
Thenar denervation <sup>Γ</sup>			
0	14 (93.3)	9 (69.2)	0.122¥
1	1 (6.7)	1 (7.7)	
2	0 (0)	1 (7.7)	
3	0 (0)	2 (15.4)	
Thenar recruitment			
Normal	13 (86.7)	5 (38.5)	0.011¥
Reduced	2 (13.3)	3 (23.1)	
Absent	0 (0)	5 (38.5)	
EDC denervation <sup>Γ</sup>			
0	13 (86.7)	8 (61.5)	0.137¥
1	2 (13.3)	2 (15.4)	
2	0 (0)	1 (7.7)	
3	0 (0)	2 (15.4)	
EDC recruitment			
Normal	9 (60)	2 (15.4)	0.016¥
Reduced	5 (33.3)	4 (30.8)	
Discrete	1 (6.7)	2 (15.4)	
Absent	0 (0)	5 (38.5)	
Deltoid denervation <sup>Γ</sup>			
0	7 (46.7)	4 (30.8)	0.390¥
1	2 (13.3)	1 (7.7)	
2	2 (13.3)	3 (23.1)	
3	4 (26.7)	5 (38.5)	
Deltoid recruitment			
Single	2 (13.3)	0 (0)	-
Reduced	6 (40)	2 (15.4)	
Discrete	0 (0)	3 (23.1)	
Absent	7 (46.7)	8 (61.5)	
Biceps denervation <sup>Γ</sup>			
0	4 (26.7)	4 (30.8)	0.569¥
1	2 (13.3)	1 (7.7)	
2	3 (20)	3 (23.1)	
3	6 (40)	5 (38.5)	
Biceps recruitment			
Single	2 (13.3)	1 (7.7)	-
Reduced	6 (40)	2 (15.4)	
Discrete	0 (0)	3 (23.1)	
Absent	7 (46.7)	7 (53.8)	

\*: Non-parametric test; ¥: Comparison based on present or absent disorder; o: compared to opposite side; Γ: fibrillation; CMAP: Compound muscle action potential; EDC: Extensor digitorum communis; SNAP: Sensory nerve action potential

Table 4: Patient's outcomes at the end of study according to degree of recovery; continuous variables are expressed as Mean±standard deviation and the other variable are expressed as frequency (%)

Outcomes	Expected recovery (non or mild deformity) (n = 15)	Poor to moderate recovery (moderate to severe deformity) (n = 13)	p-value
Self-motility	0 (0)	1 (7.7)	0.464
Homer syndrome	0 (0)	2 (15.4)	0.206
Decreased shoulder muscle force in abduction	0 (0)	0 (0)	-
Decreased elbow muscle force			
Flexion	0 (0)	0 (0)	-
Extension	0 (0)	0 (0)	-
Supination	0 (0)	0 (0)	-
Decreased wrist muscle force			
Flexion	1 (6.7)	2 (15.4)	0.583
Extension	1 (6.7)	2 (15.4)	0.583
Decreased digital muscle force			
Flexion	1 (6.7)	1 (7.7)	0.722
Extension	1 (6.7)	1 (7.7)	0.722
Contracture			
Shoulder	0 (0)	8 (61.5)	<0.001
Elbow	2 (13.3)	8 (61.5)	0.016
Wrist	0 (0)	0 (0)	-
Winging	3 (20)	3 (23.1)	0.600
Mallet	19.8±8.1	14.1±2.7	0.002*
Mallet (classified)			
15-20	5 (33.3)	12 (92.3)	0.001
21-25	10 (66.7)	1 (7.7)	
Asymmetry in upper limbs' length	7 (46.7)	11 (84.6)	0.043
Asymmetry in arm circumference	2 (13.3)	3 (23.1)	0.428
Asymmetry in forearm circumference	1 (6.7)	5 (38.5)	0.056

\*Non-parametric test

values of MALET test were significantly lower in poor to moderate recovery group. Frequency of patients with MALET test values about 15-20, was significantly higher in poor to moderate recovery group. Frequency of patients with asymmetry in upper limbs' length was significantly higher in poor to moderate recovery group. There was not any significant difference between other studied variables. All patients with complete recovery (9 of 15) had Erb palsy and postganglionic lesion.

## DISCUSSION

In this study, we investigated primary electrophysiological characteristics and the functional outcome of patients with OBPP.

**Primary characteristics of participants and known risk factors:** There is wide variation in the rate of occurrence of OBPP among different epidemiological studies. The incidence ranges from 0.38 to 3 per 1000 live births in industrialized countries (Zafeiriou and Psychogiou, 2008). In the study performed in western Sweden, the incidence of OBPP was 2.9 per 1000 live births (Lagerkvist *et al.*, 2010). The difference in incidence may depend on the type of obstetric care and the average birth weigh of infants in different geographic regions (Kay, 1998; Rouse *et al.*, 1996). In our study, we couldn't determine the incidence of OBPP because of limited data about the number of live births in our region (East Azerbaijan) in period interval of

performing this study. Moreover, there are limited reports about incidence in developing countries. In this study, there were 42 patients with OBPP, 97% of them were term and 97.6% of them had vaginal delivery. The mean weight of the patients was 3.8 kg and the mean weight of mothers on delivery was 73.5 kg. The mean age of mothers was 28.5 years on delivery. The mean number of previous deliveries was 2.3. Fetal presentations were vertex in 34 (81%), shoulder in 6 (14.3%), hand in 1 (2.4%) and breech in 1 (2.4%) in our study. Forceps was used in 4 (9.5%) cases. Similar studies have suggested various risk factors for OBPP. Shoulder dystocia, breech presentation, macrosomia, assisted delivery, multiparity and excessive maternal weight gain are known risk factors (Geutjens *et al.*, 1996; Gherman *et al.*, 1999; Gonen *et al.*, 1996; Ouzounian *et al.*, 1998; Gilbert *et al.*, 1999). The most important risk factor reported in the literature is high birth weight (>4 kg) (McFarland *et al.*, 1986; Gilbert *et al.*, 1999). According to one study, OBPP occurs least frequently in newborns weighing <4 kg and occurs three times as often in those weighing >4.5 kg (Lagerkvist *et al.*, 2010). Several studies have shown that high birth weight is associated with an increased risk of shoulder dystocia, other risk factor of OBPP (Ecker *et al.*, 1997; Langer *et al.*, 1991; Mollberg *et al.*, 2005a). OBPP occurs more frequently with breech presentation (Geutjens *et al.*, 1996; Al-Rajeh *et al.*, 1990). Several maternal risk factors cited in the literature include maternal age > 35 years, primiparity and multiparity (Geutjens *et al.*,



1996; Medlock and Hanigan, 1997; Gonen *et al.*, 1996; Shoba *et al.*, 2004; Hudic *et al.*, 2006) and obesity or excessive weight gain (Shoba *et al.*, 2004; Gurewitsch *et al.*, 2004; Mehta *et al.*, 2006). Shoulder dystocia is considered to be strong predictor for OBPP (Perlow *et al.*, 1996) and the incidence of permanent injury after shoulder dystocia is 1.6% (Gross *et al.*, 1987). Assisted delivery by forceps causes stretching of the cervical nerve roots and eventually OBPP (Mollberg *et al.*, 2005b; Gei *et al.*, 2003). Bisinella and Birch (2003), they suggested vertex presentation, vaginal delivery, shoulder dystocia and assisted delivery as risk factors for OBPP. The mean weight of neonates on delivery was 4.3 kg (Bisinella and Birch, 2003). Evans-Jones studied 323 children with OBPP. In this study 60% of patients had shoulder dystocia and 53% of them had assisted delivery. In addition, they suggested higher weight on delivery and vaginal delivery as risk factors for OBPP (Evans-Jones *et al.*, 2003). Gosk *et al.* studied 83 children. Shoulder dystocia, breech presentation and assisted delivery reported in 32.2, 4.9 and 32.2%, respectively (Gosk and Rutowski, 2005). Metaizeau and Lemelle (1991) studied 17334 patients in the United States. Shoulder dystocia, weight of delivery higher than 4.5 kg and use of forceps increased the risk of OBPP 9, 14 and 100 times, respectively. In our study, there was no statistically significant associated risk with OBPP. On the other hand, we should explain that in studies of risk factors, control group is needed. Moreover, when studies of risk factors are interpreted, we need usually to understand and determine the concepts of basic risk, relative risk, confidence interval, attributed risk, as well as the need to balance risks and benefits. Our study didn't design for determination of risk factors and it simply was epidemiological study. So we need more controlled studies with a large sample size and control group to define the risk factors of OBPP. The incidence of bilateral cases is normally 5% (Hardy, 1981; Metaizeau and Lemelle, 1991). There was unilateral paralysis in all of patients in this study. Female sex frequency was higher than males in our studied population (59.5% vs. 40.5%). Also, the mean age of the neonates was 2.6±1.7 weeks. There is not any report about impact of gender on the incidence of OBPP (Strombeck *et al.*, 2007). The duration of recovery in OBPP is important in identifying the type of treatment and surgical intervention. In many studies absent significant recovery until 3 months of age is considered as a strong indication for surgical interventions (Pondaag *et al.*, 2004). Due to the early admission of studied population (usually earlier than one month), there was no delay in treatment in this study. However, we introduced patients with poor to moderate

recovery after 3-6 months to surgical interventions, but their parents refused. On the other hand, parental education immediately after delivery is the most important helpful strategy in these patients.

#### **Electrodiagnosical findings in primary analysis of children:**

There were a reduced CMAP amplitude values of ulnar and median nerve and reduced SNAP amplitude values of median nerve compared to the unaffected side in nearly 50% of cases. Biceps and deltoid were more severely affected than thenar and EDC regarding recruitment and denervation. Erb palsy was present in 71.4% and panplexus palsy was present in 28.6% of cases. Also, 23.8% of cases had preganglionic and 76.2% of cases had postganglionic lesions. Similar to results of the present study, studies have showed that Erb palsy was the most common form of OBPP and isolated klumpke paralysis was the rare one (Al-Qattan *et al.*, 1995). In two studies conducted by Al-Qattan *et al.* (1996) and Shenaq, the incidence of Erb palsy was 73-86% and the incidence of panplexus and klumpke paralysis were 20 and 0.6%, respectively. Yilmaz *et al.* (1999) studied 13 children with OBPP. Erb palsy include in 61.5% of cases while 38.5% of them had panplexus palsy. In Gopinath *et al.* (2005) study, Erb palsy, panplexus and klumpke paralysis occurred in 42.9, 35.7 and 21.4% of cases, respectively (Gopinath *et al.*, 2005). Eng *et al.* (1996) studied 186 patients and reported Erb palsy in 88% of cases (Eng *et al.*, 1996). Our findings are similar to other studies. It is clear that the type of involvement in upper limb is greatly influenced by the affected roots. One study showed increased incidence of involvement of external rotator and abductor of shoulders, elbow flexors and wrist supinators in OBPP patients because of increased incidence of Erb palsy (Dodds and Wolf, 2000).

**Patients' outcomes in two years follow up:** We followed 28 (66.7%) patients for two years. Physiotherapy was performed in 18 (64.3%) patients which was irregular in 7 (38.9%) cases. At the end of follow up self mutilation was present in 1 (3.6%), Horner syndrome in 2 (7.1%), shoulder and elbow contracture in 8 (18.8%), winging of scapula in 6 (21.4%) and asymmetry of limbs length, biceps circumference and forearm circumference in 18 (62.9%), 5 (17.9%) and 6 (21.4%) cases, respectively. None of the patients had reduced force of muscle in shoulder and wrist contracture. Poor to moderate recovery occurred in 13 (46.4%) cases and expected recovery in 15 (53.6%) cases. Other studies have shown variable results. In various studies spontaneous recovery of OBPP was reported 90% (Terzis and Papakonstantinou, 1999; Greenberg, 2000). In a metaanalysis of the studies

conducted from 1966 to 1993 by Pondaag *et al.* (2004) spontaneous recovery varied from 5 to 93%. Bisinella and Birch (2003) followed 74 children with OBPP for 2 years. They found that spontaneous recovery, good recovery and need for surgical therapy were 52.7, 39.3 and 27%, respectively (Bisinella and Birch, 2003). In Donnelly *et al.* (2002) study conducted on 54 neonates with OBPP, 19% of them did not show any type of recovery, while Evans-Jones *et al.* (2003) reported 2% of patients without any type of recovery. In Mollberg *et al.* (2008) study, they followed 98 children for 18 months and complete recoveries of neurological findings occurred in 82% of them. As mentioned, there is a wide variation in the incidence of recovery of OBPP in different studies. There are some reasons which may explain these variations. Differences in the number of studied population, the severity of primary involvement of the limbs, the type of applied treatment, the period of follow up and different definitions of recovery and measuring instruments may be the confounding factors. The incidence of Horner syndrome was reported from 0-7.7% and the incidence of radioulnar subluxation was reported 28.5-38.5% in different studies (Bisinella and Birch, 2003; Evans-Jones *et al.*, 2003; Yilmaz *et al.*, 1999). Not obtaining radiography films from affected joint may be the underlying reason for a very low incidence of radioulnar sublocation in our study. We compared all electrodiagnostical parameters in two groups: poor to moderate recovery group with expected recovery group. In the primary electrodiagnostical study, the frequency of reduced CMAP amplitude values of median and ulnar nerve reduced SNAP amplitude values of median nerve and impaired recruitment of thenar and EDC was significantly higher in the group of patients with poor to moderate recovery. To date, we haven't found any type of parameter predicting prognostic outcome in these patients. Some studies have shown that electrodiagnostical findings are inconclusive and unreliable (Van Dijk *et al.*, 1998, 2001). For example, it is difficult to interpret the EMG findings in neonates. The reason is that it is highly dependent on spontaneous activity which needs complete flaccidity of the muscles (Pollack *et al.*, 2000). On the other hand, the only predictive parameter is the severity of lesions in these patients (Bisinella and Birch, 2003). Due to the fact that the principal role of electrodiagnostical studies in these patients is the assessment of level and severity of lesions, it seems to be of clinical importance in predicting the outcome of the patients. For example, it is showed that the outcome of Erb palsy is significantly better than pan-plexus palsy (Dodds and Wolf, 2000). Yilmaz *et al.* (1999)

showed that electromyography outcomes are of great clinical importance in predicting the outcome in these patients. For example, root rupture in 3/5 of cases was associated with poor outcome (Yilmaz *et al.*, 1999). Interestingly we found a poor recovery in patients under physiotherapy. Bahm *et al.* (2009) demonstrated that regular physiotherapy is not effective in the outcome of OBPP. However, it is recommended for at least 6 months to all affected children. Similarly, Eng *et al.* (1996) did not find any effective role for physiotherapy in the outcome of the patients. However, it seems to that the level of the primary lesion is important in the outcome of the patients.

## CONCLUSION

Most of the patients were females. Right side palsy was more prevalent than left side palsy. Vaginal delivery without forceps was the most mode of delivery. Vertex was the most common presentation. Most of the patients were term. The mean weight of the birth was 3.8 kg. Erb palsy and pan-plexus palsy consisted of 71.4 and 28.6% of lesions, respectively. In the end of study, 53.6, 35.7 and 10.7% of cases had expected, moderate and poor recovery, respectively. In the primary electrophysiological study the frequency of patients with reduced CMAP amplitude values of median and ulnar nerve, reduced SNAP values of median nerve and impaired recruitment of thenar and EDC in the expected recovery group was significantly higher compared with other group. There were significantly a higher number of patients with pan-plexus palsy in poor to moderate recovery group. The frequency of patients underwent physiotherapy was significantly higher in poor to moderate group. However, there was no any significant difference in the duration of physiotherapy.

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