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Assessment of Biceps Muscle Functional Recovery as a Predictor of Outcome in Neonatal Brachial Plexus Palsy

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Obstetrical brachial plexus palsy is a traction lesion of a part of the brachial plexus during delivery. According to the World Health Organization, prevalence is generally 1-2% worldwide. The aim of the study is to assess the time interval to biceps muscle functional recovery in relation to outcome in neonatal brachial plexus palsy. This study was conducted on 60 neonates admitted to the department of neonatal intensive care unit and outpatient follow up clinic of El Galaa Teaching Hospital, Cairo, Egypt with neonatal brachial plexus palsy. All cases were subjected to full history tasking, assessment of gestational age, thorough clinical examination, physical and neurologic examination of the affected upper extremity function including; motor assessment of biceps muscle by medical research council for grading muscle activity. Our results showed that C5-C6 injury was found in 42 patients (70%), C5-C6-C7 affection in 15 patients (25%) and three patients (5%) had total injury without associated Horner's syndrome. Motor assessment of biceps muscle activity at time of delivery revealed, that 10 patients (16.7%) had M0- grade, 34 patients (56.7%) had M1 grade and 16 patients (26.7%) had M2 grade. We conclude that majority of patients with neonatal obstetrical brachial plexus palsy had spontaneous recovery with normal function in the first three months of life. The time interval to biceps muscle recovery is an important prognostic factor in neonatal obstetrical brachial plexus palsy, as its failure to recover anti-gravity biceps function by 3 to 6 months of age is a poor prognostic sign.

Keywords: Biceps muscle function, Brachial plexus palsy, Neonate.

Obstetrical brachial plexus palsy (OBPP) is a traction lesion of a part of the brachial plexus during delivery. The incidence of OBPP has decreased significantly with improvements in obstetrical care but it is noted more frequently in countries with poor obstetrical care. The incidence ranges globally from 0.2-4% of live births [1,2] .

Perinatal risk factors include prolonged labor, large birth weight, difficult delivery and multiparous pregnancy. Difficult upper extremity extraction in a breech delivery or shoulder dystocia in a vertex delivery increases the risk of OBPP. Relative muscular hypotonia, associated with fetal distress, decreases protection of the plexus may also contribute to the development of injury [3,4] .

Most of OBPP predominantly involve the upper trunk (C5-C6), the classic Erb's palsy. However, many infants also have impairment of the C7 nerve root and this portends a poorer prognosis. Less frequently, the whole plexus (C5-T1) or the lover trunk (C8-T1, a Klumpke's palsy), may be involved [5] .

Serial clinical examinations of the infant during the first six months of life must be done to predict outcome. The timing of recovery of spontaneous motions of shoulder, elbow, wrist and fingers is monitored. Neonatal reflexes are examined to induce flexion of elbow as well as wrist and digital extension. The presence or absence of Horner's syndrome (Ptosis, miosis and anhydrosis) is also noted [6]. Following the initial evaluation, aggressive physiotherapy are started. Once physical therapy has been implemented, electrophysiological studies are ordered to assist and document the evaluation of root avulsion and possible nerve regeneration.

Electromyography (EMG) is used to evaluate the motor unit. It may be done after 2-3 weeks of age to determine sings of nerve degeneration. EMG will predict reinnervation of muscle prior to any other modality[7] (Haerle and Gilbert, 2004).

The time interval to biceps muscle recovery is an important prognostic factor in OBPP. Although the natural history is not clear, biceps muscle recovery after more than three months of age has been used to predict poor long-term shoulder function [8] .

There is a debate on the appropriate timing of micro surgical treatment for infantile brachial plexus injury, with the recommendation ranging from one month to 18 months for infants without signs of recovery, though most surgeons prefer exploration and reconstruction in the first six months of life [9]. The aim of the study is to assess the time interval to biceps muscle functional recovery in relation to outcome in neonatal brachial plexus palsy by motor assessment of biceps muscle.

Patients and methods

This follow up study was conducted on 60 neonates with brachial plexus palsy in the neonatal intensive care unit and outpatient follow up clinic of El-Galaa Teaching Hospital.

Patients

Inclusion criteria

Full term and postdate infants during the first year of life, whether male or female and all with recognized maternal risk factors for neonatal brachial plexus palsy including; multipartity, macrosomia, diabetes mellitus, shoulder dystocia difficulty of delivery of after coming head, midpelvic instrumental or vacuum delivery and previous children with OBPP.

Exclusion criteria

- Preterm infants.
- Infants with fracture of clavicle or humerus.
- Osteomyelitis.
- Sepsis of glenohumeral joints.
- Arthrogryposis.
- Brachial neuropathy secondary to sepsis.
- Lesions of the spinal cord.
- Cerebral palsy.

Ethical consent

A written informed consent was obtained from parents.

METHODS

Phase I

All cases were subjected to the followings, starting from day one of life to three weeks of age: full history taking (including antenatal, natal and post natal history), thorough clinical examination with a very detailed physical and neurologic examination of the upper limb affected attempting to grade and document the affected upper extremity function, contralateral arm function was also documented. Neurological examination (Moro's reflex, Grasp reflex), the presence or absence of a Horner's syndrome is also noted. Side of palsy (to detect right, left or bilateral injury)

- Type of palsy: By assessment of position of the limb injured at rest. The obstetric brachial plexus injury is classified into 4 groups by Narakas into:

I- C5-C6 injury:The patient has shoulder adduction internal rotation together with elbow extension and pronation, wrist extension and finger flexion (Positive grasp reflex).

II- C5-C6-C7 injury: The patient has shoulder adduction internal rotation together with elbow extension and pronation, wrist flexion (wrist drop) and finger flexion (positive grasp reflex).

III- Complete brachial plexus injury without Horner syndrome: The patient has totally paralyzed flail limb.

IV- Compete brachial plexus injury with Horner syndrome: The patient has totally paralyzed flail limb together with ptosis, miosis and anhydrosis[11] .

• Motor assessment of biceps muscle: The British Medical Research Council muscle grading M-scale for grading muscle activity has been applied, as follows:

- Mo: No contraction.
- M1: Flicker contraction.
- M2: Muscle contraction with active motion with gravity eliminated.
- M3: Full range of motion against gravity.
- M4: Full range of motion against gravity with some resistance.
- M5: Full range of motion against gravity with maximum resistance (Normal muscle power)[12] .

All affected neonates were subjected to the same course of physiotherapy for the same duration (including infant range of motion exercises, education of caregiver and tactile stimulation to the affected extremity). The rehabilitation of children with OBPP began as soon as the injury was recognized in the newborn nursery during the first week of life and continued up throughout the period of follow up.

• Phase II:

It was a follow up study of cases at three weeks , three months , six months and twelve months of age including: thorough clinical examination, examination of the upper limb affected, electromyogram (EMG) and nerve conduction velocity (NCV) studies to assess the biceps muscle function using Matrix Light (Micro med) 2 Channel EMG- EP system apparatus to detect type of lesion, presence of denervation potentials, presence of early regeneration process and nerve conduction of musculocutaneous nerve [13].

• Patient with no or poor recovery were underwent surgical intervention.

Statistical Methods

The collected data were coded, tabulated and statistically analyzed using IBM SPSS V22. Survival analysis for data of recovery of the motor power was depicted using Kaplan-Meier plots, where the differences were analyzed using log-rank test Results were considered statistically significant if P Value <0.05.

RESULTS

This study included 60 neonates, 28 males (46.7%) and 32 females (53.3%) out of them 54 cases (90%) were ± full term and 6 cases (10%) were postdate. Their birth weight was ranging between 2.7 – 4.6 kg with a mean of 4.3 ± 0.19 SD. Out of them 11 patients (18.3%), their birth weight was 2.5 – 3.5 kg and 49 patients (81.7 %) were > 3.5 kg.

Obstetrical data revealed that obstetric brachial plexus injury was more common in multiparous women, 3 patients (21.7%) were born to prim parous mothers and 47 cases (78.3%) were born to multiparous women, neither of them (100%) had previous children with obstetrical plexus palsy. Positive history of diabetes was found in 17 cases (28.3%). Nine cases (52.7%) were controlled during pregnancy while the other 8 cases (47.1%) were uncontrolled.

Table 1. Collective maternal data

Finding	Number	Percentage
Diabetes		
None	43	71.70%
Controlled	9	15.00%
Uncontrolled	8	13.30%
Mode of delivery		
Vaginal:	58	96.70%
Cephalic.	50	86.20%
Breech.	8	13.80%
C-section.	2	3.30%
Vaginal cephalic delivery		
Spontaneous	34	68.00%
Vacuum	5	22.00%
Forceps	11	22.00%
Shoulder dystocia	44	75.90%
Difficulty of delivery of after coming head	8	13.80%

Table 2. Patients' side and type of palsy

Finding	Number	Percentage
Side of palsy		
Right	32	53.30%
Left	28	46.70%
Type of palsy		
C5, 6	42	70.00%
C5,6,7	15	25.00%
Total Without Horner's	3	5.00%
Total With Horner's	0	0.00%

Table 3. Collective data of upper limb affected at time of delivery

Finding	Number	Percentage
Congenital Anomalies of joints		
Absent	60	100.00%
Present	0	0.00%
Fractures		
Yes	0	0.00%
No	60	100.00%
Reflexes		
Moro's Reflex		
Absent	60	100.00%
Present	0	0.00%
Grasp Reflex		
Absent	3	5.00%
Present	57	95.00%
Position at rest		
Shoulder		
Adduction	57	95.00%
Abduction	0	0.00%
None	3	5.00%
Internal rotation	57	95.00%
External rotation	0	0.00%
None	3	5.00%
Absent	60	100.00%
Present	0	0.00%
Elbow		
Extension	57	95.00%
Flexion	0	0.00%
None	3	5.00%
Pronation	57	95.00%
Supination	0	0.00%
None	3	5.00%
Wrist		
Extension	42	70.00%
Flexion (wrist drop)	15	25.00%
None	3	5.00%
Fingers flexion (Grasp reflex)		
Present	57	95.00%
Absent	3	5.00%
Motor assessment of Biceps muscle		
Mo	10	16.70%
M1	34	56.70%
M2	16	26.70%
M3	0	0.00%
M4	0	0.00%
M5	0	0.00%
Physio-therapy		
Yes	60	100.00%
No	0	0.00%

According to mode of delivery, obstetric brachial plexus injury occurred in 2 cases (3.3%) after caesarean section and 58 cases (96.7%) after vaginal delivery, vaginal breech delivery occurred in 8 (13.8%) and vaginal cephalic delivery occurred in 50 cases (86.2%). 16 cases of vaginal cephalic group were delivered with instrumental assistance, forceps in 11 cases (22%) and vacuum in 5 cases (10%) while 34 cases (68%) were spontaneous delivered. Shoulder dystocia was found in 44 patients (75.9%) however, difficulty of delivery of after coming head was found in 8 cases (13.8%) (Table 1).

As regards the side of the injury, the study included 32 cases (53.3%) with right sided injury and 28 cases (46.7%) with left sided injury. According to the type of injury; C5-C6 injury was found in 42 patients (70%), C5- C6- C7 affection in 15 patients (25%) and 3 patients (5%) had total injury without associated Horner's syndrome (Table 2).

By examination of upper limb affected at the time of delivery neither of them had congenital anomalies of joint nor any fractures. In all patients Moro's reflex was absent, however grasp reflex was absent only in 3 cases (5%) that is associated with total injury.

Motor assessment of biceps muscle activity by the Medical Research Council (MRC) grading scale (M-scale) revealed that 10 patients (16.7%) had MO- grade, 34 patients (56.7%) had M1 grade and 16 patients (26.7%) had M2 grade. Also assessment of position of the limb injured at rest was done (Table 3).

Regarding EMG, all patients had abnormal data including amplitude, duration and interference pattern, out of them 5 patients (8.3%) had no EMG response at 3 weeks of age.

Based on nerve conduction of musculocutaneous nerve patients had nerve conduction (N.C.) time ranged between 0-8 m. Sec. with a mean of 3.84 ± 1.775 SD and N.C. amplitude ranged between 0-4.2 m. volt with a mean of 2.55 ± 1.032 SD.

By follow up of cases at 3 weeks of age, motor assessment of biceps muscles activity revealed that 5 patients (8.3%) had absent biceps muscle function (MO), 2 patients (3-3 %) had M1 grade, 4 patients (6.7%) had M2 grade, 26 patients

(43.3%) had M3 grade and 23 patients (38.3%) had M4 grade.

At 3 months of age , out of 60 patients included in this study, there was a significant full recovery of 50 patients (83.3%) while 5 patients (8.3%) fully recovered at six months of age in relation to 5 patients (8.3%) not fully recovered at 12 months of age (P-value 0.0001).

Table (4) shows correlation between EMG data at 3 weeks and at 3 months of age with a significant difference between the two age groups regarding amplitude, duration and interference pattern (P = value 0.0001).

Table (5) shows correlation between patient's nerve conduction data at 3 weeks and at 3 months of age where there was no significant difference regarding conduction time, however there was significant difference regarding nerve conduction amplitude (P-value 0.002).

Table (6) shows correlation between motor assessment of biceps muscle in patients at 3 weeks and at 3 months of age where there was a significant full recovery of 50 patients M5 (83.3%) at 3 months of age (P-value 0.0001).

All patients were subjected to the same course of physiotherapy during the period of follow up; out of them 50 patients (83.3%) and 5 patients (8.3%) were fully recovered at 3 months and six months of age respectively. However 5 patients (8.3%) were subjected to surgical intervention

Table 4. Correlation between patients EMG data at 3 weeks and at 3 months of age

EMG		Follow-up				
		At 3 weeks		At 3 months		
		No. of patients	%	No. of patients	%	p-value
EMG	Amplitude	60	100.00%	60	100.00%	0.0001
	Normal	1	1.70%	50	83.30%	
	Increased	0	0.00%	0	0.00%	
	Reduced	54	90.00%	8	13.30%	
	No response	5	8.30%	2	3.30%	
EMG	Duration	60	100.00%	60	100.00%	0.0001
	Normal	0	0.00%	50	83.30%	
	Broad	55	91.70%	8	13.30%	
	No response	5	8.30%	2	3.30%	
EMG	Interference pattern	60	100.00%	60	100.00%	0.0001
	Normal	0	0.00%	50	83.30%	
	Poly-phasic	0	0.00%	0	0.00%	
	Improvement	0	0.00%	3	5.00%	
	Reduced	55	91.70%	5	8.30%	
	No response	5	8.30%	2	3.30%	

P-value <0.01 highly significant

Table 5. Correlation between patients' nerve conduction data at 3 weeks and at 3 months of age

Nerve conduction	No. of patients	Range	Mean	± SD	p. value
NC Time (msec.) (3wks)	60	0-8	3.8412	1.77579	0.695
NC Time (msec.) (3ms)	60	0-9	4.1937	1.69317	
NC Amplitude (m.v) (3wks)	60	0-4.2	2.5508	1.03201	0.002
NC Amplitude (m.v) (3ms)	60	0-3.8	2.6620	0.84177	

P. value <0.01 highly significant
P. value <0.05 Not significant

Table 6. Correlation between motor assessment of biceps muscle in patients at 3 weeks and at 3 months of age

Biceps muscle		Follow-up				
		At 3 weeks		At 3 months		
		No. of patients	%	No. of patients	%	P . value
Motor assessment		60	100.0%	60	100.0%	0.0001
	M5	0	0.0%	50	83.3%	
	M4	23	38.3%	2	3.3%	
	M3	26	43.3%	2	3.3%	
	M2	4	6.7%	1	1.7%	
	M1	2	3.3%	2	3.3%	
	M0	5	8.3%	3	5.0%	

(exploration and nerve grafting) between 3-6 months of age, they were not fully recovered with a significant difference between recovered and unrecovered cases (P. value 0.0001).

Also there was a significant difference between recovered and unrecovered cases as regards EMG data, nerve conduction and biceps muscle motor power both at 3 months and 6 months of age (P-value 0.0001)

On comparing EMG data, nerve conduction data and biceps motor power of uncovered cases at 6 months vs. at 12 months of age, there were no significant difference.

On the other hand our results revealed that operated cases were; one case had C5-C6 injury (20%), one case had C5-C6-C7 injury (20%) and 3 cases (60%) had total injury.

DISCUSSION

Obstetrical brachial plexus palsy (OBPP) is a lesion of a part of the brachial plexus due to traction during delivery. The incidence of brachial plexus injuries has decreased significantly with improvement in obstetrical care. In countries with poor obstetrical care, OBPP is noted more frequently. The global incidence ranges from 0.2 -4 % of live birth. Although most injuries are transient with the possibility of complete recovery, about 10% to 30% of patients having prolonged and persistent disability [14,15] .

In our study, OBPP was common in females (53.3%) in comparison to the result of Largerkvist *et al*, (2010) who found that it is more common in males (66%)[16]. However Saifuddin *et al*, (2002) found equal affection in both gender[17].

The study of maternal parity revealed that the majority of cases were born to multiparous mothers with an overall incidence (78.3%) neither of them had previous children with OBPP which were the same result found by Wlash *et al*, (2011) [18]. The study of mode of delivery revealed that 96.7% were delivered vaginally out of them 13.8% were breech. Chen *et al*, (2008) and Al-Qatan *et al*, (2010) found that breech delivery is an important risk factor in the incidence of OBPP [19,20].

On the other hand Sibinski and Synder, (2007) have found that breech delivery was not associated with higher incidence of nerve injury despite literature data pointing to the contrary [21].

Our study showed that OBPP was more common in macrosomic group of patients (81.7%). It is found that infants with birth weight 4 kg had a higher risk of 2.5 times, than that of smaller children and the risk increases to 21 times with infants weighting more the 4.5 kg [4].

In this study, the overall incidence of right sided injury was 53.3% and left sided injury occurred in 46.7% of cases. Jennifer *et al*, (2009) had found that 51% were right sided injury [22]. The explanation of that is because the common delivery presentation is left occipito-anterior vertex. In the contrary Ashrafzadeh *et al*, (2010) found that there was no difference in the involvement of right and left sides [23].

We found in our study that most of injuries were C5-C6 (70%) and C5-C6-C7 was involved in 25% of cases and total injuries in only 5% of patients. Also Ulgen *et al*, (2008) has found the same in addition to occasional combination with an injury to the C7 root and less often, the entire plexus was involved [24].

In this study, at the time of delivery, absent biceps muscle function (M0) was found in 16.7% of patients; just flicker contraction (M1) in 56.7% of cases and 26.7% of patients had muscle contraction with eliminated gravity (M2).

After three weeks of immobilization and passive range of movement although there was no full recovery, yet there were an improvement of biceps muscle power and the affected limb function. Out of all patients, 43.3% of cases had full range of motion against gravity (M3) and 38.3% of cases had full range of motion against gravity with some resistance (M4). These results were supported by EMG data that revealed normal nerve conduction of musculocutaneous nerves without denervation potentials and were associated with some MUPs of regeneration. Only 10% of patients had biceps muscle power of M1 (3.3%) and M2 (6.7%) and their EMG data revealed partial neuropathy with slowing nerve conduction and diminished amplitude of musculocutaneous nerve but associated with some MUPs of regeneration. However, absent biceps muscle function was still absent in 8.3% of patients (M0) with severe neuropathy and denervation potentials without MUPs of regeneration in their EMG study. In comparison to our results Ashrafzadeh *et al*., (2010), in his neurophysiological studies in the third week of life showed conduction blocks (partial neuropathy) in eleven infants (52.4%), one case (4.8%) was not tested and nine (42.9%) infants had axonal injuries (severe neuropathy) [23].

In addition, Terzis and Kokkalis (2009) revealed that 77.7% of patients had biceps muscle grading of ≥ M3 at ≤ 3 mounts of age had significantly best final outcome [25].

Our study revealed a significant spontaneous full recovery of 83.3% and 8.3% of patients at three and six months of age respectively in relation to 8.3% of patients were not fully recovered at 12 months of age.

Kachramanoglou *et al*., (2017) and Backe *et al*., (2010), in their analysis of prospectively collected information revealed that recovery rate was 84% at 3 months of age and permanent injury was 0.5 per 1000 births [26,27]. While Malessy and Pondaag (2009), revealed that full recovery rates are thought to be as high as 85% at six months of age [28].

In this study, although at 3 months of age 83.3% of patients had normal limb function with significant full recovery of biceps muscle function (M5) in relation to its function at 3 weeks of age, yet 5% of patients still had absent biceps muscle function (M0). This result was supported by significantly normal EMG data in 83.3% of patients and improvement of nerve conduction time and amplitude at 3 months in relation to 3 weeks of age with significant difference between them regarding nerve conduction amplitude and EMG data.

In addition, there was a significant difference between patients who were fully recovered and unrecovered cases at 3 mouths of age regarding their biceps muscle function, EMG data (amplitude, duration and interference pattern), nerve conduction time and amplitude of musculocutaneous nerve.

The collaborative perinatal study indicated that 93% of patients destined to attain completerecovery had done so by 4 months. More precisely, patients who proceed to complete recovery have antigravity strength in the deltoid and biceps by the end the second month and in the external rotators by the end of the third month. Also patients who exhibit no sign of recovery by 3 months ultimately have unsatisfactory functional outcomes [29] .

Heise *et al*., (2017) revealed that the time interval to biceps muscle recovery is an important prognostic factor in neonatal OBPP, as its recovery after more than three months of age has been used to predict poor long-term limb function [30].

As a predictor of outcome this study revealed a significant difference between recovered and unrecovered cases at 3 months of age regarding the type of palsy as 90.5% of C5-C6 injury and 80% of C5-C6-C7 injury were fully recovered and neither of 5% of cases with total injury was fully recovered however there was no significant difference between C5-C6 and C5-6-7 injuries. This results was matched with Foad *et al*., (2009) and Terzis and Kokkalis (2009) whom revealed that the type of brachial plexus injury significantly influenced the final outcome [31,26].

After extraction of cases recovered at 3 months of age, our study showed five cases were fully recovered at 3 months of age spontaneously and the other 5 patients who had biceps muscle scale of M0 and M1 underwent nerve exploration and grafting at 4-6 months of age.

After surgical intervention, four cases showed improvement of biceps muscle function (M2-M3) and one case still had absent biceps function (M0). This was supported by improvement of EMG data, nerve conduction time and amplitude a part from the case of absent biceps function that showed no EMG response or nerve conduction. By follow up of operative cases at 12 months of age, they were not fully recovered and although there was no significant difference between their biceps muscle function, EMG data and nerve conduction time and amplitude in relation to their 6 months data, yet there was an improvement of their biceps muscular recovery (M3-M4) and electrophysiological data. Only one case had absent biceps function and showed no EMG response or nerve conduction indicating axonal degeneration.

CONCLUSION

A major concern of clinicians in obstetrical brachial plexus palsy is the accurate prediction of the prognosis that makes correct assessment necessary. The time interval to biceps muscle recovery is an important prognostic factor in neonatal OBPP, as its failure to recover antigravity biceps function by 3 to 6 months of age is a poor prognostic sign.

Rehabilitation physiotherapy program is significantly vital to those infants regardless of whether surgery is indicated, as physiotherapy can preserve and build on gains made possible by surgical interventions.

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