Brachial Plexus Birth Palsy: The Natural History, Outcome of Microsurgical Repair and Operative Reconstruction

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Objective: *To document the natural history of brachial plexus birth palsy in relation to the recovery of elbow flexion and shoulder flexion in the first six months of life; to assess the outcome after microsurgery of the brachial plexus in patients who had no recovery of bicep function at six months.*
Study design: *The present study employed retrospective clinical data analysis.*
Material and Method: *The patients were divided in two groups, nonoperated and operated. The non-operative patients were followed either to full recovery or until the maximum expected motor recovery. The type of surgical procedure and final muscle strength was recorded in the operative group. Every child was evaluated for motor function including bicep muscle and shoulder elevation and then was followed until the surgeon considered the appropriate time for surgery.*
Results: *Between 2001 and 2010, 88 children with birth palsy were seen with 89 brachial plexus birth palsies. Seven children were excluded due to incomplete data. The remaining 82 palsies in 81 babies were classified in two groups. In the non-operated group, the spontaneous recovery occurred in 59 patients (73%) of 81 patients. All of these patients showed functional bicep within ten months of age. Bicep contraction was observed by six months of age in 63 patients (71%). In all, 22 infants in the operated group, underwent an exploration of the brachial plexus, neurolysis and neurotization, Functional recovery of the elbow occurred in 15 cases, The pre-operative AMS for elbow and shoulder flexion were 1.72 and 2.18, respectively. The postoperative mean AMS for elbow flexion was 5.30 and shoulder flexion was 5.55.*
Conclusion: *Most babies with traction injuries of the brachial plexus at birth have an excellent prognosis if the recovery has started within three months. Microsurgical reconstruction was effective in improving function in the small subgroup of patients with no evidence of recovery of bicep function within the first six months of life.*

Keywords: *Birth palsy, Brachial plexus birth palsy, Neurotization*

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Pediatric Brachial Plexus Palsy or Birth palsy is caused by traumatic stretching of the brachial plexus during delivery. These patients have flaccid paresis of the affected arm. In most patients, only the upper roots of the brachial plexus are affected. Klumpke lower root injury is rare (Tassin, 1983)[1].

The incidence of birth palsy is about 0.1-5.1 per 1,000 live births[2]. Breech delivery is a risk factor for injury. Permanent damage to the upper roots is uncommon. The spontaneous recovery rate is 70-92%[3]. Classically, a loss of abduction and external rotation of the shoulder, flexion of the elbow and supination of the forearm are presented. Hand function, which may already be impaired, is further compromised by the proximal muscle weakness.

Microsurgical repair was a controversial mode of treatment until Gilbert, (1980)[4], in a large series and a wide age range, showed the best results in patients under six months of age. Early microsurgical repair has a very important role in preganglionic lesion. This surgery can decrease the motor end plate loss and maximize recovery. Gilbert recommended that microsurgery not only improves function in selected patients over what would be expected from the natural history but also increases the possibilities for secondary tendon transfers.

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Objective

To document the natural history of brachial plexus birth palsy in relation to the recovery of elbow flexion and shoulder flexion in the first six months of life and to assess the outcome after microsurgery of the brachial plexus in patients without recovery of bicep function at six months.

Material and Method

The present study protocol was approved by the Rajavithi Hospital Ethics Committee (No. 56021). The patients were divided in two groups, nonoperated and operated. The non-operated patients were followed either to full recovery or until the maximum expected motor recovery. The type of surgical procedure and final muscle strength was recorded in the operated group.

Clinical assessment

All children were examined by one of the authors. The strength of individual muscles or muscle groups was recorded at each clinic visit, and mothers were instructed in stretching exercises for the shoulder to prevent joint contractures.

C5 root was considered to innervate the deltoid muscle and the external rotators of the shoulder, C6 to innervate the biceps, C7 for the extensors of the wrist and the fingers and T1 for the intrinsic muscles of the hand. Muscle strength was assessed by observing during play and by clinical examination. Muscle power was graded according to the active movement scale.

Inclusion criteria: Any patients that was diagnosed as brachial plexus birth palsy.

Exclusion criteria: 1) Any pateint that refused to join this report, 2) Any patient that had incomplete information through OPD chart review.

The recovery time for bicep function was recorded every two to three month of life.

External rotation of the shoulder is essential for full shoulder abduction but testing in infants is difficult; however, the surgeon examined this function when patients got older.

Shoulder contracture was assessed by passive motion of the shoulder. Clinical measurement for passive external rotation was available for all patients before surgery and follow-up.

Surgical techniques

The standard brachial plexus exploration and neurotization was used in our patients.

The brachial plexus was approached above the clavicle through a horizontal incision. Once exposed, damaged roots were followed proximally and neurolysis performed as far into the foramen as possible. The viability of nerve roots were assessed by inspection and electrical stimulation. Those roots were thin and attenuated or soft and edematous, with minimal distal neuroma, suggesting empty fascicles, and were considered to indicate a more proximal injury, not suitable for grafting and neurolysis. Where neuroma was present, it was excised.

The gap between the nerve ends was grafted using the sural nerve. However, this technique was rarely used in the present study. Neurotization using the spinal accessory nerve to the suprascapular nerve and a single fascicle of the ulnar nerve to nerve branch to bicep muscle was the surgery mainly used.

In cases of large neuroma, where electrical stimulation resulted in visible muscle contraction of the shoulder muscle or elbow muscle, microsurgical neurolysis was performed along the nerve as much as possible.

Statistical analysis

Analysis was performed with the SPSS version 17.0. Descriptive statistics was used to describe the details of the study group, to analyze the population. Data were presented as mean $\pm$ standard deviation (SD) or median (range) for continuous variables and number (%) for categorical variables.

Results

A total of 88 children with 89 birth palsy injuries were enrolled between 2001 and 2010. Seven children were excluded due to incomplete records. The remaining 81 babies were evaluated. In all, 53 patients had C5-C6 (65%), 23 patients had C5-C7 (25%) and 5 patients had C5-T1 (6%) injury (Table 1).

In the nonoperated group a total of 59 patients recovered spontaneously with a spontaneous rate of 73%. All had functional biceps within ten months. Bicep contraction was observed in 71% of babies by six months of age. All the babies presented between one week and four months of age. In this group 48 patients had C5-C6 injury and 11 patients had C5-C7 injury. In the C5-C6 palsy group, the age at which muscle contraction was first seen to start was related to the eventual recovery. If muscle contraction in the deltoid or bicep had started by three months of age, then a nearly full functional recovery ensued. The average follow-up duration was 2.51 years (range, 1.3 months to 4.2 years) (Table 2).

In the operated group 22 patients required surgery, and all operations were performed by the same surgeon. The patients were considered for surgery

Table 1. Subgroup of injury

Patients	C5-C6 (n = 53)	C5-C6-C7 (n = 23)	C5-T1 (n = 5)
Nonoperative group	48 (90.6%)	11 (47.8%)	0 (0%)
Operative group	5 (9.4%)	12 (52.2%)	5 (100%)

Table 2. Demographics and final elbow function of nonoperated group (n = 59)

	C5-C6 group (n = 48) mean $\pm$ SD (min-max)	C5-C6-C7 group (n = 11) mean $\pm$ SD (min-max)
Birth weight (gm)	3,783.9$\pm$271.3 (3,320-4,400)	3,897.3$\pm$373.6 (3,190-4,450)
Age at elbow flexion gr. 1 (month)	2.58$\pm$0.85 (1-4)	4.09$\pm$0.70 (3-5)
Recovery time of functional bicep (AMS gr. 6) (month)	5.69$\pm$1.47 (3-9)	6.91$\pm$2.21 (4-10)
Final elbow flexion	116.66 (100-130)	118.57 (110-130)
Average follow-up (year)	2.33$\pm$0.73 (1.4-4.2)	2.68$\pm$0.81 (1.3-4.0)

AMS = Active movement scale; SD = Standard deviation

within nine months when no functional elbow flexion was observed using the active movement scale as a guideline. Some of these patients needed a second operation if their bicep function was not improved by the first operation called neurolysis within six months. Then these patients would be considered for neurotization. The earliest age for the surgery was four months and oldest age was one year and two months. Type of surgeries performed included neurolysis in 18 patients, nerve graft in 1 patient and neurotization in 12 patients (Table 3). In this group, 15 cases had functional elbow recovery and 5 had nonfunctional elbow recovery. No recovery occurred in 2 cases. Five patients needed tendon transfer for shoulder function.

Discussion

The initial treatment of pediatric brachial plexus palsy consists of rehabilitation while waiting for spontaneous recovery[5-9]. Surgical treatment was first initiated by Kennedy (1903)[10] and Taylor (1907)[11], but the results were not very satisfactory until 1980[12-14], when surgery technique was improved by Gilbert (1984)[15].

Evaluating the treatment result by Active Movement Scale (AMS) is simple to use and has good inter- and intra-observers reliability[16] among physical therapists. It enables the therapist to follow minor changes and is used effectively in infants.

Pediatric brachial plexus palsy is mostly a temporary paresis and has good spontaneous recovery. Patients who can get partial antigravity function of the upper arm muscle within two months will have a complete recovery within one to two years. However, when patients can not achieve antigravity bicep strength within five to six months, they should have a microsurgical reconstruction because microsurgery improves treatment results better than the natural course. Patients who have C5-C7 partial recovery of antigravity strength between the ages of three and six months will have permanent impairment of movement and strength at risk of joint contracture.

At present, a clinical concern was the pre-operative evaluation of patients with C5-C7 who did not regain antigravity function at the ages of three to six months whether or not the patient needed a surgical exploration and a neural microsurgical reconstruction immediately. Patients in this group have a variety of neurologic injuries and no comparative studies are available between patients who wait for final recovery and then receive a tendon transfer later at about 6-12 years old and those patients who receive microsurgery earlier and then receive a tendon transfer.

The present study had 53 patients with C5-C6 (65%), 23 patients with C5-C7 (25%) and 5 patients with C5-T1 (2%) injuries. In all, 63 patients had bicep contraction at the age of six months.

Argument is ongoing regarding the role of microsurgery. The surgical interventions started at the beginning of the 20th century included neuroma resection and direct repair gradually have improved with the advent of microsurgery between 1970-1990 by Narakas, Millessi and Gilbert. The choices of a nerve

Table 3. Muscle strength and surgical procedure in operated group (n = 22)

Patient and injury	Frequency	Percent
C5-C6	5	22.7
C5-C7	12	54.5
TTA	2	9.1
TTA with C5-C6 recovery	1	4.5
TTA with C8-T1 recovery	2	9.1
BW		
Mean ± SD	3,605.00±581.55	
Median (min-max)	3,600 (2,400-4,900)	
Pre op function		
EF0	9	11.39
EF1	2	2.53
EF2	3	3.80
EF3	3	3.80
EF4	1	1.27
EF5	5	6.33
EF6	3	3.80
EF7	1	1.27
SF0	5	6.33
SF1	1	1.27
SF2	2	2.53
SF3	6	7.59
SF5	12	15.19
SF6	2	2.53
WE0	4	5.06
WE2	1	1.27
WE3	2	2.53
WE4	2	2.53
WE7	3	3.80
FF0	5	6.33
FF4	1	1.27
FF7	2	2.53
FE3	1	1.27
EE0	1	1.27
EE3	2	2.53
Type of surgery		
Neurolysis	18	0.56
Ulnar N to bicep	11	0.34
Other neurotization		
C7 to median nerve	1	0.03
XII nerve to SS	1	0.03
Nerve graft	1	0.03
First response		
EF1	4	0.14
EF2	3	0.10
EF3	2	0.07
EF4	1	0.03
EF5	2	0.07
EF6	5	0.17
SF1	1	0.03
SF2	1	0.03
SF3	1	0.03
SF4	7	0.24
SF6	1	0.03
EE4	1	0.03
Final result		
EF1	1	0.04
EF5	4	0.15
EF6	11	0.42
EF7	10	0.38
Age at last F/U		
Mean ± SD	43.30±20.64	
Median (min-max)	40 (7-92)	
LD transfer	2	25.0
No recovery	1	12.5
Shoulder scope	1	12.5
Then LD transfer	1	12.5
Then shoulder surgery	2	25.0
Transfer	1	12.5

EF = Elbow flexion; EE = Elbow extension; SF = Shoulder flexion; FF = Finger flexion; FE = Finger extension; WE = wrist flexion

surgery are neurolysis, neuroma resection, nerve grafting and nerve transfer. Direct repair is difficult to perform because of the nature of the disease and it may not be possible to perform a tension-free repair without nerve grafting. Neurolysis does not play a role in the avulsion injury and its functional result has not been much different from the nonoperated group especially in the C5-T1 group. However obvious evidence in an upper trunk rupture has not been observed. Laurent[17] reported that in the intra-operative electrodiagnosis study, when a muscle action potential was more than 50% across the neuroma, neurolysis should be performed. However, if these stimuli showed a weak response, then a neuroma resection and nerve grafting may be indicated.

In the present study, the author chose patients with C5-C6 and C5-C7 brachial plexus palsy to perform the neurolysis. When patients did not have functional biceps at the age of six months, the author would use a nerve stimulator to assess muscle contraction intra-operatively. After that, when patients had a strong muscle contraction, the author would perform the neurolysis. However, this patient group was followed for six months to observe bicep function. When the patients had no functional bicep activity after the neurolysis, they were considered for a nerve transfer as soon as possible.

In patients with weak biceps after they were stimulated by a nerve stimulator, the authors would perform standard nerve transfers by transfer of the fascicle of the ulnar nerve to a nerve to the biceps (Oberlin 1)[18] and the spinal accessory nerve to the suprascapular nerve.

The appropriate age for surgery is still under discussion. Bicep function is not an only indication. Strong evidence exists to support that early surgery at the age of six months or less to prevent patients from a motor endplate loss increases outcome of functional recovery in patients in an avulsion group without bicep function with or Horner Syndrome.

A reconstruction of an extraforaminal rupture should be performed between the ages of three and nine months. Mounting evidence reveals the benefits of microsurgery from three months of age when patients have no antigravity bicep function recovery. However, AI-Qattan and Waters reported that the natural bicep recovery should be waited for until the ages of four to five months. Thus, the result of the microsurgery with a secondary tendon transfer is equal to the outcomes from natural history.

According to the present study, the average age of an antigravity bicep function in patients with C5-C6 and C5-C7 palsy was 5.69 months and 6.9 months respectively. Therefore, clinically, surgery can be deferred until five to six month of age in patients with C5-C6 palsy and six to seven months of age in patient with C5-C7 palsy.

Secondary shoulder transfer can increase the function of shoulder external rotation and abduction. In the present study, 19 patients had a shoulder surgery which included subscapularis release, arthroscopic shoulder release and LD transfer.

Conclusion

Most patients with birth palsy have spontaneous functional recovery. However, the timing for surgery can be delayed up to five to six months for C5-C6 birth palsy and six to seven months for C5-C7 birth palsy in those without recovery. In patients with no bicep function at five to seven months, early surgical intervention may be better than waiting for spontaneous recovery.

Potential conflicts of interest

None.

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การศึกษาการดำเนินโรคและผลการรักษา microsurgical repair ในเด็กแรกเกิดที่มีปัญหา brachial plexus palsy

ณธพณ จันทรเสโน, กิตติวรรณ สุพิชญางกูล, วีระ ปรีชา, กมลชนก ชลปราณี

วัตถุประสงค์: *เพื่อศึกษาผลการรักษาและธรรมชาติของโรค brachial plexus birth palsy จากการฟื้นคืนของการงอข้อศอกและข้อไหล่ในคนไข้อายุ 6 เดือน และประเมินผลการรักษาทาง microsurgery ในคนไข้ที่ไม่มีการฟื้นคืนของ bicep function ที่อายุ 6 เดือน*

วัสดุและวิธีการ: *Retrospective clinical data analysis ระหว่างปี พ.ศ. 2543-2553 คนไข้ 88 รายที่มีปัญหา 89 brachial plexus birth palsy, 7 รายถูกคัดออกเนื่องจากบันทึกข้อมูลไม่ครบเหลือ 82 palsies คนไข้ 81 ราย แบ่งเป็น 2 กลุ่ม กลุ่มรักษาด้วยวิธีไม่ผ่าตัด 59 ราย, กลุ่มผ่าตัด 22 ราย โดยพิจารณาจากการมี functional elbow recovery ภายใน 6 เดือน โดยใช้ active movement scale (AMS)*

ผลการศึกษา: *22 ราย ที่ได้รับการผ่าตัดมีค่าเฉลี่ย active movement scale (AMS) ก่อนผ่าตัดสำหรับ elbow flexion 1.72, shoulder flexion 2.18 หลังผ่าตัด elbow flexion 5.30, shoulder flexion 5.55*

สรุป: *ผลการรักษาทาง microsurgery ให้ผลการรักษาที่ดีในรายที่ไม่มีการฟื้นคืนของ bicep ภายในอายุ 6 เดือน เมื่อประเมินด้วย active movement scale (AMS) หลังผ่าตัดภายใน 6 เดือน*
