Limb length discrepancy in surgically treated obstetric brachial plexus palsy

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Received 5 March 2011
Accepted 20 March 2011

Egyptian Orthopedic Journal 2012, 47:271–275

Introduction and aim of work
The purpose of this investigation was to determine limb length discrepancy between affected and unaffected upper extremities in patients with obstetric brachial plexus palsy (OBPP).
Patients and methods
Fifty patients with OBPP underwent measurements of the bilateral upper extremities. The mean age at surgery was 12.6 months (4–84 months). Active motion was assessed using the Toronto Test Score.
Results
The total limb length averaged 93.3% of that of the normal side; the humeral length averaged 94.96%, whereas the forearm length averaged 91.76%.
Conclusion
No statistically significant correlation between age and limb length discrepancy was noted. Furthermore, there were no correlations between upper limb discrepancies and measures of active motion, type of lesion, and surgical procedure in individual patients.

Keywords:
brachial plexus birth palsy, limb discrepancy, obstetric palsy

Egypt Orthop J 47:271–275

1110-1148

Introduction and background

Despite advances in obstetrics, the incidence of obstetric brachial plexus palsy (OBPP) remains ~1/1000 live births [1–3]. Established risk factors include large size for gestational age, multiparous pregnancy, difficult or prolonged labor, and history of child with OBPP [3]. Microsurgical nerve reconstruction, soft-tissue releases, tendon transfers, and osteotomies have all been proposed for infants and children with persistent neurological deficits and/or secondary joint deformities to improve function [3–9].

Whereas previous studies have focused on the natural history and surgical treatment of OBPP, little is known about the relationship between OBPP and resultant morphological and esthetic differences between affected and unaffected upper limbs [1,3,8–11]. Previous studies on limb length discrepancy [10,12] did not address its relationship with type of lesion (avulsion vs. rupture), age of surgical intervention (early, before 1 year and delayed, after 1 year), and surgical technique (neurolysis vs. grafting vs. neurotization). The purpose of this study was to determine the limb length discrepancy between the affected and normal upper extremities in OBPP patients and to determine the relationship between these difference(s) and the age of patients at operation (before and after 1 year), affected roots (upper vs. upper middle vs. total), type of lesion (rupture vs. avulsion), and reconstructive method (neurolysis vs. grafting vs. neurotization).

Patients and methods

From May 1997 to September 2003, 50 patients with OBPP were operated on for brachial plexus exploration and reconstruction. They were operated upon at the Reconstructive Microsurgery Unit, Assiut University Hospitals. Of there, 30 (60%) were boys and 20 (40%) were girls. The mean age at surgery was 12.6 months (4–84 months). Patients were followed up for 8 months–6 years (mean 21.7 months). In total, 44 patients were available for review and radiological assessment.

The right side was affected in 28 (56%) patients and the left side in 19 (38%) patients. Bilateral affection was noticed in three (6%) patients. In all of them, one side was treated conservatively and the other side was explored surgically.

Indications for surgery

When OBPP presented early after birth, infants were examined with regard to the extent of lesion and the presence of Horner's syndrome. In the case of total palsy, particularly with positive Horner's syndrome, surgery was scheduled as soon as possible depending on the general condition of the infant; usually at or little after the age of 3 months.

In cases of upper palsy or total palsy with negative Horner's syndrome, another appointment at the age of 3 months was scheduled to assess recovery. Static splinting was not used, and parents were instructed to make the

infant perform passive stretching exercises, particularly external rotation of the shoulder.

At the age of 3 months, patients who at least had no bicep contraction, particularly with wrist drop, were scheduled for surgery 2 months later and were reassessed on admission. If there had been marked improvement, that is biceps of Medical Research Council (MRC) grade 3, infants were referred to a physical therapist, meanwhile regular follow-up and monitoring were continued. In infants who presented late, the indications for surgery were flail anesthetic hand or biceps of less than MRC grade 3.

Preoperative clinical assessment

All patients were examined using the Toronto Active Movement Scale described by Clark and Curtis from the Hospital for Sick Children as shown in Table 1 [9,13]. Horner's syndrome was observed in eight patients.

Patients were classified according to the age at surgery into two groups: early surgery group, operated before the age of 1 year, and delayed surgery group, operated after the age of 1 year. The early surgery group included 34 patients, whereas the delayed surgery group included 16 patients.

The mean age of the early group was 6.9 months (4–11 months) and that of the delayed group was 23.9 months (12–84 months). Table 2 shows the number of patients and sex distribution in each group. Three patients were lost to final follow-up.

Each group was further classified into four categories according to the clinical presentation. Table 3 shows the number of patients belonging to each category.

Intraoperative findings

Forty-nine brachial plexus explorations were performed, C8 and T1 roots were absent in two patients, and T1 alone was absent in two patients. Neuroma of C4 was observed in five patients. The condition of the nerve root was recorded as intact, avulsion, or neuroma-in-continuity (root rupture), which could be a conducting or a nonconducting neuroma. Table 4 shows a summary of intraoperative findings.

The most common root lesion was nonconducting neuroma, 33.5%, and the least common lesion was conducting neuroma, 7.1%.

The upper and middle trunks were involved distal to the roots in four patients. In three patients the neuroma was isolated and in one patient it was confluent, involving both trunks.

A concomitant peripheral nerve lesion was observed in four patients. The suprascapular nerve was involved in three patients in the form of isolated neuroma, extensive fibrosis, and avulsion from the upper trunk. In the latter case, the suprascapular nerve lesion was accompanied by perineural fibrosis of the musculocutaneous, radial, and axillary nerves. The musculocutaneous nerve was avulsed at its entry into the bicep muscle in another case.

Congenital anomalies of the brachial plexus were noticed in eight patients. In four patients, the T1 root was absent and in two, the C8 root was also absent. In two patients, there were only three nerve roots continued as trunks, in one of them the ulnar nerve was missing. In one patient the median nerve originated entirely from the medial cord. The posterior division of the upper trunk was absent in another patient. A prefixed plexus was noticed in seven patients.

One patient had congenital trigger index, middle, and ring fingers, which were released at a second scission. Two patients had a fractured humerus in the affected limb after surgery by the ages of 1 and 1.5 years, respectively. They were treated conservatively.

Surgical procedures

This included neurolysis, neuroma excision, and direct suture; interposition nerve grafting; and neurotization, or combinations. Table 5 summarizes different surgical procedures performed.

Table 1 Hospital for sick children muscle grading system

Observation	Muscle grade
Gravity eliminated	
No contraction	0
Contraction, no motion	1
Motion < ½ range	2
Motion > ½ range	3
Full motion	4
Against gravity	
Motion < ½ range	5
Motion > ½ range	6
Full motion	7

Table 2 Patients number and sex in each group

Group	Early surgery	Delayed surgery	Total
Boys	21	9	30
Girls	13	7	20
Total	34	16	50

Table 3 Number of patients in each category

Category	Early group	Delayed early group
Upper C5, 6	6	5
Upper middle C5, 6, 7	9	3
Lower C8, T1	–	1
Total C5–8, T1	19	7
Total	34	16

Table 4 Intraoperative findings in 49 patients

	C5	C6	C7	C8	T1	Total	%
Intact (grossly)	4	4	10	29	28	75	31.4
Avulsion	7	18	20	11	11	67	28
Conducting neuroma	3	4	4	3	3	17	7.1
Nonconducting neuroma	35	23	15	4	3	80	33.5
Absent				2	4	NA	
Total	49	49	49	49	49		

NA, non applicable.

Our aim was to reconstruct as much of the plexus as possible and as feasible. Priority was always given to the lower trunk in an attempt to recover hand function, in contrast to brachial plexus reconstruction in adults. This is because of the good regenerative power in infants and children. In addition, it is difficult to improve hand function at a later time point in contrast to shoulder and elbow functions, which could be improved by secondary procedures.

Table 5 Frequency of individual procedures

Procedure	Number of cases (%)
Neurolysis	26 (53%)
Grafting	36 (73.5%)
Direct intraplexal neurotization	9 (18.4%)
Extraplexal Neurotization	37 (75.5%)

At the final follow-up visit, an anteroposterior radiograph for both upper limbs was obtained to calculate the residual limb length discrepancy of the affected side compared with the contralateral normal side. The measurements included humeral, radial, ulnar, and third metacarpal lengths, as well as carpal height (Fig. 1).

Figure 1

Anteroposterior radiograph showing measurements of humeral, ulnar, radial, carpal, and third metacarpal heights.

Results

As regards the correlation between lesion distribution and residual limb length discrepancy, the average limb length (expressed as a percentage of the contralateral limb length) was 93.3%. The resulting limb length discrepancy between operated and nonoperated limbs was statistically nonsignificant.

Table 6 shows the limb length expressed a percentage of that of the normal side, total and regional, in the different patterns of plexus lesions. It was noted that residual limb length discrepancy was least in the upper and upper middle palsy types with intact roots. However, this was statistically insignificant ($P>0.05$). There was little difference in the residual limb length discrepancies, whether one or more roots were ruptured or avulsed ($P>0.05$).

In general, residual total limb length discrepancy was least for the upper palsy group, followed by the upper middle group and the total palsy group; however, this was statistically insignificant ($P>0.05$).

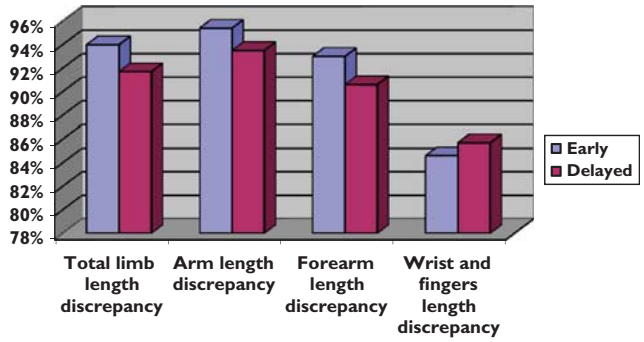
As regards the correlation between residual limb length discrepancy and age at operation, Chart 1 shows that limb length was least affected in the early operated group. However, this was statistically insignificant ($P>0.05$).

Conclusively, residual limb length discrepancy, both general and regional, was statistically insignificant among the studied group of patients ($P>0.05$).

Table 6 Correlation between residual limb length discrepancy and preoperative clinical picture and intraoperative findings

Clinical group	Root lesion	Total limb length discrepancy (%)	Arm length discrepancy (%)	Forearm length discrepancy (%)	Wrist and hand length discrepancy (%)
Upper palsy	Intact roots	97.7	96.8	97.7	100
	Rupture in one or both	93.85	96.8	93.7	85.1
	Avulsion in one or both	94.7	94.8	94.7	91.8
Upper middle palsy	Intact roots	99.4	100	99	100
	Rupture in one or more	92.5	91.3	92.9	81.5
	Avulsion in one or more	92.6	94.9	90.8	88.3
Total palsy	Rupture in one or more	90.3	95.1	88.3	84.1
	Avulsion in one or more	92.4	93.8	85.7	85.9
Lower palsy		96.8	98	96.2	95

Chart 1



Residual limb length discrepancy in different age groups.

Discussion

Efforts to define the natural history of brachial plexus birth palsy continue to be made in the hope of providing patients and families with accurate information regarding long-term prognosis and potential benefits of surgical and other treatments [11,12,14,15]. In addition to information regarding neurological recovery, longer-term functional outcomes, and indications for operative intervention, patients and families often inquire about the effect brachial plexus birth palsy will have on upper extremity size and appearance. These questions often arise at the initial orthopedic or microsurgical consultation, an emotionally charged setting for families and care providers alike. However, little information is currently available on this subject [10].

Previous studies regarding limb length discrepancy [10,12] did not address relationship with the type of lesion (avulsion vs. rupture), age of surgical intervention (early, before 1 year and delayed, after 1 year), and surgical technique (neurolysis vs. grafting vs. neurotization). This study elucidated the differences in surgically treated cases.

Radiological evaluation of regional limb length discrepancy is more accurate than clinical anthropometric measurements used in previous studies [12].

Van Heest *et al.* and Waters *et al.* [7,16] previously evaluated children with spastic hemiplegia due to cerebral palsy for upper limb length discrepancy and sensory function. Interestingly, those patients with severe sensory deficits had significantly smaller upper limbs than children with mild or moderate sensibility deficits. The authors conclude that in patients with spastic hemiplegia due to cerebral palsy, upper limb length discrepancy may be a clinical marker for underlying sensory dysfunction [7,16].

In the current study, the total limb length averaged 93.3% of that of the normal side, similar to that reported by Bae *et al.* [12] (95%) and by McDaid *et al.* [10] (92%). The humeral length averaged 94.96%, compared with 94% in the study by Bae *et al.* [12] and 93% in the study by McDaid *et al.* [10], whereas the forearm length averaged 91.76%, compared with 97% in the study by Bae *et al.* [12], and 90% in the study by McDaid *et al.* [10].

As previously reported by Bae *et al.* [12], we believe that potential reasons for the observed differences include both the effect of longstanding neurological injury on muscle bulk and atrophy in addition to nerve-mediated mechanisms of limb growth and development.

Interestingly, despite the small but significant number limb length differences, no meaningful correlations were detected in this study between the magnitude of limb length difference and functional recovery of the upper limb. This finding suggests that although upper limb size differences do exist, the magnitude of difference may not be utilized to estimate the amount of upper limb impairment. This was also reported by Bae *et al.* [12].

Similarly, patients with more limited active upper extremity movement may not necessarily have greater differences in limb length.

This finding highlights the need for surgeons and other care providers to understand both the functional and esthetic implications of OBPP on their patients.

Finally, on the basis of this analysis, it can be stated that early microsurgical repair or plexus reconstruction – and thus presumed improvement in neuromuscular function – may potentially avert the observed limb differences. This is contrary to the findings of Bae *et al.* [12].

Results of anthropometric studies performed on our patients showed that the residual total limb length discrepancy was more in total palsy than in upper middle palsy, and was least in upper palsy; however, the differences were not statistically significant ($P > 0.05$), as was reported by McDaid *et al.* [10]. It was also noted that residual limb length discrepancy was more in the delayed group than in the early operated group, but this was statistically insignificant ($P > 0.05$). Residual limb length discrepancy was also not affected by the type of lesion (rupture vs. avulsion) and the reconstructive procedure (neurolysis vs. grafting vs. intraplexal neurotization vs. extraplexal neurotization).

Conclusion

Residual limb length discrepancy, both general and regional, was statistically insignificant among the studied group of patients ($P > 0.05$).

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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