SHOULDER FUNCTION FOLLOWING LATE NEUROLYSIS AND BYPASS GRAFTING FOR UPPER BRACHIAL PLEXUS BIRTH INJURIES

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Eleven children ranging in age from 9 to 21 months underwent late nerve reconstruction for persistent shoulder paralysis following an upper brachial plexus birth injury. Only neurolysis was performed in three patients. Neurolysis and nerve grafting bypassing the neuroma with proximal and distal end-to-side repairs was performed in the other eight. All patients were followed for 2 or more years. Two patients underwent a secondary procedure before their final follow-up evaluation. All infants demonstrated significant improvement when assessed by a modified Gilbert shoulder motion scale.

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Although surgical treatment for brachial plexus birth injuries that fail to show adequate clinical motor recovery is becoming more widely accepted, the timing of operative intervention remains controversial. Most authors advocate surgery by 3 months of age for global palsies with a persistent flail limb. However, the advised time for surgery on upper and upper/middle plexus lesions varies between 3 and 8 months of age (Al-Qattan, 2000; Clarke and Curtis, 1995; Gilbert, 2001; Grossman, 2000; Grossman et al, 1997; Laurent and Lee, 1994). Little information is available regarding the outcome of later neurosurgical intervention for upper plexus lesions (Birch et al, 1998).

PATIENTS AND METHODS

During a 33-month period (1998–2001), 11 children between 10–21 months of age (mean 13 months) underwent brachial plexus surgery for an upper brachial plexus (C5/C6-upper trunk) injury sustained at birth. There were eight girls and three boys. The injury involved the right plexus in six patients and the left plexus in five patients (Table 1). All children had persistent severe limitation of active shoulder movements (elevation-lateral rotation), but full passive mobility. All patients had biceps and deltoid recovery of M3 or better.

All of the patients underwent a microsurgical neurolysis using intraoperative neurophysiologic monitoring. Three patients received neurolysis only, but in the other eight cases a less than 50% increase in latency and amplitude were recorded from the target muscles (infraspinatus, deltoid, biceps) after the neurolysis and bypass grafting was performed. Bypass nerve grafting using the end-to-side technique proximally and distally from C5 or C6 into the suprascapular nerve was performed in four children. In another three children in whom persistent weakness of the biceps and deltoid was noted, bypass grafting was performed into both the suprascapular nerve and upper trunk divisions. A transfer of the spinal accessory nerve into the suprascapular nerve was combined with bypass grafting into the upper trunk divisions in one child. A supraclavicular cervical plexus branch was used as the nerve graft in six children, and sural nerve grafts were used in two patients. Intraoperative botulinum toxin A (10 u/kg) was administered as a divided dose to the pectoralis major and latissimus dorsi in two cases (Table 1). This appears to prevent the tendency to develop an exaggerated medial rotation posture early after upper plexus neurolysis and repair, especially when some tightness is noted on an examination under anaesthesia.

All children received weekly physical and occupational therapy, or both. There were no perioperative complications. A second surgical procedure was performed prior to the final evaluation in two children. In both cases, postoperative improvement had been seen during the first year followed by a progressive deterioration of shoulder function. One child underwent release of a shoulder contracture and open reduction of the glenohumeral joint with a posterior capsuloplasty 3 years after surgery. The second required a subscapularis slide 18 months following the neurolysis. All children were evaluated a minimum of 2 years following their latest procedure. Results are reported using the modified Gilbert system for documenting shoulder function (Grossman et al., 2003; Table 2).

Table 1—Patient and surgical data

Patient	*Gender*	*Limb*	*Age at surgery (months)*	*Sural graft(s)*	*Cervical plexus graft*	*Botulinum toxin A*	*Presurgical score*	*Post-surgical score*	*Follow-up (months)*	*Secondary procedure*
1	F	R	12	2			2	4	28	36-month postoperative subscapularis slide and posterior capsuloplasty
2	F	L	11	3		X	1	4	60	
3	M	L	10		1	X	1	5	27	
4	F	R	11		2		2	5	28	
5	F	R	11				2	3	36	
6	F	R	14		2		2	4	38	
7	F	R	11		1		1	4	55	18-month postoperative subscapularis slide
8	M	L	15	1 + XI→SS*	1		2	5	41	
9	M	L	14		1		2	5	45	
10	F	R	21				3	5	30	
11	F	L	15				3	5	39	

*SS indicates spinal accessory to suprascapular transfer.

Table 2—Modified Gilbert shoulder evaluation scale

Grade 0	Completely paralysed shoulder or fixed deformity	
Grade 1	Abduction $=45°$	No active external rotation
Grade 2	Abduction $<90°$	Active external rotation
Grade 3	Abduction $=90°$	Active external rotation $<30°$
Grade 4	Abduction $<120°$	Active external rotation 10 – 30°
Grade 5	Abduction $>120°$	Active external rotation 30 – 60°
Grade 6	Abduction $>150°$	Active external rotation $>60°$

From Grossman JAI, Price AE, Tidwell MA, Ramos LE, Alfonso I, Yaylali I. (2003) Outcome after late combined brachial plexus and shoulder surgery following birth trauma. Journal of Bone and Joint Surgery, 85B:1166–1168.

RESULTS

The median increase in the shoulder function score in these 11 children was 3 grades (range, 1–4) at the last evaluation (Table 1). In six cases, the improvement was 3 or more grades.

DISCUSSION

The major goal of early nerve repair in children with an upper brachial plexus injury (Erb's palsy) is to maximize shoulder function and the most common indication for early surgical intervention is a failure of biceps recovery by 3 months of age (Gilbert and Tassin, 1984; Kay 1998; Waters, 1999). Published results show that over half of C5–C6 cases can achieve a good to excellent result and this may be increased to over 80% when a secondary contracture release or muscle transfer is also performed (Gilbert, 2001). In certain upper plexus lesions operated on between 3 and 8 months of age, even neurolysis without neuroma resection and graft reconstruction may be beneficial (Clark et al., 1996; Laurent and Lee 1994). The results of early neurosurgical treatment are dramatic when compared to the natural history of those lesions for which selection criteria would have indicated surgery, but no surgery was performed (DiTaranto et al., 2004).

All of the children in this series underwent surgery at age 10 months or later, which is beyond the latest age suggested for such intervention. All of the children had recovered biceps function of M3 or better by the time of surgery. The goal of late intervention in this small group was to improve shoulder function without risking a loss of the recovery that had already occurred spontaneously, particularly biceps function. Weak or absent shoulder lateral rotation and limitation of abduction with a moderate to full clarion sign (Gilbert, 2001) was noted in all cases. Thus, the neurolysis was carefully performed with neurophysiological monitoring until a plateau of improvement in latency and amplitude, as recorded from the target muscles, was reached. For the same reason, the end-to-side technique of nerve repair (Rowan et al., 2000; Viterbo et al., 1992, 1994) was used both proximally and distally to "bypass" the neuroma and avoid damage to contained nerve fibres that would have occurred with neuroma resection. In the cases in which neurolysis alone was done, the latency and amplitude in the target muscles doubled following neurolysis, which was completely different from the cases in which grafting was performed.

The early results seen with this strategy suggest the possibility for significant benefit and support the observations of Birch et al. (1998) who reported several successful cases of late grafting into the suprascapular nerve. While one may argue that these children could have been treated at a later age with a muscle–tendon transfer to improve shoulder elevation and lateral rotation, this option involves waiting and risks the development of further muscle imbalances, joint

contracture, and skeletal deformity. Furthermore, the average composite gains in shoulder motion that occurs with a secondary muscle transfer (Edwards et al., 2000; Suenaga et al., 1999) is less than was obtained in this group, when calculated using the same evaluation system.

In a recent report by Nehme et al. (2002), which analysed the outcome following spontaneous recovery in a series of 30 infants with upper plexus injuries, 13% of infants who failed to show good recovery at 9 months ultimately progressed to this level. While it is possible that patients in this series could have improved further without the benefit of the surgical procedure, our clinical parameters for selection suggest otherwise. Additionally, the absence of operative complications and the level of improvement found would indicate benefits to this operative approach.

Shoulder function was evaluated using a modified Gilbert system (Grossman et al., 2003) which, in spite of some limitations, is generally accepted as a reliable measure of outcome following surgery for obstetric palsies.

It is our practice to perform a high-resolution MRI of the shoulder and brachial plexus in all infants who are to undergo plexus reconstruction. In only three of these patients was a normal glenohumeral joint seen on the pre-operative MRI, with the others showing varying degrees of glenoid hypoplasia. All patients, however, had a full passive range of shoulder motion pre-operatively, which was maintained postoperatively in all cases. Careful follow-up, including imaging of the glenohumeral joint, upto skeletal maturity might provide convincing evidence as to whether this type of late nerve reconstruction can either prevent or reverse changes in the glenohumeral joint. Long-term follow-up will also determine if these children avoid the need for secondary skeletal and soft tissue procedures, which are frequently required for the medial rotation deformity and limitations of shoulder movement (Birch, 2002). Based on these results, it appears that the window of opportunity for successful primary neurosurgical treatment of infants with an upper brachial plexus birth injury extends past 3 to 8 months. Late neurolysis with ''bypass'' grafting is a safe treatment option for those children who present even after 10 months with recovery of some biceps function but poor recovery of active shoulder motion.

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