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Microsurgery in brachial plexus lesions

Twenty-two patients with brachial plexus lesions were reviewed 3–6 years after microsurgical repair. Four patients underwent nerve transfer between intercostal nerves and the musculocutaneous nerve. None of these achieved useful elbow flexion. Nerve grafting mainly in the upper part of the plexus was performed in six patients of whom five recovered a useful motor function in at least one important area. Twelve patients underwent neurolysis; useful motor function in at least one important area was achieved in eight.

We conclude that microsurgical treatment of brachial plexus lesions is useful in lesions of the upper part of the plexus, distal to the dorsal root ganglion.

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Brachial plexus lesions are usually the result of high energy traffic accidents, and the majority of the victims have multiple injuries. Formerly, treatment of irrecoverable brachial plexus was by physiotherapy, muscle tendon transfer, arthrodesis, amputation and prosthesis (Yeoman & Seddon 1961). Microsurgical techniques now permit exploration of the brachial plexus with the possibility of nerve grafting or neurolysis (Millesi 1977, Kline & Judice 1983).

Patients and methods

Twenty-four of 72 patients admitted to Odense University Hospital with brachial plexus lesions in 1972–1978 were operated on in the Department of Neurosurgery, using microsurgery. These 24 patients were scheduled for follow-up with a minimum observation time of 3 years. One patient did not return for follow-up, and another had died. The remaining 18 male and four female patients had a median age of 21 (4–70) years. Three had sustained open direct lesions of the brachial plexus following a knife cut, a glass lesion and a shooting accident. The remaining 19 closed lesions were all traction injuries; all but two were caused by traffic accidents, of which 12 were motorcycle accidents. Thirteen patients were multi-traumatized. Among the 22 patients, 11 had concomitant local injuries (three clavicular fractures, four fractures of the humerus shaft, three forearm fractures, two shoulder dislocations, two subclavian artery lesions and one subclavian vein lesion). The fractures were treated closed. Reconstruction of the two arterial lesions by vein grafts had been attempted at local hospitals, but on admission to our hospital none of the grafts were functioning.

Before operation and at follow-up, all muscles in the affected upper extremity were graded from M-0 to M-5, according to the (British) Medical Research Council (1943). Sensibility to touch, cold/warm, pain and two-point discrimination was evaluated. Tests for painful neuroma, Hoffman-Tinel signs and Horner's syndrome were included. A histamine test (Robles 1968) was used to estimate whether the lesions were supra- or infraganglionic. Before operation, all patients were examined with regard to root avulsion by cervical myelography using Duroliopaque® (Robles 1968). Successive neurophysiological examinations were performed in all cases at the Department of Neurophysiology at our hospital.

Preoperatively, seven patients had complete paralysis of the whole extremity; 15 had partial paralysis, i.e. at least one muscle in the upper extremity was functioning. The major lesion in 10 patients was avulsion of one or more roots verified by myelography. Five patients had a lesion of one or more trunks, and in seven patients one or more cords were affected. Ten of the 22 patients had mixed lesions localized at different levels. Nine patients had a lesion in their dominant arm.

We operated when evidence of reinnervation had not appeared 9 (3–36) months after injury. Patients with neurapraxia or axonotmesis as the essential lesion, with a good prognosis for spontaneous recovery, were thus not operated.

Operation

We used the operative technique described by Millesi (1977). During the operation, electric nerve stimulation was used to estimate whether function was established following neurolysis. In lesions peripheral to the spinal ganglion, neurolysis and/or free nerve grafting were performed.

Neurolysis was carried out after a median time of 10 (3–36) months following injury and grafting after a median time of 8 (3–14) months.

In cases with complete loss of continuity in the upper part of the plexus, grafting to the musculocutaneous nerve was done in an attempt to establish function in the proximal muscle groups of the extremity, especially the biceps. In a few cases, nerve grafting in the lower part of the plexus was done in the hope of establishing some protective sensibility in the hand. In none of the cases was it possible to perform direct end-to-end suture of the lesion. In four cases with complete root avulsion, nerve transfer between intercostal nerves and the musculocutaneous nerve was performed. In each case two intercostal nerves from the second to the sixth intercostal space were used. The transfer took place from 4–6 months after the injury.

There were no serious complications to the microsurgical operative interventions. One small haematoma, one superficial skin infection, one non-union of the clavicle and one minor pneumothorax were experienced. In no case did the operations lead to decreased motor or sensory function.

Follow-up

The follow-up was carried out by one of the authors (KS) who had not participated in the primary treatment and had not seen the patients before. The median observation time was 4 (3–6) years. The clinical evaluation was carried out without knowledge of the operative treatment. Although testing of every single muscle was carried out, a functional graduation of movement and power around the shoulder, elbow, wrist and fingers was used for convenience.

Results

Four patients had nerve grafting between transferred intercostal nerves and the musculocutaneous nerve; none of them obtained active flexion of the elbow joint.

Following nerve grafting, two patients obtained shoulder function, three flexion and one extension in the elbow joint, one obtained finger flexion, and one had no recovery (Table 1).

Following neurolysis, three patients obtained function around the shoulder joint, five flexion and four extension at the elbow joint; one obtained flexion and two extension in the wrist, two obtained extension in the fingers, and four had no motor recovery (Table 2).

Eighteen of 22 patients obtained some degree of protective sensibility. Two-point dis-

Table 1. Results of nerve grafting in six patients. Only functional recovery of M-3 or more is shown. Figures are pre/postoperative

Lesion[a]	No. of grafts	Length (cm)	Functional recovery			
			Shoulder	Elbow Flex.	Elbow Ext.	Fingers Flex.
ST	2	8	3/4			
L	5	5		0/4		
L	2	9				
M	2	9	nr			
L	3	6		0/3		
P	1	4				
L	2	4				1/5
M	3	4				ulnar
L	2	11				nerve
M[b]	2	14	0/4	0/4	0/3	

[a] ST = superior trunk. L = lateral cord. M = medial cord. P = posterior cord.
[b] Neurolysis of posterior cord. nr = no recovery.

Table 2. Results of neurolysis in 12 patients. Only functional recovery of M-3 or more is shown. Figures are pre/postoperative

Lesion[a]	Functional recovery					
	Shoulder	Elbow Flex.	Elbow Ext.	Wrist Flex.	Wrist Ect.	Fingers Ext.
C_5C_6 root		0/4				
C_7C^8 root	nr					
ST	1/3					
ST		1/4				
ST	nr					
IT	nr					
ST, P	2/4	2/4	2/4			
L, P	0/5	0/5	1/4		0/3	0/3
L, P		0/4	0/4			
L, P			0/3			0/4
L, P	nr					
M, P				0/5	2/5	

[a] IT = inferior trunk. Other symbols as in Table 1.

Table 3. Sensory function at follow-up in 22 patients

	S-0	S-1	S-2	S-2+
Intercostal nerve transfer	2	2	0	0
Nerve graft	0	2	4	0
Lysis	2	6	3	1

crimination was not obtained in any case (Table 3).

Among 10 patients with lesions proximal to the dorsal root ganglion, three were without pain at follow-up, two had some discomfort, three moderate pain and two severe pain; three patients felt that pain had decreased after operation. Among 12 patients with lesions distal to the dorsal root ganglion, four had some discomfort but there were no cases of severe pain, and six patients found that pre-operative discomfort had decreased or disappeared after the operation.

In total, six patients used the arm during work, eight used the arm as a support, three could use their arm when it was placed in a functional position, and five did not use their arm at all. None of the latter five considered amputation. Among the partial lesions the functional use of the arm was substantially related to the existing function in the intact parts of the plexus. Sixteen patients felt the operations had improved the functional use of the extremity, and six felt there had been no change.

At follow-up, three of six patients receiving an academic education were still studying while the other three had finished their education and started work. Six of 15 patients undergoing technical education or in manual jobs were at work.

One patient with a total paralysis of the arm used a full flail arm splint with an elbow lock and forearm piece fitted with an artificial limb appliance operated by the shoulder harness on the opposite arm. Three patients used splints for the wrist and fingers. Two patients had had tendon transfers for the purpose of establishing active extension of the fingers, and one required a capsulectomy of the metacarpo-phalangeal joint to obtain finger function. Two patients did not accept the offered operations. Three patients were on the waiting list for reconstructive treatment. Ten patients did not need reconstructive surgery or bandages.

Discussion

Our results may appear modest and, they cannot be compared with results obtained following nerve grafting or neurolysis of more peripherally located lesions (Haase et al. 1980, Simesen et al. 1980). However, the patients appreciated even minor functional improvements.

In the four cases with intercostal nerve grafting, no function was obtained. Sedel (1982) obtained elbow flexion of M-3 in five of six cases. He used three to four intercostal nerves and in three cases the accessory nerve. Solonen et al. (1984) used neurotization with intercostal nerves 2–7 in 12 cases and achieved functional recovery in four cases. The reason for failure in our cases may be the limited number of axons available when using only two intercostal nerves.

Our operations were carried out relatively late after the injury, due to a pool of patients with older lesions and a delay in referring the patients from other hospitals in the first years. Kline & Judice (1983) advocated acute exploration and repair in lesions not in continuity, especially if sharply transected. In closed traction lesions it is difficult to tell if there is any permanent damage to the nerves. Narakas (1977) showed that one third of traction lesions undergoing exploration had ruptures amenable to grafting. Kline & Judice (1983) advised that stretch injuries without signs of regeneration should be explored after 4–5 months. In gunshot wounds the best interval was found to be 2–4 months.

We agree with Solonen et al. (1984) that the best time to operate is as early as possible. In a traction lesions it may be possible to tell within 3 months of the injury if spontaneous recovery will occur. Among our cases, however, we could not show any correlation between the time interval and the result. Successful neurolyses were carried out even after 36 months.

Pain is a serious problem following brachial plexus lesions, especially when medullary inju-

ries based on root avulsions are part of the lesion (Wynn Parry 1980a). It is known that the destruction of afferent fibres produces spontaneous firing of dorsal horn cells, released from their inhibition (Loeser & Ward 1967). This central pain is extremely resistant to standard analgesic treatment, including morphine, and amputation definitely has no effect (Ransford & Hughes 1977). Wynn Parry (1980b) reported a good effect of transcutaneous electrical stimulation. Nine of our patients experienced a decrease of pain following microsurgical intervention. Normally the pain decreases or disappears after some time (Wynn Perry 1980a) and that may be the reason for our success.

We conclude that the microsurgical treatment of brachial plexus lesions is useful, especially in lesions of the upper part of the plexus distal to the dorsal root ganglion. For a patient with no or only minimal function of an upper extremity, even a minor improvement is of great importance.

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