THERAPY

Follow-up evaluation of neurolysis of brachial plexus and peripheral nerves of upper extremities

Matejcik V, Penzesova G

*Department of Neurosurgery, Faculty of Medicine, Comenius University, and University Hospital, Bratislava.***bll@fmed.uniba.sk**

Abstract

Background: **The work presents the results of neurolysis of brachial plexus and peripheral nerves of upper extremities performed in the Neurosurgical clinic of the Faculty Hospital Bratislava during the 18-year period from 1985 to 2003.**
Patients and methods: **59 patients were subject to surgical therapy by neurolysis, including 10 treatments of brachial plexus and 49 treatments of the upper limb nerves. The average age in the patient group was 35 years. The average period between the injury and surgical treatment was 6.9 months. Extremely long period over 12 months occurred in 3 cases. The treatment was performed in patients with complete or persisting neurological deficit. The external neurolysis was performed in 59 patients and this treatment was supplemented also by internal neurolysis in two cases. Cases requiring resection of fascicles and reconstruction with autotransplants and cases where reconstruction surgery has been already performed in the past have not been included into the study. The analysis of results was performed with respect to the period between the injury and operation, patient age, the type of injured nerve and the degree of fibrotic changes that have been identified peroperationally.**
Results: **The evaluation of results has been performed according to Seddon classification (1975). The complete recovery of mobility, strength and BMG findings (classification grade M5) was observed in 25 patients. The functional grade M3 and more was present in 52 patients. The best results were observed in the youngest patient group aged below 20 years, in cases of early therapy onset, in patients with distal traumatic lesions and for neurolyses of n. radialis.**
Conclusion: **Based on our experience we believe that the early surgical revision is the critical factor determining the outcome of the operations in indicated cases.** ***(Tab. 6, Ref. 3.)***
Key words: traumatic lesions of peripheral nerves, neurolysis.

The movements of head or shoulder require motion of brachial plexus with respect to the surrounding tissues. Analogous condition is valid also for peripheral nerves during the movements of extremities. Such unrestricted movements are assured by the free connective tissue – mesoneurium, which spreads between the epifascicular epineurium and connects the neural trunk with the surrounding tissues such as tendons, arteries, fascial surface and periosteum. In normal nerves, mesoneurium is fine and transparent, holding arteries and veins related to the vascular system of the nerve. It is usually thinned above and below each lesion site.

Fibrotic changes of mesoneurium that emerge after the injury are initiated by the formation of an oedema or haematoma and they are aggravated in cases accompanied by infection. They result in the adherence of various parts of plexus to surrounding tissue and are subject to compression and traction as a result of progressive scarring. These changes have particularly severe consequences in regions where mobility is important, especially in regions specific for potential strait syndromes. Chronic compression may lead to changes in small vessels of endo- and perineurium and later to perineural and endoneural fibroses. The more severe the injury, the more probable is the formation of cicatricial tissue in the nerve.

Department of Neurosurgery, Medical Faculty, Comenius University, Bratislava

Address for correspondence: V. Matejcik, MD, CSc, Dept of Neurosurgery, Medical Faculty, Comenius University, Limbova 5, SK-833 05 Bratislava 37, Slovakia.
Phone: +421.2.59542532, Fax: +421.2.59543532

Tab. 1. Classification of motor functions.

M 0 —	no contractions
M 1 —	recovery of perceptible contraction in proximal muscles
M 2 —	recovery of perceptible contraction in proximal and distal muscles
M 3 —	recovery of function in both proximal and distal muscles to such an extent that all important muscles are capable of sufficient response against resistance
M 4 —	the same as M3 with addition that all synergy and in dependent movements are possible
M 5 —	full improvement

Tab. 2. Classification of sensitive functions.

S 0	—	absence of sensitivity in nerve area
S 1	—	recovery of deep cutaneous sensitivity to pain within nerve area
S 1+	—	recovery of superficial cutaneous sensitivity
S 2	—	recovery of superficial cutaneous sensitivity to pain and partial tactile sensitivity
S 2+	—	the same as S 2 with slight additional response
S 3	—	recovery of both superficial sensitivity to pain and tactile sensitivity in nerve area and disappearance of paraesthesia
S 3+	—	the same as S 3 plus a partial improvement in two-point discrimination sensitivity
S 4	—	full improvement

To protect the fascicles from compression, the neural trunk is able to change its shape. Individual fascicles of the neural trunk are able to move independently and to adjust to the pressure and movement. In this work we present our experience with the neurolyses of brachial plexus and peripheral nerves.

In the available literature we have not encountered any report dealing exclusively with the problem of neurolyses after injuries of peripheral nerves of upper extremities and brachial plexus. The same conclusion has been presented by Kline and Hudson (1).

Patients and methodology

Neurolysis has been performed in 49 patients with injured peripheral nerves of upper limbs: neurolysis of n. radialis in 19 patients (39 %), neurolysis of n. ulnaris in 13 patients (26 %), neurolysis of n. medianus in 11 patients (22 %), neurolysis of n. axilaris in 3 patients (6 %). In 3 cases (6 %) neurolysis included more than a single nerve (n. medianus and n. ulnaris). Neurolysis of the brachial plexus has been performed in 10 patients. Fibrosis of grade I.A, II.A and III.A with changes in epifascicular epineurium was detected in 8 of them while 2 patients had fibrosis of the grade I.B, II.B and III.B. The results of external neurolysis were affected by the severity of nerve damage.

Tab. 3. Classification of fibrosis according to the localisation.

Type A – epifascicular epineurium Type B – interfascicular epineurium Type C – perineurium and endoneurium
Type A Cases where fibrosis is located mainly in epifascicular epineurium. Fascicular tissue is compressed as by a tight stocking. The treatment consists of a longitudinal epineurotomy from normal (healthy) tissue to normal (healthy) tissue. If deeper structures of the nerve stem remained intact, compressed tissues might expand.
Type B Cases where fibrosis of the interfascicular epineurium was present as well. Full decompression can be obtained dependent on the degree of fibrosis: 1) by epifascicular epineurotomy – fibrotic epineurium is excised around the nerve stem to allow the decompression of superficially located fascicles; 2) by interfascicular epineurotomy – fibrotic tissue between fascicles is excised resulting in partial elimination of interfascicular tissue and complete separation of individual fascicles. The elimination of tissue is incomplete to prevent danger of limited blood supply for the fascicles.
Type C If fibrosis includes perineurium and endoneurium in the fascicles, they are perceived as rigid by palpation and they do not re-expand after decompression. Successful treatment can be expected only in cases where perineurium is fibrotic and shriveled but endoneurium is still intact.

The nerve damage was usually a secondary injury caused mainly by fractures or by iatrogenic injuries, capture of the nerve in the suture, improperly fixed plaster splint, compression by fixation material or by fibrotic changes in its proximity.

All patients underwent a close clinical investigation before the treatment. The indications for the treatment were complete or severe motor deficit with the absence of spontaneous improvement during 2–3 months. Indications for surgical treatment included also cases where the loss of function was only partial or where an intense pain not responding to medication was present.

All operations were performed by the microtechnique. Surgical treatment started with external neurolysis followed in two cases by internal neurolysis that determined the degree of the neural injury.

Pre-operational EMG examination revealed denervation in 24 patients (49 %) with injuries of peripheral nerves of upper limbs that have been treated by external neurolysis and in all 10 patients with injured brachial plexus. EMG activity from deep cervical muscles was present in all patients with injuries of brachial plexus.

Repeated post-operational EMG examination was performed in all patients. The follow-up period lasted from 1 to 18 years.

All patients passed a set of post-operational examinations that were aimed to determine the degree of restoration of sensitivity and motoric activity. The results of neurolysis in upper limbs were evaluated according to Seddon classification (1975). Motoric improvement was evaluated by a 5-grade scale (Tab. 1) and the degree of improvement of sensitivity by a 4-grade scale (Tab. 2). As excellent and very good were evaluated functional

Tab. 4. Classification of fibrosis according to the grade.

Grade I	Nerve segment lost the conductivity but preserved its morphological intactness. This state corresponds with the neuropractice, we may expect spontaneous recovery. This may not happen in the presence of external or internal compression due to fibrosis. The fibrosis may be of Type A or Type B.
Grade II	Axons have lost their continuity. All other structures remained intact. Spontaneous recovery may be expected also here, although it may be prevented by external compression or development of fibrosis of the type A or type B.
Grade III	Neural tissue is damaged also in these cases, however, the fascicular pattern remains intact. Spontaneous regeneration is possible but it may be threatened by development of type A or type B fibrosis. Type C fibrosis is present in cases where endoneural tissue becomes fibrotic. For these cases, spontaneous recovery is improbable. Fascicles should be excised and the nerve reconstructed by neural graft.
Grade IV	Nerve has lost its fascicular pattern and the continuity is ensured only by the connective tissue. Successful regeneration cannot be expected neither in cases where some axons penetrate the damaged site and certain degree of conductance is demonstrated during peroperational electric stimulation.

Tab. 5. Dependence of the outcome of external neurolysis of brachial plexus and peripheral nerves on the period between the injury and surgical treatment.

Time (months)	Number of patients	External neurolysis	Internal neurolysis
0-3	24	24/24	
4-12	35	33/28	2/0
Sum	59	57/52	2/0

Values are expressed as the number of treated cases/number of cases with functional status M3 and more.

Tab. 6. Dependence of the outcome of external neurolysis of brachial plexus and peripheral nerves on patient age.

Age (years)	Number of patients	External neurolysis	Internal neurolysis
less than 20	18	18/18	
over 20	41	39/34	2/0
Sum	59	57/52	2/0

grades M4 and S3 (or higher), as good were estimated the grades M3 and S2. Grades M0-M2 ad S0-S1 were considered to be unsatisfactory.

The evaluation of the degree of improvement included also the peroperational finding of the connective tissue fibrosis of peripheral nerves. We followed the classification of Millesi et al (1993) 3 that categorizes the fibrosis according to localization (Tab. 3) and its degree (Tab. 4). The peroperational evaluation of the degree of fibrotic changes was difficult and often only provisional approximate. Patients were organized into two groups. The first group included 57 patients treated by external neurolysis and represented the grades IA, IIA and IIIA of fibrotic changes. The second group included 2 patients treated also by internal neurolysis with fibrotic changes classified as IB, IIB and IIIB grade.

The analysis of the results of post-operational examinations was performed with respect to the period between the injury and surgical treatment (Tab. 5) and with respect to the age (Tab. 6).

Results

The complete recovery of mobility, strength and EMG findings were observed in 25 patients (42 %) classified in the M5 grade. Grade M3 and higher was attributed to 52 patients (88 %). Neurolysis improved also the restoration of sensitivity. This effect was dependent on the period between the injury and surgical treatment, patient age and on the type of injured nerve. The untile degree of reconstitution was observed in 16 cases of treatment of n. radialis (94 %).

The first signs of improvement were observed sometimes after hours or days past deliberation surgery of upper limbs. In the cases of treatment of brachial plexus, this effect was observed after weeks or months, in two cases even after more than one year (with significant improvement after 2–3 years). The complete recovery of sensitive functions was not observed in any of the patients aged over 40 years.

In some cases the objective examination and subjective feeling of patients indicated an improvement while EMG examination did not reveal any change compared to previous examination. The recovery of sensitive and motoric functions depends on the period between the injury and operation. The best results were obtained for the early surgery up to three months after the injury where all 40 patients (100 %) were classified to very good or good grade (M3 and higher). The results were getting worse with increasing length of this period (Tab. 5). In the age group of young patients (under 20 years) all results were classified as excellent (Tab. 6).

Haematoma as the most frequent complication occurred in two cases and it required a timely re-operation. Dehiscence of the wound appeared in one case.

We did not observe any pains after external or subsequent internal neurolysis. Any relapse after the operation was only of transient nature.

Discussion

Peripheral nerves can be comprimed on two levels of cicatrization: superficially by surrounding tissues and intrafascicularly by a fibrotic compression of axons.

Exact and timely treatment performed most often by external neurolysis is the initial step in the majority of operations. It is indicated in cases of posttraumatic fibrosis. It creates the elementary conditions for the reduction of the period required for the functional recovery of nerves after posttraumatic axonotmesis. In the period after surgical treatment, the fibrotic tissue around the nerve proliferates and sometimes acquires even cartilaginous

consistence interfering thereby with the identification of the specific nerve. We recognized in our patient group that the formation of cicatrized tissue was less pronounced and less compressive in children compared to adults. We did not find such observation in the available literature. A thickened neuroma was frequently observed after the release of the nerve. In such cases, the presence of soft neuroma with preserved fascicular pattern was the indication for internal neurolysis. The presence of a hard stony neuroma was always the ground for its resection and subsequent reconstitution surgery.

Deliberation operations provided optimal conditions for the adjustment of motoric and sensoric functions even after prolonged time intervals. They are based on the release of the nerve from the surrounding ligamentous tissue. Preparation is localized in the fibrotic tissue, former mesoneurium, and in the upper layers of epifascicular epineurium. It can be performed in the "sharp" way by scalpel or in the "blunt" way by fine surgical scissors. It is better to proceed from the proximal site distally as such a preparation gives a higher chance of preservation of outgoing (descending) branches. The success of the treatment depends on the ability of nerve tissue to generate a new type of "sliding tissue" (analogy of the mesoneurium). This is possible in the absence of post-operational complications such as haematomas or infections.

Injuries of grades IA, IIA and IIIA can improve spontaneously. If this does not occur or if the recovery is only partial, fibrotic compression of axons prevents further improvement. In such cases neurolysis is required for sustained improvement. External neurolysis is performed only if the intactness of internal layers of the epifascicular epineurium is preserved. Unfortunately, it is improbable that fibrosis would remain limited to perifascicular epineurium. The presence of the fibrosis of interfascicular epineurium complicates the determination of the degree of injury, determination of the site for epineurotomy as well as the selection of the cases where internal neurolysis is required.

If the peroperational inspection reveals a severe damage to a part of the nerve (injury grade IIIC), remaining fascicles may be evaluated by stimulation and separated from the damaged ones by internal neurolysis. Damaged fascicles may be resected and repaired by neural graft. In the cases of suspected grade IV injury, we performed the reconstruction surgery by means of an autotransplant. Such cases were not included into this study.

Surgical treatment was indicated in cases where absolutely no improvement was observed 2 months after the injury of brachial plexus and the deep pressure sensitivity was absent on all fingers. On the other hand, if the recovery is persistent and all nerve roots show certain signs of continuity, surgical reconstruction may be postponed. The results of neurolysis of brachial plexus roots were dependent on the root types. Selective neurolysis of one or several parts of brachial plexus may be indicated if the recovery ceases and the residual deficit is still significant.

In contrast to the treatment of roots C5 and C6, neurolysis of lower roots (C8 and Th1) did not result in the expected recovery to grades M4 or M5. This may be caused by complexity of the functions of hand related to C8, Th1 compared to simple musculature of shoulder and elbow.

The evaluation of the neurolysis outcome is difficult since it is not clear which improvements could be related to the surgical treatment and which result from the spontaneous recovery of the preserved nerve parts. Inferior results of internal neurolysis are explained not only by damaged fascicles present in the nerve as a complex bunch but also by the reaction of the intraneural connective tissue on the new trauma resulting in the formation of even more pronounced accretions.

References

1. Kline DG, Hudson AR. Nerve injuries. Operative results for major nerve entrapment, and tumors. Philadelphia; WB Saunders, 1995.

2. Seddon HJ. Surgical disorders of the peripheral nerves. London; Churchill Livingstone, 1975.

3. Millesi H, Rath T, Reihsner R, Zöch G. Microsurgical neurolysis: its anatomical and physiological basis and its classification. Microsurgery 1993; 14: 430—439.

Received August 18, 2004.
Accepted October 27, 2004.