NERVE TRANSFER IN THE TREATMENT OF ADULT BRACHIAL PLEXUS PALSY

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Abstract: *The nerve transfer represents a current technique for the treatment of the adult posttraumatic brachial plexus lesions, the objective of our study being to mention the neurotization variants used in our clinic for the therapy of this paretic pathology and to present the results from the restoration of the important motor functions of the superior limb. The surgical methods of nerve transfer used as donor nerve intra and extraplexal sources which were neurotised to supra and infraclavicular branches of the brachial plexus. The functional evaluation at 1 year postoperatively revealed a favourable evolution both for shoulder abduction and for elbow flexion. We can conclude that the nerve transfer method has several advantages over the other classical techniques of reconstruction of the brachial plexus but it requires following some technical rules in order to obtain a positive surgical result. It has to be mentioned that the final functional result is primary dependent from the surgical success but also from a series of other factors that together can regain the reintegration of the patient in the working place and into the society.*

INTRODUCTION

In the last 20 years the understanding of microanatomy of the nerve and the intrafascicular topography, together with the development of the research of the nerve regeneration lead to the apparition of the nerve transfer microsurgical techniques – or "neurotization".(1,2) In the treatment of the brachial plexus lesions, due to improved functional outcomes, decreased morbidity and decreased surgical time, we can see a shift in between nerve grafting towards nerve transfers.(3)

The motor function after nerve injury is dependent of the number of the axons reinnervating the target muscle and of the period of time between the moment of trauma and the surgical intervention, the nerve transfer assumes the use of a healthy donor nerve whose function can be transferred to a denervated receptor nerve in order to restore its function to the recipient end-organ (muscle for motor function and skin for sensitive function).(4)

The donor nerves can have an extra-plexal origin (spinal accessory nerve, intercostals nerves, phrenic nerve, cervical plexus, contro-lateral C7 root) intra-plexal origin (ipsi-lateral nerve trunk of fascicle from ulnar or median nerve).(5) The actual indications for these nerve transfer techniques are evolving, and currently include brachial plexus root avulsions, proximal lesions of the peripherical nerves, neuromas-in-continuity, multiple nerve lesions, reinterventions after failed neuroraphy, significant vascular or bony associated lesions near the brachial plexus.(6,7)

In our series we used this technique of nerve transfer for the treatment of the posttraumatic lesions of the brachial plexus in adult patients; its palsy being a rare pathology and also very special due to its invalidating aspect in the context of the young age of the patients.

PURPOSE

The scope of our study is to mention several techniques of nerve transfer that we used in this severe pathology and to evaluate the results by the restoration of the movement of abduction of the shoulder and the flexion of the elbow.

MATERIALS AND METHODS

In our clinic, between 2000-2014, there were operated 18 patients, 17 males (94.45%) and 1 female (5.55%), with the age between 19 -77 years old (average age - 36 years old). The etiology of the lesions was the car accident in 15 cases (83.34%) and trauma of other nature in 3 cases (16.66%). This leads to the palsy of the left brachial plexus in 13 cases (72.22%) and right brachial plexus in 5 cases (27.78%). The period of time between the moment of the trauma and the surgical intervention was of 4,5 months on average. The operating time was between 3 – 8 hours, without immediate or late local complications.

The surgical techniques of nerve transfer were:

- spinal accessory nerve to suprascapular nerve in 13 cases: with posterior approach we identify the nerve close to the margin of the trapezius muscle, with this approach being able to identify also the suprascapular nerve (figure no. 1) and it is possible to cut the transverse ligament of the scapula so we avoid the compression syndrome at this level
- ulnar nerve to musculocutaneus nerve in 5 cases: incision into the medial bicipital groove where we can dissect the ulnar nerve (figure no. 2) medially to the brachial artery and the musculocutaneous nerve in the space in between the biceps and brachialis muscles)
- intercostals nerves to musculocutaneus nerve in 5 cases: there are used at least two nerves, ideally tree – the IVth intercostal nerve being in central position (figure no. 3); the incisions at the level of the intercostal space are longitudinal, the pectoralis major muscle is reflected superiorly and medially and through the fascicles of the serratus anterior muscle we reach the costal surface. In the intercostal space we find the intercostal nerve into the

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costal groove – here, careful attention should be paid as not to intercept the pleural lesions.

Figure no. 1. Preparation of spinal accessory nerve and suprascapular nerve

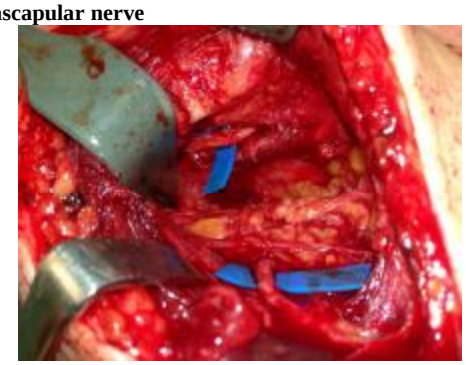


Figure no. 2. Preparation of ulnar nerve (motor fascicle) and musculocutaneous nerve (motor branch for biceps brahii muscle)

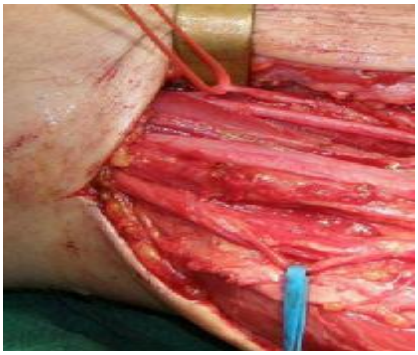
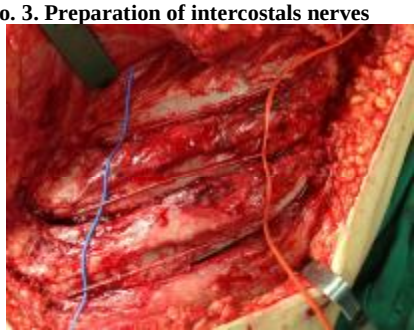


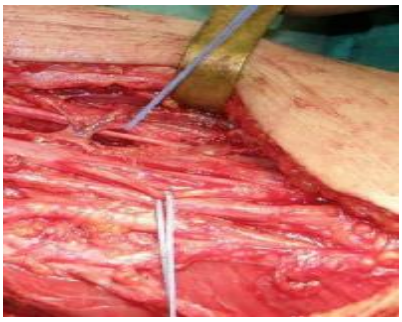
Figure no. 3. Preparation of intercostals nerves



- median nerve to musculocutaneous nerve in 3 cases: approach through the medial bicipital groove where we can dissect the median nerve (figure no. 4) laterally to the brachial artery
- spinal accessory nerve to musculocutaneus nerve (with interposition of antebrahial cutaneus nerve graft) in 1 case;
- radial nerve to axillar nerve in 1 case;
- phrenic nerve to the lateral fascicle of the median nerve in 1 case;
- inferior trunk to middle trunk in 1 case;
- I digital common nerve to IV-V digital common nerves in 1 case.

In all patients, there was used a technique of nerve transfer for the restoration of the movement of the shoulder and another method of nerve transfer for the flexion of the elbow and vice-versa.

Figure no. 4. Preparation of median nerve (motor fascicle) and musculocutaneous nerve (motor branch for brachialis muscle)



After we identified the donor nerve we applied electrostimulation, so we can determine which were the motor (that will be used later on) and the sensitive fascicles. After that, we prepared the ends of the donor and acceptor nerves and with the use of the operating microscope we accomplished the microsurgical neuroraphy with isolated monofilament threads of 9.0.

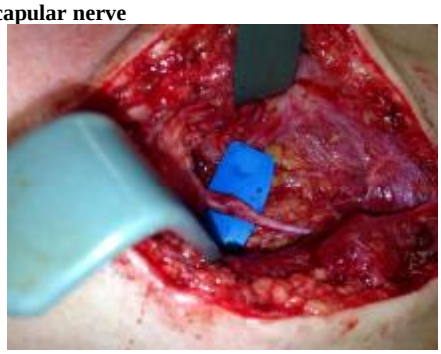
In 6 patients, there were also used some other methods for the restoration of the function of the superior limb:

- free functional transfer of gracilis muscle in 2 cases;
- superior trunk to musculocutaneus nerve (with interposition of sural nerve graft) in 2 cases;
- neuroraphy of superior trunk to middle trunk in 1 case;
- muscular transfer of trapezius muscle to deltoid muscle in 1 case.

RESULTS

The most frequently used method in our study was the nerve transfer from the spinal accessory to suprascapular nerve (figure no. 5) – here, we prepared the spinal nerve as distal as possible close to the trapezius muscle were it gives several branches – due to this, the accessory nerve can be cut without impairing the innervation of this muscle. By this technique, we restore the abduction of the shoulder.

Figure no. 5. Neurotization of spinal accessory nerve to suprascapular nerve



The second method, in terms of frequency in our study, is the nerve transfer from ulnar motor fascicles to musculocutaneous branch for the biceps brachii muscle (figure no. 6). This technique has the advantage of a single incision and is technically more accessible, being used to restore the flexion of the elbow.

The transfer of intercostals nerves to musculocutaneous nerve (figure no. 7) is a method used in our study with the same frequency as the previous one. This method

is applied when the ulnar and median nerve are damaged and they cannot be used as donor nerves.

Figure no. 6. Neurotization of ulnar nerve to musculocutaneous nerve

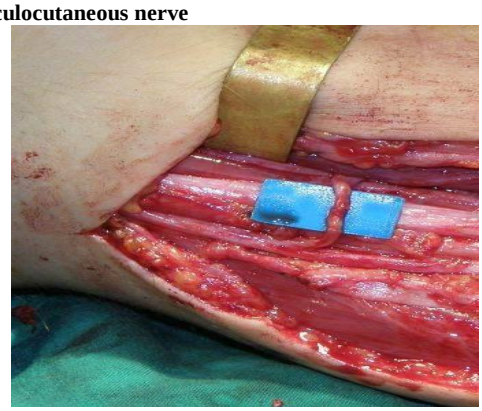
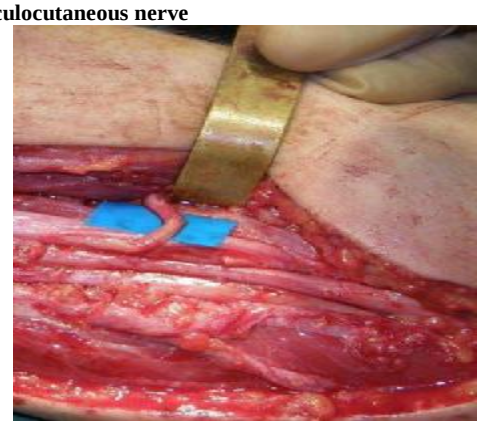


Figure no. 7. Neurotization of intercostals nerves to musculocutaneous nerve

The neurotization of the motor fascicle of the median nerve to the musculocutaneous nerve (figure no. 8) is a technique used together with the nerve transfer of the ulnar nerve to the same musculocutaneous nerve but to the branch meant for the brachial muscle, thus, increasing when needed, the potential of the restoration of the flexion of the elbow.

Figure no. 8. Neurotization of median nerve to musculocutaneous nerve



The other types of nerve transfer or the other surgical techniques listed were used in a smaller proportion reported as singular methods but they were associated with the first four techniques which are the most frequently used.

The functional evaluation at 1 year postoperatively demonstrated a favourable evolution by monitoring the abduction of the shoulder:

- 10 patients presented a good abduction of the shoulder (with a median range of 60 degrees);
- 5 patients presented a satisfactory abduction of the shoulder (with a median range of 30 degrees);
- 3 patients cannot present an abduction of the shoulder (but the shoulder was more stable).

The functional evaluation at 1 year postoperatively demonstrated a favourable evolution by monitoring the flexion of the elbow (Medical Research Council (MRC) units):

- 2 patients had no benefit in terms of MRC 0 (no contraction);
- 1 patient had 1 MRC restoration (perceptible contraction at the level of the muscle but no movement);
- 2 patients had 2 MRC restoration (contraction with the gravity eliminated);
- 5 patients had 3 MRC restoration (contraction against gravity);
- 8 patients had 4 MRC restoration (contraction against resistance).

DISCUSSIONS

The restoration of the abduction of the shoulder represents a major goal in the treatment of the lesions of brachial plexus. In this pathology of the adults, the primary nervous repair or by interposition of a nerve graft had less satisfactory results, the nerve transfer being initially a alternative method which time proved to have an increased potential for the restoration of the function.(8) As donor nerve, there were used multiple nervous sources with variable results, but the branch for the long head of the triceps (transferred to axillary nerve) and the spinal accessory nerve (its distal part used with posterior approach and transferred to the suprascapular nerve) they had good functional outcomes.(9)

For the other major goal of functional restoration in this pathology which is the flexion of the elbow, the classical treatment method is the nerve transfer from ulnar to musculocutaneous nerve.(10) This method is used in patients with severe lesions of the superior trunk and with intact inferior trunk. The intraoperative careful selection of the fascicles of the ulnar nerve allows its use as a donor nerve without impairing its motor or sensitive function and also with good functional results from the motor action point of view of the musculocutaneous nerve.(11)

When it is needed that the flexion of the elbow to be augmented, a double nerve transfer can be done: neurotization of median nerve to musculocutaneous nerve associated with that of the ulnar nerve to the same musculocutaneous nerve, each of them being addressed separately to its two different motor branches, with good results and without motor or sensorial morbidity.(12)

The idea of using the intercostals nerves for the treatment of the lesions of brachial plexus is not new (13), but its practical validation was proved later by the transfer to musculocutaneous nerve with good functional results regarding the flexion of the elbow – which is the other major goal of the restoration of the function in this pathology.(14) This method is especially valuable in severe plexopathy when the intraplexal nerve sources are not available. Used in combination with proper muscles, the intercostal nerve transfer can yield adequate power to the paretic limb and the reinnervation of the native muscle (i.e. latissimus dorsi) should always considered as they can be transferred later on for further functional restoration.(15)

The ideal timing of nerve transfer is not clear defined but a general consensus indicates that muscular reinnervation over 12-18 months from the moment of lesion does not have

proper results due to the fact that after this period, irreversible lesions occur at the site of the neuro-muscular plaque.(3)

The palsy of brachial plexus represents a surgical challenge which has a series of technical solutions that are used more often but they can be associated with other surgical procedures that are not so common as we have showed in our study, in the end with good results from the point of view of the restored movements of the superior limb (abduction of the shoulder and flexion of the elbow). It must be underlined that the evolution of the patients with nerve transfer also depends by the cortical plasticity (7) which represents the physiological basis of the functional recovery – the final goal of the complex treatment addressed to this pathology.

CONCLUSIONS

The advantages of the neurotization method are:

- they are applied at distance from the lesional area and from the scar but at the same time, they are done close to the target nerve allowing its rapid reinnervation and a faster recovery of the function of the target organ;
- they can be done in patients with late presentation regarding the moment of the trauma;
- by using this method (so avoiding the nerve interposition technique), an increase of the number of regenerative nervous fibers towards the target organ is achieved.

In order to achieve a good nerve transfer, there must be observed several conditions:

- the donor nerve has to have a large number of viable axons;
- the calibre of the donor nerve has to be comparable with that one of the receptor nerve;
- the donor nerve has to have enough length;
- the drop of the function of the target organ of the donor nerve has to be minimal;
- the receptor nerve has to be neurotized as close as possible to his target organ.

The result of the treatment is influenced by:

- the process of healing (which depends on the age of the patient; on the localisation, extent and grade of the lesion; on the time period in between the moment of the trauma and the operation);
- the surgeon (because there is need for thorough knowledge of macro and microanatomy of the brachial plexus, understanding of nervous pathophysiology, meticulous microsurgical technique);
- the patient (his/her desire to be treated and the postoperative cooperation)
- the rehabilitation programme (which includes physiotherapy, pain treatment, passive and active counselling for the restoration of the function of the superior limb) which, in the end, leads the patient to his reintegration at the working place and in society.

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