CASE STUDY: AQUATIC THERAPEUTIC EXERCISES AFTER NERVE TRANSFERS IN THE UPPER EXTREMITY

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ABSTRACT

Introduction. The nerve transfer is a procedure in which a healthy peripheral nerve is engrafted to a damaged one in order to restore the initial function. It is used for treatment of late brachial plexus injuries. The aim of the study is to present the effects of aquatic therapeutic exercises after nerve transfers for two patients with late brachial plexus injuries. Methodology. Both patients received a nerve transfer of n.accessorius to n.suprascapularis, n.phrenicus to n.axillaris, and modified Oberlin transfer for the recovery of the elbow function. The physiotherapeutic program included exercises which are activating the donor nerves out and inside the aquatic environment. The results were reported each month until the 6th postoperative month (POM). The active range of motion was measured by goniometry out and inside the aquatic environment. For the evaluation of motor function of the shoulder and elbow muscles, the Medical Research Council Scale (MRCs) was applied. Results. The active range of motion to all movements for both patients started at 0°. The first patient had 45° shoulder abduction in the aquatic environment versus the 20° outside the aquatic environment. The second one had respectively 80° and 45° shoulder abduction. Values of 130° elbow flexion in the aquatic environment and 100° outside it, were measured for the first patient. The other patient had similar results-140° elbow flexion in aquatic environment versus 120° outside the aquatic environment. According to the MRCs in 6th POM, both patients had reached M2 for shoulder abductors and M3 for elbow flexors. Conclusion: Timely included aquatic therapeutic exercises are a good strategy for early isotonic muscle contraction, for patients with nerve transfers in the upper extremity.

Key words: *N.phrenicus transfer, physical therapy*

INTRODUCTION

Brachial plexus injuries are devastating injuries that lead to partial or total functional impairment of the upper extremity. Nerve transfers (neurotisations) are one possible option for their treatment. In this procedure an expendable donor nerve or fascicle is redirected to a foreign nerve stump in order to innervate and restore the function to a denervated end-organ (muscle or skin). For such a functional reconstruction with this method, the priorities are generally as follows: elbow flexion, shoulder abduction and stability, hand sensibility, wrist and fingers flexion, wrist and fingers extension and intrinsic hand muscle function (Chung et al., 2006). Physical therapy after the nerve transfers is consistent with the recovery period of the nerves and the treatment stage. Essential of it are the special exercises which activate the donor's nerves (Kahn, Moore, 2016). We assume that if those activating exercises are performed in an aquatic environment, they will be more effective due to the physical properties of the water (buoyancy, resistance, facilitating movements, etc.) That's why the aim of the study is to present the effects of aquatic therapeutic exercises after

nerve transfers for two patients with late brachial plexus injuries.

METHODOLOGY

Both patients had C5-C6-C7 brachial plexus root avulsion due to a motorcycle crash. They were surgically treated with a nerve transfer in Sofamed Hospital. During the 3rd month after the injury, a modified Oberlin transfer for the recovery of the elbow function was performed. This is a method for selective nerve transfer of m.biceps brachii and m.brachioradialis. This is a method for selective nerve transfer of m.biceps brachii and m.brachioradialis. The n.ulnaris and n.medianus fascicles are directed to the middle third level of the arm and attached to the motor branches of these muscles without disturbing the initial function of the arm (Kateva et al., 2017c). For the recovery of the shoulder function, another nerve transfer was also performed at the same stage. N.accessorius is dissected as far distally as possible and then was directly coapted to the n.suprascapularis (Kateva et al. 2017b). During the 6th month after the injury, a neurotization of n.axillaris was made with the full length of n.phrenicus harvested endoscopically be-

fore sinking into the diaphragm (Kateva, Vrachanski, 2019).

The physiotherapeutic program of the both patients included exercises which are activating the donor nerve out and inside the aquatic environment, for the abduction and flexion of the shoulder, as well as for the elbow flexion.

Outside of the aquatic environment, emphasis is on

auto-assisted exercises which activate the donor's nerve. Examples of such exercises are:

- The patient is sitting on a chair, the elbow is 90° flexed and the forearm is leaned on the thigh (Figure 1A). The patient then performs simultaneous finger flexion and trunk flexion combined with a passive elbow flexion in the full possible range of motion (Figure 1B)

Figure 1. Auto-assisted flexion in the elbow

- The patient is in a supine lying position with flexed knees and feet on the couch. The patient performs simultaneous resistive diaphragmatic

breathing and shoulder abduction. On Figure 2 there is an active-assisted abduction, and on the Figure 3 the abduction is facilitated by the couch.

Figure 2. Active-assisted abduction in the shoulder

Figure 3. Shoulder abduction facilitated by the couch

The aquatic therapeutic exercises may begin as soon as a muscle contraction has appeared. This is usually observed after the 2nd postoperative month (POM). We recommend the water temperature to be indifferent, the pool depth to be no more than 150 cm and a suitable ladder for entering the pool to be available. The aquatic therapeutic session lasts about 45 minutes. The dosage of the exercises is determined by the patient's individual abilities and the subjective

feeling of fatigue. The following exercises were applied:

- The patient is kneeled while the operated upper limb is under the water. The patient performs simultaneous diaphragmatic breathing and shoulder abduction (Figure 4)
- The patient is kneeled while the operated upper limb is under the water. The patient performs simultaneous finger and elbow flexion (Figure 5)

Figure 4. *Shoulder abduction assisted by the water*

- The patient is kneeling while the operated upper limb is under the water (Figure 6A). The patient grips with both hands to a fixed support (the pool ladder, the pool overflow) and performs

Figure 5. *Elbow flexion assisted by the water*

- elbow flexion with both arms (Figure 6B). This exercise may be upgraded by performing with the operated hand only (Figure 6C)

A

B

C

Figure 6. *Complex exercise for the elbow flexion*

- The patient is kneeling while the operated upper limb is under the water and the shoulder is 90° abducted (Figure 7A). The patient grips with both hands to a fixed support (the pool ladder, the pool overflow) and performs an elbow flexion (Figure 7B)

A)

B)

Figure 7. *Complex exercise for the shoulder abduction and the elbow flexion*

In the complex therapeutic program we also used various therapeutic exercises and techniques, such as electrostimulation with biphasic trapezoidal or triangular impulses of varying pulse duration, passive exercises, active-assisted exercises, etc.

The results were reported for each month until the 6th POM. The active range of motion was measured by goniometry out and inside the aquatic en-

vironment. To evaluate the motor function of the shoulder and elbow muscles, the British Medical Research Council Scale (BMRC) was applied.

Results. The active range of motion to all movements for both patients started at 0°. The first patient had 45° shoulder abduction in the aquatic environment versus the 20° outside the aquatic environment. The

second one had respectively 80° and 45° shoulder abduction (Figure 8).

Figure 8. Results of the shoulder abduction

Values of 130° elbow flexion in the aquatic environment and 100° outside it, were measured for the first patient. The other patient had similar results - 140° elbow flexion in aquatic environment versus 120° outside the aquatic environment (Figure 9).

Figure 9. Results of the elbow flexion

According to the BMRC both patients started at M0. In 6th POM, both patients had reached M2 degree (active movement with gravity eliminated) for shoulder abductors and M3 degree (movement against gravity) for elbow flexors (Figure 10).

Figure 10. Results of the BMRC scale for the shoulder abductors and elbow flexors

Discussion. Moses et al. (2019) presents a case study of a 25-year old patient with root avulsion of C5-C6. A double Oberlin nerve transfer was performed on the 5th month after the injury. In the 12th POM an excellent functional recovery was achieved - 140° active flexion in the elbow and M4+ for m.biceps brachii and m.brachioradialis. A follow-up between 6th and 36th POM of patients with different nerve transfers was conducted by Mohammad-Reda (2013). In 5 of 6 patients with Oberlin nerve transfer, a functional muscle strength of the elbow's flexors (M5-M3) was achieved. Long-term outcomes for such a transfer also show good results. Verdnis & Kapickis (2018) followed-up 10 patients on an average 43.6 POM. Six of them gained M5 of the flexors of the elbow, and the rest gained M4. These results are sufficiently functional. The Bulgarian experience with this kind of surgery shows similar outcomes – 4 adult patients reached M4/M5 after the 12th POM (Kateva et al., 2017c).

Bhandari P et al (2009) performed nerve transfer n.accessorius to n.suprascapularis for shoulder function recovery in 19 patients. The average post-operative follow-up was over 18 months. 5 patients achieved M4 of the abductors of the shoulder, 3 of them – M3+, and the rest – M2. The average active shoulder abduction was 95° (range 50° - 170°). Kostas-Agnantis et al (2013) treated 11 patients with C5-C6 avulsions with nerve transfers of n.radialis to n. axillaris and n.accessorius to n.suprascapularis. There were good postoperative results. Average active shoulder abduction was 112.2° and average active external rotation was 66°. The muscle function of the abductors and external rotators of the shoulder was M3+. Similar results of the same nerve transfers were achieved by Kateva et al. (2017a). Their 5 patients reached M3-M4 for abductors and external rotators of the shoulder.

The use of n.phrenicus by its full length as a donor is an excellent method for re-innervation of affected muscles after plexus brachialis injury. It shortens the re-innervation time of the recipient's muscles with a 7-12 months postoperative period until the occurrence of muscle contractions. The use of n. phrenicus as a donor nerve in the case of end-to-end co-adaptation does not lead to permanent impairment of respiratory capacity and pulmonary function of the patient. (Kateva, Vrachanski 2019).

Despite of the short-term follow-up for the two patients in the present study, we have a reason to expect better functional outcomes in the future.

CONCLUSION

Timely included aquatic therapeutic exercises are a good strategy for early isotonic muscle contraction, for patients with nerve transfers in the upper extremity. Further studies with larger contingent are needed.

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