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Comparison of short-term surgical outcomes of patients with closed brachial plexus traction injury

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Abstract

Brachial plexus traction injury is common and is an important socioeconomic issue with surgical outcomes being essential for neurosurgery, neurology, trauma, orthopaedic and rehabilitation specialists. **The objective** was to compare short-term surgical outcomes in patients with closed brachial plexus traction injuries. **Material and methods** The study involved 61 patients with closed brachial plexus traction injuries who were divided into two homogeneous groups according to sex, age and severity of neurological deficit. Patients of Group I (n = 33) underwent microsurgical neurolysis as a surgical treatment and patients of Group II (n = 28) underwent microsurgical neurolysis in combination with single-level electrical stimulation. Clinical and functional status of the upper limb was assessed in dynamics using scales and electrophysiological monitoring. **Results** Short-term results of surgical treatment were significantly better in Group II compared to Group I. **Discussion** A more apparent recovery of the upper limb function was observed in patients of Group II that indicated advantages of microsurgical neurolysis in combination with electrical stimulation to repair closed brachial plexus traction injuries. **Conclusion** The combination of microsurgical neurolysis and single-level electrical stimulation improves short-term surgical outcomes of patients with closed brachial plexus traction injuries due to a faster pain relief in the postoperative period and positive dynamics in clinical and electrophysiological parameters.

Keywords: brachial plexus, traction injury, surgical management, electric stimulation

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INTRODUCTION

Closed brachial plexus traction injuries (CBPTI) occur in 20 % of injuries to the peripheral nervous system [1, 2]. The problem has both medical and social role with permanent disability reaching 81 % of cases [2, 3]. The traction mechanism of injury to the brachial plexus (BP) commonly involves stretching of the trunks as a result of neck tilt, shoulder drooping, forcible abduction of the arm to the side and shoulder dislocation. CBPTI are commonly caused by direct trauma to the shoulder girdle, road traffic accidents, falls from a height and other factors.

CBPTI are accompanied by multiple musculoskeletal injuries in 65 % of cases and are normally combined [1, 2, 4]. The most severe type of CBPTI is a total injury with both primary and secondary trunks being affected [5, 6]. Despite the use of a full range of therapeutic measures, a favorable outcome can hardly be predicted with no recovery of the upper limb function [7, 8]. Failed conservative treatment for more than 3 months is one of the indications for surgical intervention in CBPTI to rule out parabiosis mimicing irreversible total BP injury [9, 10]. Microsurgical neurolysis (MN) of BP trunks and methods of electrical stimulation (ES) including direct ES of primary and secondary BP trunks, epidural ES, multilevel ES are surgical treatment options for injuries of peripheral nerves [2]. The effectiveness of ES in the treatment of BP injury remains a debatable issue.

Some authors [11, 12–14] reported improved regeneration after ES techniques, however, an alternative opinion can be found in the literature. Some authors [15, 16] reported suppression of growth bulbs with use of ES for neuron bodies with no clear criteria for ES identified, and most scientists use ES empirically selecting indications specifically for each patient. Surgical treatment of CBPTI with the use of ES is essential in the complex management of a total BP injury and requires further research.

The objective was to compare short-term surgical outcomes in patients with closed brachial plexus traction injuries.

MATERIAL AND METHODS

The design is a retro- and prospective, single-center, randomized study. The inclusion criteria were a total BP injury, the traction mechanism of injury, available medical history, absent injury to major vessels, the injury that occurred no later than 3 months and had been treated conservatively. The study included 61 patients with CBPTI who were hospitalized at the Saratovsky National Research Institute for Trauma and Orthopaedics between 2005 and 2021. The study was conducted in two groups, homogenous in gender, age, severity of neurological deficit that was associated the total involvement of of PS lesions and was accompanied by the complex regional pain syndrome (CRPS) in the affected upper limb, decreased muscle strength to 0 points, and sensory disorders to anesthetic effect of the upper limb. The criterion for grouping was the method of surgical treatment used. MN was performed as a standalone procedure in group I (n = 33) (retrospective study) and combined with single-level ES in group II (n = 28). The preoperative workup included physical and neurological examination using visual analog scale (VAS), the Medical Research Council Weakness Scale (MRC), the Quick Disability of the Arm (DASH) scale, Barthel index (BI) and standard electroneuromyography (ENMG) performed preoperatively and at 6 months of surgery using Keypoint electromyograph (Alpine Biomed ApS, Denmark). A registration document created for each patient included a coding card and electronic database was consisted of the data sheets [17].

Surgical intervention in patients of group I was performed under total intravenous anesthesia with artificial lung ventilation. The patient was placed on the operating table with the head turned towards the healthy limb, a roller mounted under the scapula, and the arm fixed in moderate tension. We used a non-projective Pussep access for BP trunks. C5-D1 spinal nerves, upper, middle, lower BP trunks were exposed. MN was performed with visualized BP trunks at the level of injury (Fig. 1). Intraoperative ultrasound examination (ultrasound) was performed to assess intra-trunk changes. The wound was sutured in layers with thorough hemostasis performed.

Surgical treatment in group II (n = 28) included MN multichannel electrodes placed on C5, C6, C7, C8, the spinal nerves, upper, middle and lower BP trunks and were drawn from the wound through the counter-opening and fixed to the skin with interrupted stictches (Fig. 2). The wound was sutured in layers. ES was performed starting from the first day after the operation using a portable test stimulator that was adjusted with a programmer. The stimulation parameters were adjusted for each patient, focusing on the paresthetic feeling at the site of innervation of the BP trunks. The parameters of the stimulating current frequency varied from 18 to 30 Hz, current strength from 0.5 to 3 mA, pulse duration from 100 to 380 ms with higher stimulation parameters being used for more severe lesions. Stimulation sessions were performed 3 times a day for 15 minutes for 14 days. The patients (n = 61) received medical and physio-functional treatment postoperatively.

Statistical analysis data was performed using Microsoft Office Excel 2019, IBM SPSS Statistics v23. The data were evaluated using descriptive and nonparametric statistical methods. The Mann-Whitney U test and the Wilcoxon test were used. The Mann-Whitney U-test was used for assessment of the significant differences in the dynamics of the parameters in groups I and II. Differences between groups were considered statistically significant at $p < 0.05$.

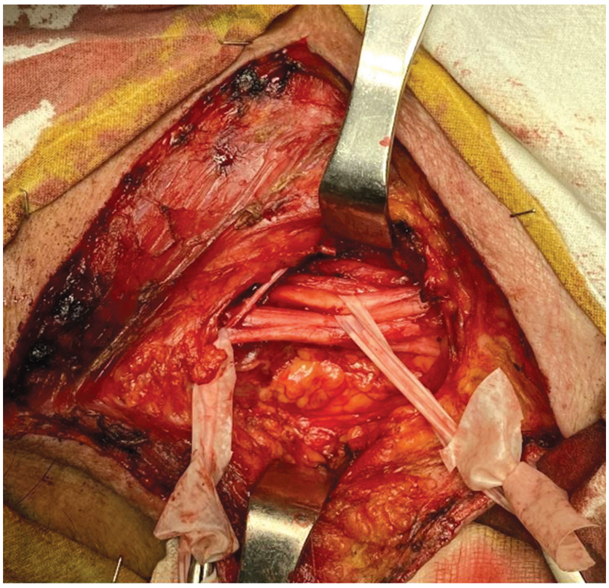

Fig. 1 Upper, middle and lower BP trunks after neurolysis

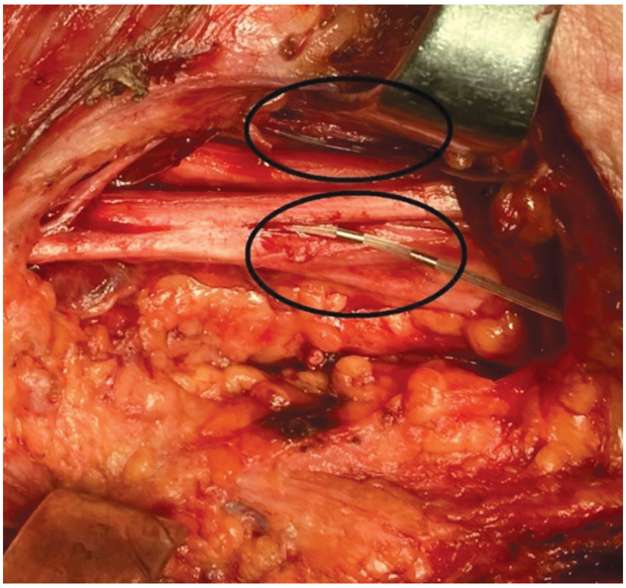

Fig. 2 Electrodes implanted on the trunks of the brachial plexus

RESULTS

CRPS was observed preoperatively in patients of group I and group II and Me (Q1; Q3) scored 8 (7; 9) on VAS scale. There were no differences between the groups ($p = 0.487$). Assessment of the sensitivity and muscle strength of the injured limb showed Me (Q1; Q3) of 2 (2; 3) points ($p = 0.318$), and sensitivity Me (Q1; Q3) scored 3 (2.5; 3) ($p = 0.788$). DASH score showed a high and moderate deficiency due to the severity of CRPS, Me (Q1; Q3) measuring 46.3 (42.2; 51.15) in group I and 51 .7 (42.68; 55.10) in group II, while the deficiency was less pronounced with moderate and low pain intensity ($p < 0.005$). Injury to the long trunks of the BP was preoperatively registered in all patients with the damage to the ulnar nerve being more pronounced.

The ENMG of the nerves of the upper limb were characterized by decreased amplitude and increased latency of responses and decreased speed of impulse conduction. No differences were found in the study groups ($p = 0.342$). An extremely severe nerve injury was noted in 11 cases with no M-response of the distal stimulation points, and no response could be registered in 5 cases out of 11 from the proximal points. All patients included in the study demonstrated a syndrome of impaired nerve conduction of the upper limb with severe axonal demyelinating lesions. Patients of both groups showed a decreased severity of CRPS postoperatively. The VAS measured Me (Q1, Q3) 5 (6; 3) in group I and 4 (5; 3) in group II with a greater pain reduction noted in group II, however, none of the groups demonstrated complete regression ($p < 0.005$) (Fig. 3).

Although significant increase in strength of the injured limb was seen at 6 months in both groups measuring 3 (2; 3) points ($p < 0.001$) in groups I and II, there were significant differences in the muscle strength between the groups after surgical treatment ($p = 0.353$). Positive dynamics was noted in the dynamic assessment of sensitivity that was more pronounced in group II ($p < 0.05$). There was no recovery of sensitivity to a normal level. Patients of both groups showed a decrease in functional insufficiency of the upper limb (according to DASH) postoperatively due to a greater regression of the pain. The function of the upper limb scored 42.5 (36.45; 54.35) postoperatively in group I and 48.6 (42.27; 52.50) ($p = 0.043$) in group II. ENMG demonstrated increased amplitudes and decreased latency of the M-response in all patients. The recovery of electrophysiological parameters correlated with clinical findings in all cases and was better in patients with less severe nerve damage. More significant dynamics was noted in the study of the ulnar and radial nerves both in the proximal and distal sections (Fig. 4).

Short-term outcomes were significantly better in patients of group II compared to group I due to a faster reduction in pain and the extent of functional deficiency of the upper limb and positive dynamics in electrophysiological parameters.

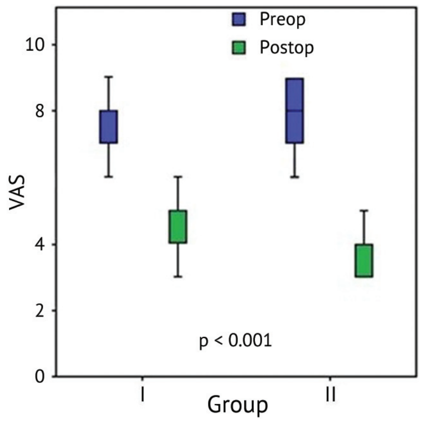

Fig. 3 Dynamics in pain

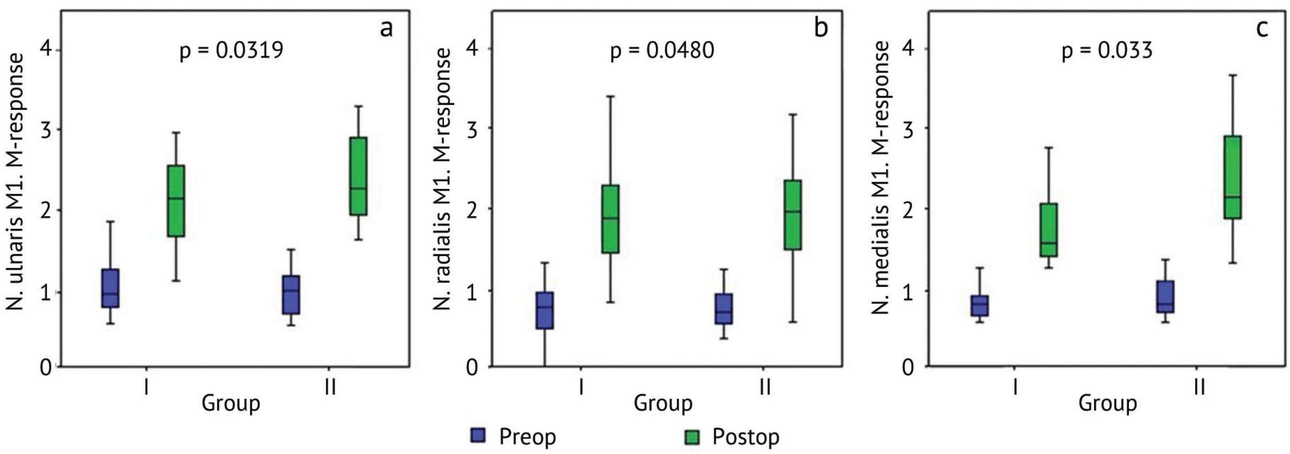

Fig. 4 Dynamics in M-response of ulnar nerve (a); radial nerve (b); median nerve (c)

DISCUSSION

The results obtained correlate with the literature data. Some authors report similar results of ES effect [11, 15, 18]. ES is reported to cause pain relief by more than 50 % in neuropathic pain caused by occipital nerve neuralgia [15, 16]. Other researchers [8, 11, 19] used minimally invasive technologies of neurolysis and ES to provide a pronounced analgesic effect (more than 50 % of cases) and restoration of muscle strength due to electrical stimulation, however, these studies do not compare MN in combination with ES and MN in terms of regression of the pain and rates of reinnervation of peripheral sensory and motor structures. The dynamic clinical studies of the series and ENMG showed the effectiveness of MN in combination with ES only before MN. Some authors ascribe the effect to activation of neurotrophic factors [20–22]. The positive effect of ES in restored reinnervation of peripheral sensorimotor structures is reported to be associated with the preservation of muscle contractility prior to regeneration of peripheral sensorimotor structures [23]. Ever greater findings about activated regenerative activity due to ES can be helpful in expanding indications for its use and requires the definition of criteria for selecting patients in various clinical scenarios [7, 12-14]. a more pronounced recovery of the upper limb function was noted in patients of group II treated with microsurgical neurolysis combined with electrical stimulation in case of closed brachial plexus traction injuries.

CONCLUSION

Although MN is the most common surgical treatment of peripheral nerve injuries and ES is considered as a surgical option, the dynamics in clinical, neurological and functional status has demonstrated a greater effectiveness of MN combined with ES (Group II) as compared to MN alone (Group I). The combination of MN with single-level ES improves short-term outcomes of surgical treatment of patients with CBPTI due to a faster pain relief in the postoperative period and positive dynamics in clinical and electrophysiological parameters.

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