 doi:10.20944/preprints202207.0142.v1

Article

Comparison of the Short-term Surgical Outcomes in Patients with Closed Traction Injuries to Brachial Plexus

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Abstract: As the problem of traction injuries to brachial plexus is a common one and of high socio-economic significance, the analysis of the surgical outcomes in patients with this pathology is significant for neurosurgery, neurology, traumatology-orthopedics, and rehabilitation. The **aim** of the research is to compare the short-term outcomes of using various surgical methods for managing patients with closed traction injuries of brachial plexus. **Material and methods**. The research involved 61 patients with closed traction injury of brachial plexus divided into two groups homogeneous in sex, age and severity of their neurological deficit: Group I – 33 patients who underwent microsurgical neurolysis, Group II – 28 patients who underwent microsurgical neurolysis combined with one-level electrostimulation. The dynamic assessment of clinical and functional status of upper limbs was performed using scale methods and electrophysiological monitoring. **Results**. The research revealed a more evident recovery of the upper limb function in Group II patients suggesting the method of microsurgical neurolysis combined with electrostimulation to be preferable in case of closed traction injuries to brachial plexus. **Conclusion**. The combination of microsurgical neurolysis with one-level electrostimulation improves the short-term outcomes of surgical treatment in patients with closed traction injuries of brachial plexus due to a sooner decrease in pain in postoperative period, and positive dynamics of clinical and electrophysiological parameters.

Keywords: brachial plexus; traction injury; surgical treatment; electrostimulation

1. Relevance

Closed traction injuries to brachial plexus (CTIBP) make up as much as 20% of all cases injuries to the peripheral nervous system [1]. This problem is not just a medical one, it's also social since 81% of brachial plexus injuries result in permanent disability [2]. The traction mechanism of brachial plexus (BP) damage is conditioned by stretching of its trunks as a result of neck tilt, shoulder drooping, forced abduction of the arm to the side, and dislocation in shoulder joint. CTIBPs are most frequently caused by direct trauma to shoulder girdle, traffic accidents, falls from a height, and other factors. Some authors claim these traumas are accompanied by multiple injuries of the musculoskeletal system in 65% of cases, and are of combined nature [1, 3].

The most severe type of CTIBP is its total type when both primary and secondary trunks are affected [4]. In these cases the failures are possible despite the full range of therapeutic measures taken, so the functioning of upper limb renders unrecoverable [5]. One of the indications for surgical intervention in CTIBP is the absence of conservative treatment effect for more than 3 months as it enables excluding parabiosis, which mimics the pattern of irreversible total BP damage [6, 7]. The options for surgical treatment of peripheral nerve injuries include microsurgical neurolysis (MN) of BP trunks and various methods of electrostimulation (ES), for example, direct ES of primary and secondary BP trunks, epidural ES, multilevel ES.

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The ES efficacy in the treatment of BP injuries remains a debatable issue. Some authors [8-10] report the improvement of regeneration after ES, however, there is an alternative opinion found in the literature. The authors of [11] report the suppression of growth flasks when using ES on neurocytons, and also notes that at the moment no clear criteria for ES use are defined causing most scientists use it empirically, adjusting the main indicators for each patient.

Thus, surgical management of CTIBP with ES as a part of the combination treatment for total BP injury is a challenging issue in medical science and requires further research.

The **objective** of this research is to compare the short-term outcomes of various surgical methods for patients with CTIBP.

2. Materials and Methods

This research was a retro- and prospective, single-center, randomized. The research protocol was approved by the Ethics Committee of the Federal State Budgetary Educational Institution of Higher Education V.I. Razumovsky Saratov State Medical University of the Russian Federation Healthcare Ministry.

The inclusion criteria for patients were the total BP injury, the traction mechanism of the injury considering the history data, the absence of damage to great vessels, the age of the injury no later than 3 months with previous conservative treatment.

The study involved 61 patients with CTIBP who underwent hospital treatment in the Scientific Research Institute of Traumatology, Orthopedics and Neurosurgery, Federal State Budgetary Educational Institution of Higher Education 'V.I. Razumovsky Saratov State Medical University', the Russian Federation Ministry of Healthcare in 2005-2021. The patients were divided in two groups homogeneous in gender, age, severity of neurological deficit which in all cases corresponded to the total total BP injury and accompanied by complex regional pain syndrome (CRPS) in the affected upper limb, a decrease in muscle strength to 0 scores, sensory disorders up to anesthesia degree in the upper limb. The criterion for dividing the patients into groups was the surgical method: patients in Group I (n=33) underwent MN (retrospective study), in Group II (n=28) MN with single-level ES was used.

The preoperative examination included both clinical and neurological examination using various scales and questionnaires, such as the visual analogue scale (VAS), Medical Research Council (MRC) Scale for Muscle Strength, the disabilities of the arm, shoulder and hand (DASH) questionnaire, Barthel index (BI) as well as the findings of the standard electroneuromyography (ENMG) performed both before the surgeries and 6 months after surgeries on Keypoint electromyograph (Alpine Biomed ApS, Denmark).

A registration document (coding card) was created for each patients; the data of the cards constituted the electronic database [12].

Surgical intervention in Group I patients was performed under general anesthesia with artificial lung ventilation. The patient was placed on the operating table with the head turned towards the healthy limb, a roll was put under the scapula, and the arm was fixed in a moderate tension position. We used an extra-projective access to get to BP trunks. C5-D1 spinal nerves, upper, middle, lower BP trunks were isolated. As BP trunks at the level of damage were visualized, MN was performed (Fig. 1). Intraoperative ultrasound examination was performed to assess intra-stem changes. The wound was meticulously hemostasized and sutured in layers.

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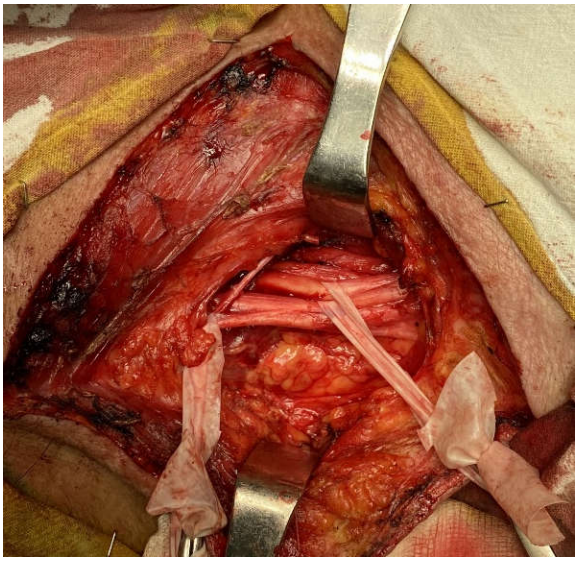

Figure 1. Upper, middle and lower brachial plexus trunks after neurolysis.

For Group II patients (n=28) the surgical treatment involved MN with further placing of multichannel electrodes on C5-C8 spinal nerves as well as upper, middle, and lower BP trunks. The electrodes were led out of the wound through the counter-opening and anchored to the skin with interrupted stitches (Fig. 2). The wound was sutured in layers. ES was started on Day 1 after the surgery with a portable test stimulator adjusted using a programmer. The stimulation parameters were customized for each patient considering the paresthesia sensation in the area of BP trunk innervation. The frequency of stimulation current varied from 18 to 30 Hz, the rate from 0.5 to 3 mA, pulse duration from 100 to 380 ms, while higher stimulation parameters were used for more severe damages. 15 min stimulation sessions were performed 3 times a day for 14 days.

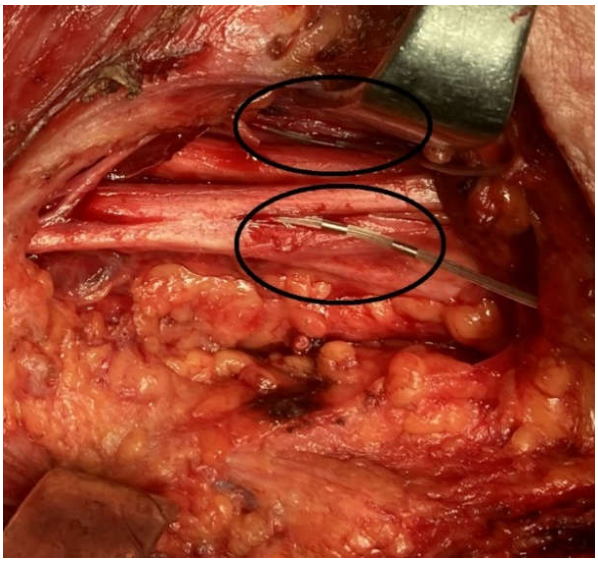

Figure 2. The electrodes implanted on the brachial plexus trunks.

In the postoperative period, all patients (n=61) received medical and physio-functional treatment.

Statistical analysis of the findings was performed using Microsoft Office Excel 2019, IBM SPSS Statistics v23. Data were evaluated using descriptive and nonparametric statistical methods. The Mann-Whitney U test and the Wilcoxon test were employed. When assessing the significance of the difference in the dynamics of the analyzed parameter, the

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Mann-Whitney U-test comparison was used in Groups I and II. Differences between groups were considered statistically significant at $p<0.05$.

3. Results

At the preoperative stage, CRPS was observed in patients of both Group I and II, while its VAS Me (Q1; Q3) was 8 (7; 9) scores. However, no differences were found between the groups (p=0.487).

When assessing the sensitivity and muscle strength of the injured limb, Me (Q1; Q3) of the latter was 2 (2; 3) scores (p=0.318), and sensitivity Me (Q1; Q3) was 3 (2.5; 3) scores (p= 0.788).

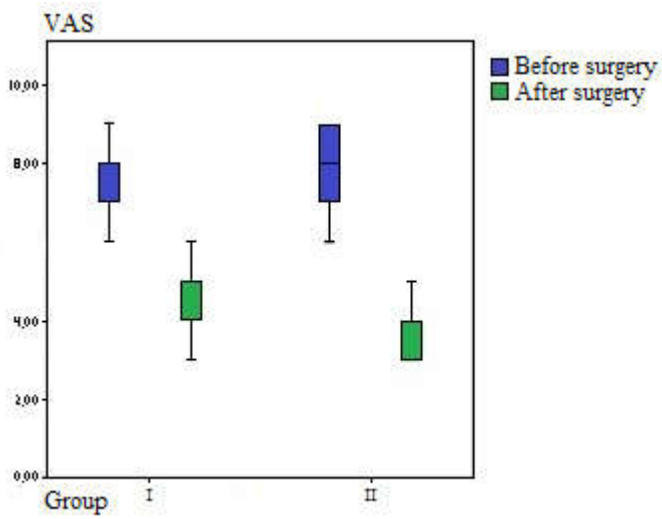
The assessment with the functional deficiency DASH scale revealed high and moderate deficiencies, mainly due to CRPS severity, its Me (Q1; Q3) in Group I was 46.3 (42.2; 51.15) scores, and in Group II 51.7 (42.68; 55.10) scores, while the deficit was less pronounced with moderate and low pain severity ($p<0.005$).

At the preoperative stage, damage to long BP trunks was noted in all patients, while the damage to the ulnar nerve was more pronounced.

The ENMG parameters of the upper limb nerves featured a decrease in the amplitude, an increase in the latency of responses, and the reduction of impulse conduction speed. There were no differences in the analyzed groups (p=0.342). 11 nerves were damaged severely – no M-response was registered from the distal stimulation points, and in 5 cases out of 11 no response was registered from the proximal points, too.

Thus, a syndrome of impaired nerves conduction of in the upper limb was observed in all patients included in the study with severe axonal demyelinating lesions prevalence.

In the postoperative period, patients in both groups featured a decrease in CRPS severity. VAS Me (Q1, Q3) were 5 (6; 3) scores in Group I and 4 (5; 3) scores in Group II. While the pain reduction rate was higher in Group II, no complete regression was observed in either of the groups ($p<0.005$) (Fig. 3).



p<0,001.

Figure 3. Pain syndrome dynamics.

6 months after surgical treatment, a significant increase in strength in the injured limb was noted in both groups: up to 3 (2; 3) scores in Group I and 3 (2; 3) in Group II ($p<0.001$). However, the assessment of strength in the compared groups after surgical management revealed no significant differences (p=0.353).

Also, the dynamic assessment of sensitivity showed some positive dynamics which was more pronounced in Group II ($p<0.05$) but no recovery of sensitivity to a normal level was observed.

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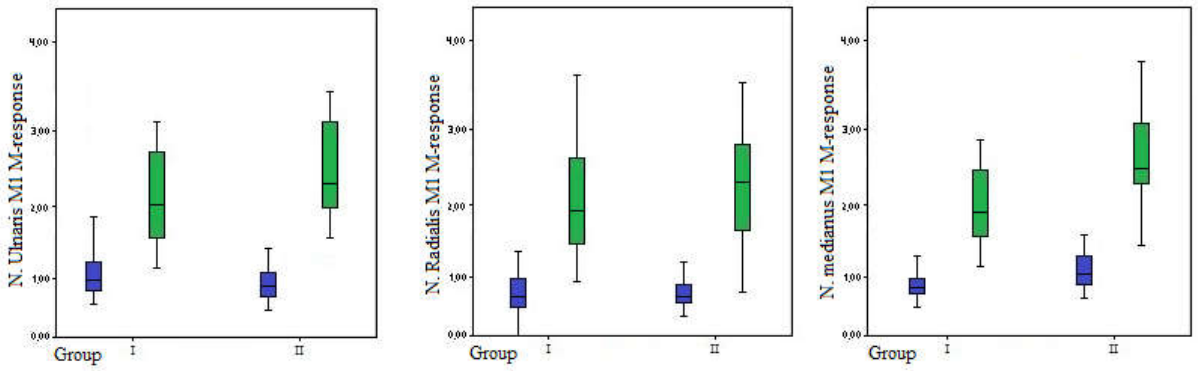
In the postoperative period, patients in both groups showed a decrease in functional insufficiency of their upper limbs (by DASH) probably due to a greater regression of pain syndrome. The results of the upper limb function evaluation after surgeries were 42.5 (36.45; 54.35) scores in Group I and 48.6 (42.27; 52.50) scores in Group II (p=0.043).

The analysis of ENMG parameters in all patients revealed an increase in amplitudes and a decrease in the latency of M-response. In all cases, the recovery of electrophysiological parameters correlated with clinical data and proceeded more actively in patients with less severe nerve damage. Notably, in both proximal and distal sections of ulnar and radial nerves the dynamics was more significant (Fig. 4).



p=0.0319 p=0.0480 p=0.033

a) b) c)

Figure 4. Dynamics of M-response indicators: a) ulnar nerve; b) radial nerve; c) median nerve.

Thus, in Group II patients the short-term outcomes of surgical treatment were significantly better compared to those in Group I due to a faster reduction in pain syndrome and functional insufficiency of the upper limb, as well as positive dynamics of electrophysiological parameters.

4. Conclusion

Though MN is the most common method of surgical treatment for peripheral nerve injuries, and ES is considered to be a surgical option, the dynamics of clinical, neurological and functional status indicators show a greater efficiency of MN combined with ES (Group II) compared to MN alone (Group I). The combination of MN with a single-level ES improves the shorty-term outcomes in patients with CTIBP due to a faster decrease in pain in postoperative period and positive dynamics of clinical and electrophysiological parameters.

Author Contributions: Conceptualization, V.D. and AK.; methodology, K.D.; software, K.D.; validation, V.D., K.D. and AK.; formal analysis, V.D., K.D. and AK.; data curation, V.D., K.D. and AK.; writing—original draft preparation, V.D., K.D. and AK.; writing—review and editing, V.D., K.D. and AK.; visualization, K.D.; supervision, V.D.; project administration, V.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research is part of the NIR NIITON SSMU project *Designing medical decision support system in the complex treatment of peripheral nerve injuries using electroneuromodulation methods*, state registration number 121032300173-9. It received no specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

Informed Consent Statement: All authors give their consents to distribute the full text of this paper to Ulyanov V.Yu., MD, Associate Professor, DSc.

Conflicts of Interest: The authors declare no conflict of interest.

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