

# Effectiveness of the program for restoring the function of the upper limb in traumatic and compression-ischemic injuries of the peripheral nerves and brachial plexus

**Olena Bismak**

*National University of Ukraine on Physical Education and Sport, Kyiv, Ukraine*

**Purpose:** to determine the effectiveness of the developed program for the restoration of upper limb function in traumatic and compression-ischemic injuries of the peripheral nerves.

**Material & Methods:** the study involved 173 patients who were divided into 2 main rehabilitation groups: group I – patients with acute traumatic damage to the peripheral nerve or plexus (132 people), group II – patients with compression-ischemic (tunnel) neuropathies and plexopathies (41 people). The study was conducted on the basis of the Institute of Neurosurgery acad. A. P. Romodanova of the National Academy of Medical Sciences of Ukraine” (2015–2018) and on the basis of neurological departments No. 1 and No. 2 of the Kiev City Clinical Hospital No. 4 (2017–2019). To assess impaired motor function of the nerve and sensitivity, a 6-point scale was used according to the method of R. B. Zachary, W. Holmes, N. Millesi. The Boston Questionnaire (Boston Carpal Tunnel Questionnaire) was used to assess the severity of symptoms, activity, and participation in daily life.

**Results:** during the initial examination, we found that in the majority of patients of the 1st rehabilitation group, motor disorders on a 6-point scale were at the level of M1-M2 in 27,3% and 31,8% of individuals, respectively, and M3 in 15,9% of patients. In patients of the rehabilitation group II, the indicators of motor disorders were not so pronounced: patients with impaired motor function at the level of M2-M3 prevailed (34,1% and 24,4% of patients, respectively). According to the scale of functional disorders of the Boston questionnaire, the patients with the studied groups experienced the greatest difficulties when bathing and putting on clothes – 17,4%, doing homework – 13,6% of people, fastening buttons on clothes – 15,2%. In patients of the rehabilitation group II, approximately the same results were observed. In the main group, we used the program of rehabilitation measures that we developed, in the comparison group, the program that is used in the hospital for this category of patients. The therapy lasted 3 months. Upon repeated examination in patients of the main I rehabilitation group, motor disorders decreased under the influence of physical therapy, which were used in them. In the main group, a greater number of patients (12,3%) showed normal strength in the affected limb (M5), in the control group this indicator was lower (7,5%). Movements with overcoming the weight of the limb (M3) and movements with overcoming the resistance (M4) were observed in 24,6% and 30,8% of patients in the main group, which significantly exceeds similar indicators of the control group.

**Conclusions:** as shown by the results of studies, physical therapy and occupational therapy in the complex treatment of people with traumatic and compression-ischemic neuropathies of the upper limb contributed to a more intensive restoration of arm functions and increased results of motor therapy. The following rehabilitation measures are most effective for this category of patients: kinesiotherapy, taping, massage, physiotherapy, mechanotherapy and hydrotherapy.

**Keywords:** neuropathy, upper limb, trauma, physical therapy, ergotherapy.

## Introduction

Damage to the peripheral nerves reaches 4% of all injuries, constitutes a major medical and social problem, since they are characterized by a significant and long-term decrease in limb function, and a high level of patient disability [1; 2]. As the analysis of world literature shows, despite the introduction of new diagnostic and microsurgical techniques, a number of problems remain in the treatment of peripheral nerve injuries, associated primarily with the timely use of physical therapy and occupational therapy [3; 7].

According to Yu. V. Demin, up to 40% of patients sought specialized care more than 6 months after the injury, 19,9% were treated conservatively unreasonably for a long time [5]. This leads to an increase in the share of unsatisfactory treatment results, since with an increase in the time after injury the prognosis for a further functionally useful degree of nerve repair worsens. Injury can cause concussion, bruising, compression, stretching, a complete cross section of the nerve, that is, damage to certain structures of the nerve of varying severity.

The complexity of the use of rehabilitation measures lies in the severe consequences of injuries and compression of the peripheral nerves and brachial plexus of the upper limb, a long treatment period, the development of motor, sensory disorders, leading to disability of patients of working age.

All of the above indicates the relevance of the topic of application and study of the effectiveness of physical therapy and occupational therapy with this pathology.

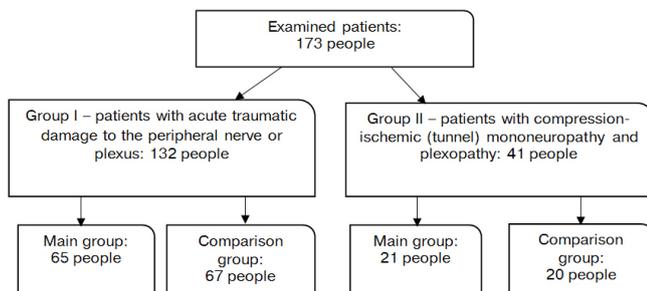
**Purpose of the study:** to determine the effectiveness of the developed program for the restoration of upper limb function in traumatic and compression-ischemic lesions of the peripheral nerves.

## Material and Methods of the research

A content analysis of 424 medical records of patients was carried out, of which 353 were medical records of patients with the consequences of traumatic and compression injuries of the peripheral nerves of the upper limb, which were operated on at the Department of Reconstructive Neurosurgery of the

Institute of Neurosurgery named after acad. A.P. Romodanova of the National Academy of Medical Sciences of Ukraine "from 2015 to 2018, and 71 medical history of patients with compression-ischemic (tunnel) neuropathies who underwent conservative treatment on the basis of neurological departments No. 1 and No. 2 of Kiev City Clinical Hospital No. 4 (2017–2019). When analyzing medical records, we studied the etiopathogenesis of this disease, trauma mechanisms, age, sex of patients, the duration of the disease, methods, results of conservative and surgical treatment, the number of relapses in tunnel syndromes, the number and types of surgical intervention for traumatic neuropathies of the upper limbs, functional disorders of the damaged upper limb that arose as a result of an injury or illness, etc.

The study involved 173 patients who were divided into 2 main rehabilitation groups: group I – patients with acute traumatic damage to the peripheral nerve or plexus (132 people), group II – patients with compression-ischemic (tunnel) mononeuropathy and plexopathy (41 man). In addition, in each rehabilitation group, we still identified the main and comparison groups (Fig. 1).



**Fig. 1. Distribution of patients examined by rehabilitation groups**

Among the patients with neuropathies of the peripheral nerves of the upper limb, men predominated – 129 (74.6%) people, women – 44 (25.4%) people. For patients who underwent surgical treatment, the duration of the disease ranged from 3 to 12 months, with conservative treatment – from 1 to 6 weeks. The age of the examined varied from 18 to 69 years, an average of  $45.9 \pm 4.6$  years. The distribution of patients by clinical syndromes is presented in Table 1.

**Table 1  
Distribution of patients according to clinical syndromes (I rehabilitation group, n=132)**

Clinical syndromes	Number of patients
Brachial plexus injuries	68 (51,5%)
Injuries of the ulnar nerve	27 (20,5%)
Injuries to the radial nerve	23 (17,4%)
Injuries to the median nerve	8 (6,1%)
Injuries to the median and ulnar nerves	6 (4,5)

As can be seen from the table. 1, half of the observations were patients with the consequences of damage to the brachial plexus – 68 (51,5%) people. Carpal tunnel syndrome – 23 (56,1%) people and cubital syndrome – 16 (39,0%) patients prevailed among tunnel neuropathies.

According to the mechanism of trauma, traumatic damage to the peripheral nerves and brachial plexus in most

cases occurred as a result of traffic accidents – 47,7% and a fall from a motorcycle – 21,9% (Table 2).

**Table 2  
Distribution of patients according to the mechanism of trauma (I rehabilitation group, n=132)**

Mechanism of trauma	Number of patients
traffic accidents	63 (47,7%)
motorcycle injuries	29 (21,9%)
chopped, chipped	18 (13,7%)
traction	7 (5,3%)
gunshot	6 (4,5%)
mixed	9 (6,9%)

In patients with tunnel neuropathies, the main reason was compression of the nerve in the anatomical tunnel.

To assess the functional state of the upper limb, a clinical and neurological (by a doctor) and rehabilitation (physical therapist) examination was carried out, the purpose of which was to establish the presence of neuropathy, damage level, degree of neurological deficit, muscle hypotrophy and atrophy, joint and muscle contractures. When collecting an anamnesis, it was found out the presence of trauma in the past (traffic accidents, falls, fractures, stab wounds, gunshot wounds, etc.), provoking factors (profession, occupation), the time of symptom manifestation and its development in the course of treatment was clarified in SI «Institute of Neurosurgery named. acad. A.P. Romodanova of the National Academy of Medical Sciences of Ukraine”, a history of concomitant diseases and previous surgical interventions was collected.

We used the following research methods: to assess the state of impaired motor function of the nerve and its recovery after surgery, as well as to study sensitivity disorders, we used the generally accepted scheme of English surgeons R. B. Zachary; W. Holmes, Austrian surgeon N. Millesi, modified by the Leningrad Research Institute of Neurosurgery [4]. According to this scale, motor function is evaluated by the ability to contract muscles from M0-M5 (M0 – lack of muscle contraction (complete paralysis) – M5 – normal strength, complete clinical recovery) and sensitivity S0-S5 (S0 – anesthesia in the autonomous innervation zone – S5 – normal pain sensitivity). The Boston Questionnaire (Boston Carpal Tunnel Questionnaire, BCTQ) was used to assess the severity of symptoms, activity, and participation in daily life. [6].

In the main groups, we used the rehabilitation program developed by us, in the comparison group – the standard one, which is used in this category of patients. The therapy lasted three months.

## Results of the research

It is known that injuries of the peripheral nerves of the upper limb significantly reduce the motor function of the limb and sensitivity in the affected segment, require additional surgical interventions, increase the duration of treatment and rehabilitation, increase the number of patients with unsatisfactory treatment results [3]. At the initial examination, we found that in most patients and the rehabilitation group, motor disorders on a 6-point scale were at the M1-M2 level – weak and rare muscle contractions without signs of movement in the joints and movement when the limb weight was turned off (27,3% and 31,8%, respectively) and M3 – movements

Table 3

Indicators of motor disorders in the examined patients before the rehabilitation course

Indicators	I rehabilitation group (n=132)		II rehabilitation group (n=41)	
	Abs. units	%	Abs. units	%
Lack of muscle contraction (complete paralysis) (M0)	19	14,4	2	4,9
Weak and rare muscle contractions without signs of movement in the joints (M1)	36	27,3	7	17,1
Movement when turning off the weight of the limb (M2)	42	31,8	14	34,1
Movement with overcoming limb weight (M3)	21	15,9	10	24,4
Movement with overcoming resistance (M4)	14	10,6	8	19,5
Normal strength, complete clinical recovery (M5)	0	0	0	0

Table 4

Indicators of sensitive disorders in the examined patients before the course of rehabilitation

Indicators	I rehabilitation group (n=132)		II rehabilitation group (n=41)	
	Abs. units	%	Abs. units	%
Anesthesia in the autonomous innervation zone (S0)	8	6,1	3	7,3
Uncertain pain (S1)	27	20,5	6	14,6
Hyperpathia (S2)	31	23,5	12	29,3
Hypesthesia with a decrease in hyperpathy (S3)	34	25,7	7	17,1
Moderate hypesthesia without hyperpathy (S4)	26	19,7	8	19,5
Normal pain sensitivity (S5)	6	4,5	5	12,2

with overcoming the weight of the limb (15,9%).

In patients of the II rehabilitation group, the indicators of motor disorders were not so pronounced: patients with impaired motor function at the level of M2-M3 predominated (34,1% and 24,4%, respectively). This is due to the fact that with traumatic neuropathy, a more severe nerve damage is observed (neuropraxia, axonotmesis, neurotmesis), which leads to peripheral paresis or paralysis, compared to tunnel hand syndromes, in which paralysis rarely occurs (Table 3).

According to A. S. Gilveg, V. A. Parfenov et al., in cases of lesions of the peripheral nerves of the upper limb, sensitivity disorders are manifested in the appearance of zones with complete or partial loss of sensitivity, but along with this, nerve irritation phenomena - hyperesthesia, paresthesia [3]. At the initial examination in patients of both groups, the sensitivity indicators were at the level of S1-S3 (vague pain, hyperpathy, hypesthesia with a decrease in hyperpathy) (Table 4).

The indicators of the Boston questionnaire showed that on the symptom severity scale (Symptom Severity Scale, SSS) during the initial examination in patients of both groups, mainly moderate and severe pain in the affected upper limb prevailed, which bothered patients both day and night. An analysis of sensitivity disorders in the indicated questionnaire confirmed the data of a previous study: most patients complained of a moderate expressed feeling of numbness.

According to the scale of functional disorders of the Boston questionnaire (Function Status Scale, FSS), the patients of the studied groups experienced the greatest difficulties when bathing and putting on clothes – 17,4%, doing homework – 13,6% of people, fastening buttons on clothes – 15,2%. In patients of the II rehabilitation group, approximately the same results were observed.

To restore and improve the function of the affected upper limb for patients of the main groups, we developed

Table 5

Indicators of functional disorders in the examined patients before the rehabilitation course

Actions	I rehabilitation group (n=132)		II rehabilitation group (n=41)	
	Abs. units	%	Abs. units	%
Writing difficulties	16	12,1	4	9,8
Button fastening on clothes	20	15,2	7	17,1
Reading book content	9	6,8	5	12,2
Phone handset content	15	11,4	4	9,8
Bottle opening	17	12,9	4	9,8
homework	18	13,6	7	17,1
Carrying food bags	14	10,6	6	14,4
Bathing and putting on clothes	23	17,4	4	9,8

an algorithm of rehabilitation measures depending on the treatment method (surgical, conservative), the severity and level of the lesion, and the results of the initial examination.

In the first rehabilitation group of patients with acute traumatic damage to the peripheral nerve or plexus, surgery was used. Before carrying out rehabilitation measures, the patients and the rehabilitation group were randomly divided into 2 groups: the main (65 people) and the comparison group (67 people).

In the main group of patients with acute traumatic damage to the peripheral nerve or plexus (and the rehabilitation group), the developed algorithm of rehabilitation measures was used: kinesitherapy (passive and active exercises, resistance exercises, in isometric mode, with objects), taping, massage, apparatus physiotherapy, mechanotherapy and hydro rehabilitation. Patients of the comparison group were engaged in the rehabilitation program of the medical institution (physical exercises, massage, hardware physiotherapy). All funds in both groups were allocated in accordance with the rehabilitation period: the period of preoperative preparation; early postoperative period; immobilization period; post-immobilization period; period of stage functional therapy. To correct the performance of household actions in patients, means of ergotherapy were used.

Tunnel neuropathy was treated conservatively. In patients of the rehabilitation group II of tunnel neuropathies in the main group, the rehabilitation measures included the same physical therapy as in the first group, but they were supplemented by neurodynamic techniques. In the comparison group, rehabilitation measures were applied according to the program

of the medical institution. Period: acute, subacute recovery.

After 3 months, a re-examination of patients was conducted. In patients of the main group and the rehabilitation group, motor disorders improved under the influence of physical therapy, which were used in them. As can be seen from table 6, in the main group, a greater number of patients (12.3%) showed normal strength in the affected limb (M5), in the control group this indicator is lower (7.5%). Movements with overcoming the weight of the limb (M3) and movements with overcoming the resistance (M4) were observed in 24.6% and 30.8% of individuals, respectively, in the main group, which significantly exceeds similar indicators of the control group.

After the rehabilitation course, we noted an improvement in sensitivity in the affected limb in the main and comparison groups, however, in the main group, a greater number of patients showed indicators at the levels of S3 (33.8% of cases) and S4 (29.2% of people). In the comparison group, we found sensitivity at the S1 level in 19.4% of individuals, S3 in 28.5 patients, S4 in 22.4% of patients (Table 7).

After a rehabilitation course, most patients in both groups decreased pain according to the Boston questionnaire (symptom severity scale). The use of ergotherapy helped to improve self-care skills in patients of both the main and comparison groups (I rehabilitation group). However, the patients of the main group could do their homework better, carry bags of food, bathe and dress in comparison with the control group (Table 8).

Patients of the rehabilitation group of tunnel neuropathies of the II rehabilitation group before physical therapy and

**Table 6**  
**Indicators of motor disorders in patients of the rehabilitation group I after a rehabilitation course (n=132)**

Indicators	Groups of surveyed			
	Main group (n=65)		Comparison group (n=67)	
	Abs. units	%	Abs. units	%
Lack of muscle contraction (complete paralysis) (M0)	4	6,2	6	8,9
Weak and rare muscle contractions without signs of movement in the joints (M1)	8	12,3	12	17,9
Movement when turning off the weight of the limb (M2)	9	13,8	15	22,4
Movement with overcoming limb weight (M3)	16	24,6	11	16,4
Movement with overcoming resistance (M4)	20	30,8	18	26,9
Normal strength, complete clinical recovery (M5)	8	12,3	5	7,5

**Table 7**  
**Indicators of sensitive disorders in patients of the rehabilitation group I after a rehabilitation course (n=132)**

Indicators	Groups of surveyed			
	Main group (n=65)		Comparison group (n=67)	
	Abs. units	%	Abs. units	%
Anesthesia in the autonomous innervation zone (S0)	4	6,2	6	8,9
Uncertain pain (S1)	7	10,8	13	19,4
Hyperpathia (S2)	9	13,8	12	17,9
Hypesthesia with a decrease in hyperpathy (S3)	22	33,8	19	28,5
Moderate hypesthesia without hyperpathy (S4)	19	29,2	15	22,4
Normal pain sensitivity (S5)	4	6,2	2	2,9

**Table 8**  
Indicators of functional disorders in the examined patients after a rehabilitation course (I rehabilitation group, n=132)

Actions	Groups of surveyed			
	Main group (n=65)		Comparison group (n=67)	
	Abs. units	%	Abs. units	%
Writing difficulties	6	9,2	4	5,9
Button fastening on clothes	13	20,0	14	20,9
Reading book content	3	4,6	2	2,9
Phone handset content	4	6,2	5	7,5
Bottle opening	7	10,8	5	7,5
homework	9	13,8	11	16,5
Carrying food bags	11	16,9	12	17,9
Bathing and putting on clothes	12	18,5	14	20,9

**Table 9**  
Indicators of motor disorders in patients of the II rehabilitation group after a course of rehabilitation (n=41)

Indicators	Groups of surveyed			
	Main group (n=65)		Comparison group (n=67)	
	Abs. units	%	Abs. units	%
Lack of muscle contraction (complete paralysis) (M0)	1	4,8	2	10,0
Weak and rare muscle contractions without signs of movement in the joints (M1)	2	9,5	4	20,0
Movement when turning off the weight of the limb (M2)	3	14,3	5	25,0
Movement with overcoming limb weight (M3)	5	23,8	4	20,0
Movement with overcoming resistance (M4)	4	19,0	2	10,0
Normal strength, complete clinical recovery (M5)	6	28,6	3	15,0

**Table 10**  
Indicators of functional disorders in the examined patients after a rehabilitation course (II rehabilitation group, n=41)

Actions	Groups of surveyed			
	Main group (n=65)		Comparison group (n=67)	
	Abs. units	%	Abs. units	%
Writing difficulties	2	9,5	1	5,0
Button fastening on clothes	4	19,0	3	15,0
Reading book content	1	4,9	1	5,0
Phone handset content	2	9,5	1	5,0
Bottle opening	2	9,5	2	10,0
homework	4	19,0	6	30,0
Carrying food bags	3	14,3	2	10,0
Bathing and putting on clothes	3	14,3	4	20,0

occupational therapy were also divided into 2 groups: the main group (21 patients) and the comparison group (20 people). The motor function improved in most patients of the main group to the level of M4-M5, in the comparison group these indicators are lower to the level of M3-M4 (Table 9).

After a course of rehabilitation in the examined patients, we noted an improvement in the sensitivity to S3-S4.

Patients with tunnel syndromes (rehabilitation group II) also improved the performance of various domestic activities. As can be seen from Table 10, difficulties in homework were observed in 19.0% of the main group, in the comparison group this indicator was significantly higher – 30.0% of cases, when bathing and dressing - 14.3% and 20.0 cases, respectively.

## Conclusions / Discussion

As the research results showed, the means of physical therapy and ergotherapy in the complex treatment of people with traumatic and compression-ischemic neuropathies of the upper limb contributed to a more intensive restoration of the functions of the hand and increased results of motor therapy.

The following rehabilitation measures are most effective for this category of patients: kinesitherapy (passive and active exercises, exercises with resistance, in isometric mode, with objects), taping massage, apparatus physiotherapy, mechanotherapy and hydro rehabilitation.

**Prospects for further research** are to develop technology for restoring quality of life in this pathology.

**Conflict of interests.** The author declares that no conflict of interest.

**Financing sources.** This article didn't get the financial support from the state, public or commercial organization.

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Received: 27.12.2019.

Published: 29.02.2020.

## Information about the Authors

**Olena Bismak:** PhD in Physical Education and Sport, Associate Professor: National University of Ukraine on Physical Education and Sport: Fizkul'tury str. 1, Kyiv, 03150, Ukraine.

**ORCID.ORG/0000-0002-6495-6170**

**E-mail: ebismak@gmail.com**