MOVEMENT REHABILITATION AFTER SURGICAL TREATMENT OF TRAUMATIC UPPER LIMB NEUROPATHY
MOTORICKÁ REHABILITÁCIA PO CHIRURGICKEJ LIEČBE TRAUMATICKEJ NEUROPATIE HORNEJ ČASTI KONČATINY

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ABSTRACT

Background: Traumatic neuropathy is one of the most common diseases of the peripheral nerves of the upper limb.

Objective: To determine the effectiveness of the developed movement rehabilitation programme for traumatic upper limb neuropathies.

Sample: The study involved 93 patients with the consequences of traumatic injuries of the peripheral nerves of the upper limb, which were operated based on SI "Institute of Neurosurgery named after acad. Romodanov", Department of Reconstructive Neurosurgery.

Methods: According to Zachary, Holmes, Millesi Assessment Scale for Muscle Reduction and Sensitivity and DASH questionnaire.

Results: From the initial examination we found that in most patients the examined movement disorders on a 6-point scale were at the level of M1-M2 in 31.2 and 34.4 %, and M3 in 17.2 % of patients. In patients of the main group, motor rehabilitation included: Kinesitherapy, according to the method of Efimenko (2013), hardware physiotherapy, mechanotherapy according to the method of Popadyukha (2018), and hydrorehabilitation. Patients of the control group used standard rehabilitation measures – physical exercises, therapeutic massage according to the method of Stepashko (2010), hardware physiotherapy and mechanotherapy. During the re-examination of the main group, there was noticed an improvement in motor function to the M3 and M4 levels (23.4 and 27.7 % of patients), which was significantly higher than in the control group.

Conclusions: Our programme of movement rehabilitation for people with traumatic upper limb neuropathies promoted more intensive hand function restoration and increased results of motor therapy, compared to standard rehabilitation measures that were used in the control group.

Key words*:* Neuropathy. Upper limb. Trauma. Movement Rehabilitation.

ABSTRAKT

Východiská: Traumatické neuropatie sú jedným z najčastejších ochorení periférnych nervov hornej končatiny.

Cieľ: Určiť účinnosť vyvinutého programu motorickej rehabilitácie pre traumatické neuropatie horných končatín.

Súbor: 93 pacientov s následkami traumatických poranení periférnych nervov hornej končatiny, ktorí boli hospitalizovaní na Oddelení rekonštrukčnej neurochirurgie, Štátny ústav „Ústav neurochirurgie pomenovaný po M. Acad. AP Romodanov NAMS, Ukrajina".

Metódy: Stupnica hodnotenia svalovej schopnosti a citlivosti podľa Zachariho, Holmesa a Millesiho a DASH dotazník.

Výsledky: Pri počiatočnom vyšetrení sme zistili, že u väčšiny skúmaných pacientov boli poruchy pohybu na 6-bodovej stupnici na úrovni M1–M2 u 31,2 %, respektíve 34,4 %, a M3 u 17,2 % pacientov. U pacientov hlavnej skupiny zahŕňala motorická rehabilitácia: kinezioterapiu podľa Efimenka (2013), robotická fyzioterapia, mechanoterapia metódou Popadyukha, (2018) a hydrorehabilitácia. Pacienti porovnávacej skupiny použili štandardné rehabilitačné opatrenia – fyzické cvičenia, terapeutické masáže podľa Stepaškovej metódy (2006), robotická fyzioterapia, mechanoterapia. Pri následnom vyšetrení pacienti v hlavnej skupine hlásili zlepšenie motorickej funkcie na úroveň M3 a M4 o 23,4 %, resp. M4 o 27,7 %, čo je výrazne viac ako v porovnávacej skupine.

Záver: Náš program motorickej rehabilitácie u ľudí s traumatickou neuropatiou hornej končatiny spôsobil v porovnaní so štandardnými rehabilitačnými opatreniami použitými v porovnávacej skupine intenzívnejšie obnovenie funkcií rúk a zlepšenie výsledkov motorickej terapie.

Kľúčové slová: Neuropatia. Horná časť končatiny. Poranenie. Motorická rehabilitácia.

INTRODUCTION

In recent years, there has been an increase in the frequency of nerve injuries among other injuries of the musculoskeletal system. The number of iatrogenic nerve injuries has significantly increased, which is associated with increased operative activity in various anatomical areas. Peripheral nerve injuries range from 1.5 to 6 % of total injuries. However, they occupy the first place in terms of disability (Asilova et al., 2009; Tatarchuk, 2015). An important feature of these injuries are predo-minantly young people, of which 60 % become disabled (Belova, 2014).

One of the main symptoms that occur in traumatic upper limb neuropathies is impaired motor and manipulative hand's function: Impaired coordination of the hands, hands and fingers, which often leads to difficulties in performing daily functions such as eating, dressing and washing. More than half people with traumatic neuropathies have problems with their motor function from a few months to several years after an injury. The im-

provement of hand function is a key element in rehabilitation (Bismak, 2019; Scott et al., 2013).

Movement rehabilitation is carried out in the form of individual lessons, apply therapeutic exercises, training on special simulators for upper limbs, massages, hardware physiotherapy procedures, and others. Effective rehabilitation treatment for traumatic upper limb neuropathies requires the cooperation of the patient, the rehabilitation team and people caring for the patient. All of the above indicates the relevance of the chosen research topic.

OBJECTIVE

To determine the effectiveness of the developed motor rehabilitation programme for traumatic upper limb neuropathies.

SAMPLE

The study involved 93 patients with the consequences of traumatic injuries of the peripheral nerves of the upper limb, who were operated based on SI "Institute of Neurosurgery named after acad. Romodanov, National Academy of Medical Sciences of Ukraine", Department of Reconstructive Neurosurgery during 2015–2018. All patients were randomly divided into two groups: The main group (47 people) and the control group (46 patients).

Among the patients with neuropathies of the peripheral nerves of upper limb there were 64 men (68.8 % of the patients) and 29 women (31.2 %). For patients who underwent surgical treatment, the duration of the disease ranged from 3 to 12 months. The age of the examined ranged from 18 to 74 years, on average 47.9 ± 6.2 years. The distribution of patients by clinical syndromes is presented in the tab. 1.

As can be seen from the table 1, the majority of observations were the patients with consequences of Brachial Plexus Injuries – 41 (44.1 %). According to the mechanism of trauma, traumatic damage to the peripheral nerves and brachial plexus injuries in most cases was due to road accidents – 47.7 % and falling of the motorcycle – 21.9 % (Tab. 2).

METHOD

To assess the functional state of the upper limb, a clinical and neurological rehabilitation examination performed to determine the presence of neuropathy, the level of damage, the degree of neurological deficit, muscle hypertrophy and atrophy, joint and muscle contracture.

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 scale of English surgeons Zachary, Holmes, Austrian surgeon Millesi, modified by the

Table 1 Distribution of patients by clinical syndromes (n=93)

Clinical syndromes	Number of patients
Brachial Plexus Injuries	41 (44.1 %)
Ulnar Nerve Injuries	23 (24.7 %)
Radial Nerve Injury	19 (20.4 %)
Median Nerve Injury	6 (6.5 %)
Median and Ulnar Nerve Injury	4 (4.3 %)

Table 2 Distribution of patients by mechanism of injury (n=93)

Injury mechanism	Number of patients
Road accidents	43 (46.2 %)
Motorcycle injuries	21 (22.6 %)
Gunshot wound	8 (8.6 %)
Cuts and scrapes	9 (9.7 %)
Stretch injury	5 (5.4 %)
Mixed	7 (7.5 %)

Table 3 Muscle Strength Assessment Scheme

Indicator	Definition
M0	No muscle contraction (complete paralysis)
M1	Weak and infrequent contractions of the muscles without signs of movement in the joints
M2	Movements when turning off limb weight
M3	Movements to overcome limb weight
M4	Movements with overcoming resistance
M5	Mormal force, complete clinical recovery

Table 4 Sensitivity Assessment Scheme

Indicator	Definition
S0	Anesthesia in the autonomous zone of innervation
S1	Vague pain
S2	Hyperpathy
S3	Hypesthesia with reduction of hyperpathy
S4	Goderate hypesthesia without hyperpathy
S5	Normal pain sensitivity

Leningrad Research Institute of Neurosurgery (Grigorovich, 1981). According to the mentioned scale, the motor function assessed by the ability to reduce muscles from M0–M5 and sensitivity S0–S5 (Tab. 3, 4).

To assess activity and participation in daily life, we used DASH (Disability of the Arm, Shoulder and Hand Outcome Measure) questionnaire (Moradi et al., 2016; Yagdzhyan et al., 2005).

Statistical analysis. The generalization of the studied characteristics assessed by mean arithmetic value and standard deviation. Confidence of differences between mean values was stated by Student's t-criterion. The assessment of statistical hypothesizes was based on 5 % significance level. For the statistical processing of data, we used licensed program Microsoft Excel (2010). The statistical analysis of the received results was conducted, considering the recommendations on Microsoft Excel tables used for computer data analysis.

THE RESEARCH DESIGN

In the patients of the main group, movement rehabilitation included: Kinesitherapy (passive and active exercises, resistance exercises, in isometric mode, with objects), massage according to the method of Efimenko, (2013), hardware physiotherapy, mechanotherapy according to the method of Popadyukha (2018) and hydrorehabilitation. Patients of the control group used standard rehabilitation measures – physical exercises, therapeutic massage according to the method of Stepashko (2010), hardware physiotherapy and mechanotherapy. All means of motor therapy in both groups were intended according to the rehabilitation period: The period of preoperative preparation; early postoperative period; immobilization period; after the immobilization period; period of functional therapy. Movement rehabilitation lasted 6 months, and patients were monitored at the beginning and at the end of the rehabilitation course.

Table 5 Indicators of motor disorders in the examined patients before the course of rehabilitation

Indicators	Examined patients (n=93)	
	Qty.	%
No muscle contraction (complete paralysis) (M0)	9	9.7
Weak and infrequent contractions of the muscles without signs of movement in the joints (M1)	29	31.2
Movements when turning off limb weight (M2)	32	34.4
Movements to overcome limb weight (M3)	16	17.2
Movements with overcoming resistance (M4)	7	7.5
Normal force, complete clinical recovery (M5)	0	0.0

RESULTS

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 treatment duration and rehabilitation, and increase the number of patients with unsatisfactory treatment results (Tsymbalyuk et al., 2002; 2016).

From the initial examination, we found that in most patients, movement disorders on the 6-point scale were at the level of M1–M2 weak and rare muscle contractions with no signs of movement in the joints and movements with the exclusion of limb weight (31.2 and 34.4 %) and M3 – movements with overcoming limb weight (17.2 %) (Tab. 5).

According to Gilveg et al. (2018), with co-authorship, in cases of lesions of the peripheral nerves of the upper limb, sensitivity disorders are expressed in the zones appearance with complete or partial loss of sensitivity, but at the same time, the nerve irritation phenomena – hyperesthesia, paresthesia are possible. At the initial patients' examination of both groups, the sensitivity indicators were at the level of S1-S3 (an undetermined pain, hyperpathy, hypesthesia with a reduction of hyperpathy).

Table 6 Indicators of sensitive disorders in the examined patients before the course of rehabilitation

Indicators	Examined patients (n=93)	
	Qty.	%
Anesthesia in the autonomous zone of innervation (S0)	8	8.6
Vague pain (S1)	24	25.8
Hyperpathy (S2)	31	33.3
Hypesthesia with reduction of hyperpathy (S3)	18	19.4
Moderate hypesthesia without hyperpathy (S4)	8	8.6
Normal pain sensitivity (S5)	4	4.3

In the study, we used the main section of the DASH Questionnaire (Inability / Symptom Scale), which consists of 30 points-questions related to the state of brush function over the past week.

Moreover, 21 of them show a degree of difficulty of performing various physical actions due to function limitation of the shoulder or hand; 6 points relate to the severity of some symptoms and 3 to socio-role functions. In addition, patients answered the additional section of the questionnaire – section of work. We did not apply an additional section for professional athletes and musicians, since patients with the indicated professions did not participate in the study.

Indicators of the DASH questionnaire showed that the mean scores on the main section of the DASH questionnaire (Inability / Symptom Scale) were at the level of 83.4 ± 11.3 points, and according to the additional scale – 71.5 ± 8.7 points (Tab. 7).

In a detailed analysis of the results of the DASH questionnaire, we found that 73.5 % of patients had difficulty opening a tightly closed or new jar with a lid, 69.7 % of people had difficulty to turn a key and cook, 86.4 % had difficulty to perform hygienic procedures and home care work. In addition, 84.7 % of patients complained of severe pain in the arm, 94.7 % of patients complained of weakness and stiffness in the affected limb. On an additional scale (work section), 57.8 % of patients noted that problems with an injured hand somewhat influenced on the performance of professional activity, 34.8 % of patients said that it was very difficult for them.

All of the above disorders indicate that after surgical treatment, the patients with traumatic upper limb neuropathies had problems with the motor function of the affected limb and required a course of rehabilitation.

We conducted a follow-up examination after 6 months, during which the developed movement rehabilitation program used in the main group and the motor therapy programme in the in the control group, usually used in a hospital.

First of all, there was a regression of neurological deficit in the examined patients. In patients of the main group, motor function improved under the influence of the physical therapy they used. As can be seen from table 8, in the main group, the greater number of patients, the indicators of motor function were at the level of M3 and M4 – 23.4 and 27.7 % of individuals, in the control group these indicators were much lower – 15.2 % of persons, movements with overcoming limb weight (M3) were noted, and 19.6 % of patients with resistance (M4) were noted. It should be noted that in both groups after the course of movement rehabilitation there was a normalization of muscle strength in the affected limb, but in the main group of such patients there were more – 7 (14.9 %) persons, in the control group – 3 (6.5 %) patients.

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, more patients had indicators at the levels of S3 (21.3 % of cases) and S4 (25.5 % of people). In the control group, we found sensitivity at a slightly lower level of S1 in 23.9 % of individuals, S2 in 21.7 patients, and S3 in 17.4 % of sick patients (Tab. 9).

Movement rehabilitation positively affected the ability of patients in both groups to do homework,

Table 7 Indicators of examined patients according to the DASH questionnaire before the rehabilitation course

Indicators (points)	Examined patients (n=93)
	$\bar{x}$±S
According to the main section of the DASH questionnaire	83.4±11.3
According to the additional scale of the DASH questionnaire	71.5±8.7

Table 8 Dynamics of motor functions indicators in patients of both groups after the course of rehabilitation

Indicators	MG (n=47)		CG (n=46)	
	Qty.	%	Qty.	%
No muscle contraction (complete paralysis) (M0)	3	6.4	5	10.9
Weak and infrequent contractions of the muscles without signs of movement in the joints (M1)	6	12.7	8	17.4
Movements when turning off limb weight (M2)	7	14.9	14	30.4
Movements to overcome limb weight (M3)	11	23.4	7	15.2
movements with overcoming resistance (M4)	13	27.7	9	19.6
Normal force, complete clinical recovery (M5)	7	14.9	3	6.5

Table 9 Sensitivity indicators in patients of both groups after the course of rehabilitation

Indicators	MG (n=47)		CG (n=46)	
	Qty.	%	Qty.	%
Anesthesia in the autonomous zone of innervation (S0)	2	4.3	4	8.7
Vague pain (S1)	9	19.1	11	23.9
Hyperpathy (S2)	8	17.0	10	21.7
Hypesthesia with reduction of hyperpathy (S3)	10	21.3	8	17.4
Moderate hypesthesia without hyperpathy (S4)	12	25.5	9	19.6
Normal pain sensitivity (S5)	6	12.8	4	8.7

Table 10 Indicators of the DASH questionnaire in the examined patients after the course of rehabilitation

Indicators (points)	MG (n=47)	CG (n=46)	t	p
	$\bar{x}$±S	$\bar{x}$±S		
According to the main section of the DASH questionnaire	54.2±7.4	71.3±7.8	3.85	p<0.05
According to the additional scale of the DASH questionnaire	53.6±6.9	59.7±5.3	3.24	p<0.05

carry food bags, bathe and dress, and others, as evidenced by the DASH questionnaire after the rehabilitation course. The average scores on the main section of the DASH questionnaire significantly decreased in the main group patients to 54.2±7.4 points, compared with the control group 71.3±7.8 points (p <0.05).

On the additional scale of the DASH questionnaire, we also noted a significant improvement in professional performance (Tab. 10).

After we analyzed the patients' answers to the DASH questionnaire, we noticed that in the main group, fewer patients had difficulty opening a tightly closed or new jar with a lid – 49.2 %, in the control group - this indicator was higher in the number of patients (58.9 %), to turn a key and cook food – 47.3 % in the main group, in the control group – 56.3 % of patients. After a course of motor rehabilitation, the patients in both groups noted that problems with an injured hand had less influence on the performance of professional activities (additional scale of the DASH questionnaire (work section), but the patients could not fully involve the injured hand. This is all due to the long term recovery of the injured nerve and recovery functional state of the upper limb.

DISCUSSIONS

Our studies have confirmed the relevance of movement rehabilitation problem in traumatic upper limb neuropathies. In the works of Yamaletdinova, Shtokolok, Makeev (2013), it is emphasized that modern society with its high development rates puts great demands on human health. The partial or total loss by a person of any vital functions, or ability to perform certain activities necessary for a full life activity, leads to a loss of professional suitability, and quite often – to the loss of interest in life. Therefore, the restoration of lost body functions to the patient's household self-care and ability to perform professional activities is an urgent task. This is especially true for the patients with the consequences of traumatic upper limb neuropathies, in which there are significant movement disorders – peripheral paresis and paralysis.

According to various authors, traumatic neuropathy is one of the most common diseases of the peripheral nerves of the upper limb. Such injuries in almost 65 % of cases lead to long-term disability with a high incidence of disability (Tatarchuk et al., 2015; Tsymbalyuk et al., 2016; Milicin, 2018).

Researchers Snytnikov et al. (2016), note that restoration of hand function in traumatic neuropathies is not possible without the use of physical exercises, massages, and special simulators for the hand.

In other studies, it is recommended to include self-massage in combination with reflexology, passive and active exercises aimed at improving movement coordination, personal training (Biryu-kov, 2004; Scott et al., 2013).

Further study of this problem and generalization of the scientific experience described in the literature will facilitate the development of new algorithms for movement rehabilitation for patients with traumatic upper limb neuropathies and the use of modern restorative technologies.

CONCLUSIONS

Despite the active search for ways to resolve the

problems of restoration the motor function of the hand after surgical treatment of traumatic injuries of the peripheral upper limb nerves, movement rehabilitation programs that ensure consistent pa-tient's recovery in accordance with the rehabilitation period have not yet been developed.

In connection with the above, we developed and implemented a rehabilitation program, which included: kinesitherapy (passive and active exercises, resistance exercises, in isometric mode, with objects), massage according to the Efimenko, (2013), hardware physiotherapy, mechanotherapy by the method of Popadyukha (2018), and hydro-rehabilitation. Developing movement rehabilitation programme for the patients in the main group, we took into account the rehabilitation period, the degree of peripheral nerve damage, features of surgical intervention, severity of motor disorders. At the same time, correction of movement rehabilitation was carried out according to the functional state of the patient, taking into account the concomitant diseases, the level of mastery of knowledge, and the degree of the patient's physical readiness.

An initial patients' examination with traumatic upper limb neuropathies showed the presence of motor disorders in the form of flaccid paresis and paralysis; in most patients, 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 when turning off limb weight (31.2 and 34.4 %) and M3 – movements with overcoming limb weights (17.2 %). The indicators of the DASH questionnaire indicated that the mean scores on the main section of the DASH questionnaire (Inability / Symptom Scale) were at the level of 83.4 ± 11.3 points, with an additional scale at the level of 71.5 ± 8.7 points.

After 6 month re-examination of patients in the main group motor function improved under the influence of the physical therapy tools they used. In more patients the indicators of motor function were at the level of M3 and M4 – 23.4 and 27.7 % of persons, in the control group these indicators were significantly lower – in 15.2 % of the persons there were movements with overcoming of limb weight (M3) and 19.6% of patients had movements with overcoming resistance (M4). It should be noted that in both groups, after the course of movement rehabilitation, normalization of muscle strength in the affected limb was noted, but in the main group of such patients there were more – 7 (14.9 %) people, in the control group – 3 (6.5 %) patients.

The patients after a rehabilitation course improved their results on the DASH questionnaire. The average scores for the main section of the DASH questionnaire significantly decreased in patients of the main group to 54.2 ± 7.4 points, compared with the control group 71.3 ± 7.8 points ($p < 0.05$).

Based on the abovementioned, it can be concluded that active movement rehabilitation in the complex treatment of persons with traumatic upper limb neuropathies contributed to a more intensive restoration of hand functions.

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