Neuropathic pain in patients with compression-ischemic neuropathy of the upper limb: diagnosis and assessment of the effectiveness of rehabilitation measures

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Abstract
The purpose of the work is to assess the severity of neuropathic pain and determine the effectiveness of rehabilitation measures in people with compression-ischemic neuropathy of the upper limb in the subacute period.

Material and methods. Analysis and synthesis of literature data, visual analogue pain scale (VAS), DN4 questionnaire for diagnosing the nature of pain, rehabilitation examination, methods of mathematical statistics. The study involved 73 patients with compression-ischemic neuropathy of the upper limb. Patients were divided into 2 groups: the main (37 people) and control (36 people). The duration of the disease ranged from 3 to 18 months. The age of the examined ranged from 18 to 57 years, an average of 39.4±6.7 years.

Results. At the initial examination, we found that in patients of both groups, carpal tunnel syndrome was diagnosed more often than other tunnel syndromes. In patients of the main and control groups, pain and control indicators were above average (6.62 ± 0.21 and 6.58 ± 0.18 points, respectively). No significant difference between the groups was found (p>0.05). In patients of the main group, we used the following rehabilitation measures: kinésithérapie with neurodynamic mobilization, taping, apparatus physiotherapy and mechanotherapy procedures. Patients in the control group were engaged in a standard rehabilitation program - physical exercises, apparatus physiotherapy, mechanotherapy. Upon repeated examination by YOUR, a decrease in pain was observed in both groups, however, in the main group, the severity of pain was significantly lower than in the control group (p<0.001).

Conclusions. The study confirmed that the inclusion of kinésithérapie with neurodynamic mobilization, taping, apparatus physiotherapy and mechanotherapy in the complex treatment of compression-ischemic neuropathies of the upper limb contributed to a significant reduction in pain in patients in the main group compared with the control group, in which the standard rehabilitation program was used.

Key words: pain; compression-ischemic neuropathy; tunnel syndrome; examination

Анетоция
Бісмак О.В., Калмикова Ю.С., Калмиков С.А. Невропатичний біль у пацієнтів з компресійно-ішемічними невропатіями верхній кінцівки: діагностика та оцінка ефективності реабілітаційних заходів

Мета роботи − оцінити вираженість невропатичного білу та визначити ефективність реабілітаційних заходів в осіб з компресійно-ішемічними невропатіями верхніх кінцівок у підгодівневий період.

Матеріал і методи. Аналіз та узагальнення даних літературних джерел, візуальна аналогова шкала болю (VAS), опитувальник DN4 для діагностики характеру болю, реабілітаційне обстеження, методи математичної статистики. У дослідженні брали участь 73 хворих на компресійно-ішемічні невропатії верхніх кінцівок. Пацієнти були розподілені на 2 групи: основну (37 осіб) та контрольну (36 осіб). Тривалість захворювання становила від 3 до 18 місяців. Вік обстежених варіював від 18 до 57 років, в середньому становив 39,4±6,7 року.

Результати. При першовірному обстеженні ми виявили, що у пацієнтів обох груп синдром карпального каналу діагностували частіше, ніж інші тунельні синдроми. У пацієнтів основної та контрольної групи ВАШ були вище за середні (6,62 ± 0,21 та 6,58 ± 0,18 бала відповідно). Достовірних різниць між групами не виявило (p>0,05). У пацієнтів основної групи ми застосовували такі реабілітаційні заходи: кінезіотерапію з нейродинамічної мобілізацією, тейпування, процедури апаратної фізіотерапії і механотерапії. Пацієнти контрольної групи займалися за стандартною програмою реабілітації − фізичні вправи, апаратна фізіотерапія, механотерапія. Після повторного обстеження по ВАШ спостерігалось зменшення болю в основній групі у 2,5 рази (p<0,001).

Висновки. Проведення дослідження підтвердило, що включення кінезіотерапії з нейродинамічною мобілізацією, тейпування, процедур апаратної фізіотерапії та механотерапії в комплексному лікуванні компресійно-ішемічних невропатій верхніх кінцівок сприяло досвідченню зменшення болю у пацієнтів основної групи порівняно з контрольною групою, в якій застосовували стандартну програму реабілітації.

Ключові слова: біль; компресійно-ішемічна невропатія; тунельний синдром; обстеження.

Анетоция
Бісмак Е.В., Калмикова Ю.С., Калмиков С.А. Невропатичний біль у пацієнтів з компресійно-ішемічними невропатіями верхніх кінцівок: діагностика та оцінка ефективності реабілітаційних мероприєтів

Мета роботи − оцінити вираженість невропатичного білу та визначити ефективність реабілітаційних заходів у пацієнтів з компресійно-ішемічними невропатіями верхніх кінцівок у підгодівневий період.

Матеріал та методи. Аналіз та обзір праць наукових авторитетних інститутів, візуальна аналогова шкала болю (VAS), опитувальник DN4 для діагностики характеру болю, реабілітаційне обстеження, методи математичної статистики. У дослідженні брали участь 73 хворих на компресійно-ішемічні невропатії верхніх кінцівок. Пацієнти були розподілені на 2 групи: основну (37 осіб) та контрольну (36 осіб). Вік обстежених варіював від 18 до 57 років, в середньому становив 39,4±6,7 року.

Результати. При першовірному обстеженні ми виявили, що у пацієнтів обох груп синдром карпального каналу діагностували частіше, ніж інші тунельні синдроми. У пацієнтів основної та контрольної групи ВАШ були вище за середні (6,62 ± 0,21 та 6,58 ± 0,18 бала відповідно). Достовірних різниць між групами не виявило (p>0,05). У пацієнтів основної групи ми застосовували такі реабілітаційні заходи: кінезіотерапію з нейродинамічної мобілізацією, тейпування, процедури апаратної фізіотерапії і механотерапії. Проведення подібних обстежень у пацієнтів основної групи сприяло зменшенню ішемічного синдрому в основній групі у 2,5 рази (p<0,001).

Висновки. Підтвердило включення кінезіотерапії з нейродинамічною мобілізацією, тейпування, процедур апаратної фізіотерапії та механотерапії в комплексному лікуванні компресійно-ішемічних невропатій верхніх кінцівок сприяло досвідченню зменшення болю у пацієнтів основної групи порівняно з контрольною групою.

Ключові слова: біль; компресійно-ішемічна невропатія; тунельний синдром; обстеження.
**Introduction**

Chronic pain is a leading cause of disability in economically developed countries, with pain affecting 15 to 40% of people in the population [1], and the incidence of chronic pain syndromes continues to grow steadily and does not tend to decrease [1, 2].

According to Andreeva [1, 3] and Yemelyanova [3], peripheral nervous system diseases account for 48% of the structure of nervous diseases, ranked third after influenza and domestic traumatism, and first among chronic population diseases. The presence of prolonged pain syndrome, which often accompanies peripheral nerve disease, can cause a decrease in the quality of life of patients.

Compression-ischemic neuropathies occupy an important place in neurological practice, as they account for up to a third of peripheral nervous system diseases, and more often persons of the most working age - 30-50 years suffer [2].

It is known that the main clinical features of compression-ischemic neuropathy are: a combination of sensory and motor manifestations; the clinical picture is dominated by pain and autonomic disorders, characterized by the presence of paresthesias; Palpation in most patients is determined by local pain that corresponds to the site of compression of the nerve trunk [4].

Pain syndrome is one of the main symptoms in compression ischemic upper limb neuropathies. Usually, pain occurs during movement (loading), then occurs and at rest. Sometimes the pain wakes the patient at night, exhausting the patient and forcing him to see a doctor. Tunnel syndrome pain may include both a nociceptive component (pain due to inflammatory changes occurring in the area of neuromuscular conflict) and neuropathic (since nerve damage occurs). Tunnel syndromes are characterized by such manifestations of neuropathic pain as allodynia and hyperpathy, the feeling of passage of an electric current (electrical lapse), burning pain. In later stages, pain may be due to muscle spasm [2, 5].

The study of therapeutic and rehabilitation tools aimed at reducing pain in compression-ischemic upper limb neuropathies is an urgent problem in view of the prevalence of the disease, the long-term suffering of patients and the disability of various degrees.

The aim of the study was to evaluate the severity of neuropathic pain and to determine the effectiveness of rehabilitation measures in individuals with upper extremity compression-ischemic neuropathy in the subacute period.

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**Material and methods**

**Participants**

The study involved 73 patients with upper limb compression-ischemic neuropathy. Patients were divided into 2 groups: main (37 people) and control (36 people). The duration of the disease ranged from 3 to 18 months. The age of the surveyed ranged from 18 to 57 years, averaging 39.4 ± 6.7 years.

**Procedure**

The study was conducted on the basis of neurological and physiotherapy department of Kyiv City Clinical Hospital №4, Kyiv, from 2017 to 2019. We used the following methods of research: analysis and generalization of data from literature sources, visual analog pain scale (VAS), questionnaire DN4 for the diagnosis of pain, rehabilitation examination, methods of mathematical statistics [6, 7, 8]. The criteria for inclusion in the study were: the age of 60 years, the presence of long-term pain. The diagnosis was made by neurological department physicians based on clinical and instrumental research data. Rehabilitation examination of the upper limb was performed, which included the collection of anamnesis, the detection of pain and motor, sensory and autonomic disorders in the affected upper extremity.

Statistical analysis was performed using traditional methods of mathematical statistics. For each indicator, the arithmetic mean, the error of the mean, the estimation of the probability of differences between the parameters of the initial and final results were determined according to the Student’s t-test with the corresponding level of significance (p). The obtained data were processed by mathematical statistics using Microsoft Excel 2010 software. The differences and the presence of relationships were considered significant at 95% significance level (p <0.05).

**Results**

At any compression of nerve trunks, it is necessary to take into account not only mechanical influence directly on them, but also disturbances of blood circulation, as together with nerve trunks the vessels are subjected to compression. The emergence of tunnel syndrome is facilitated by various common diseases and the state of local structures [9, 10]. The main factor of local pathological influence is the overstrain of the connective apparatus and the muscles surrounding the nerve. In this case, it is
possible to squeeze and stretch the nerve. There are swelling or aseptic inflammation of the vagina of the tendon, proliferation of connective tissue elements of the canal walls, hyperplasia of fibrous tissues in places of their attachment to the bone projections. As the volume of the nerve itself and the surrounding tissues increase, or the thickening of the tunnel walls, the following mechanism of nerve fiber injury is observed: compression - ischemia - edema or edema - compression - ischemia. Such a mechanism is possible when the nerve fibers pass through the muscles, which are in a long reflex-tonic voltage. Thus, it is a tunnel acute compression and chronic compression-ischemic neuropathy [10, 11].

The most promising in the treatment of chronic pain in compression-ischemic neuropathies are integration approaches that combine the principles of the complexity of rehabilitation measures and the individual approach to each patient. The main group of physiotherapy interventions included the following activities: kinesitherapy with neurodynamic mobilization, teupying, procedures of hardware physiotherapy and mechanotherapy. All patients were also treated with medication using appropriate medication.

Kinesitherapy with neurodynamic mobilization contributed to the restoration of functional indicators of the wrist and wrist, strengthening the muscles of the affected upper extremity, increasing the amplitude of movements, increasing endurance. Kinesiotherapy was used to eliminate pain, improve circulation, activate proprioceptive sensitivity, increase muscle tone, increase range of active movements in the affected upper extremity. Performing procedures of hardware physiotherapy allowed to reduce pain, eliminate swelling, improve trophic processes in the affected area. Mechanotherapy was used to increase flexibility and amplitude of movements, improve coordination of movements, increase sensory-motor control and proprioceptive sensitivity, increase muscle strength.

In the control group, standard rehabilitation measures were applied - physical exercises, hardware physiotherapy, mechanotherapy.

The aforementioned rehabilitation measures lasted 4 weeks (started in a hospital setting, after discharge, the patients continued to practice independently). Initial (at the beginning of the rehabilitation course) and re-examination (at the end) were conducted. The effectiveness of the therapy was evaluated by the results of the re-examination.

In the initial examination, we found that patients in both groups were diagnosed with carpal tunnel syndrome more often than other tunnel syndromes: in the main group 22 (59.5%) persons, in the control group – 21 (58.3%) patients had median nerve lesions in carpal canal (table 1).

| Types of tunnel syndromes in the examined patients |
|---------------------------------------------------|
| **Main group (n=37)** | **Control group (n=36)** |
| **Absolute units** | **Relative units, %** | **Absolute units** | **Relative units, %** |
| Carpal tunnel syndrome, quantity | 22 | 59,5 | 21 | 58,3 |
| Cubital tunnel syndrome, quantity | 10 | 27,0 | 9 | 25,0 |
| Radial nerve compression syndrome, quantity | 5 | 13,5 | 6 | 16,7 |

Upon admission, patients complained of constant aching pain, which periodically increased in the area of innervation of the affected nerve, as well as paresthesia, numbness, weakness in the injured hand. Neurological examination revealed sensitive disorders (hyperesthesia, reduction of superficial and deep sensitivity); vegetative-trophic disorders (discoloration of skin, sweating disorders); motor disorders (weakness of the flexors and extensors of the fingers, muscle hypotrophy, contracture of the joints).

In carpal tunnel syndrome, patients experienced pain in the fingers, usually pronounced and with causal features, tenderness on the inner surface of the forearm. Pain and numbness also extended to the palmar surface of I, II, III and half IV fingers, as well as to the dorsal surface of II and III fingers. Initially, the symptoms occur when performing any action using the brush (computer work, drawing, driving), then numbness and pain appeared and at rest, sometimes arising at night.

In cubital syndrome, pain and paresthesias were found in the lateral part of the shoulder and spread to the V and to the half of the IV fingers, and in some patients the pain spread to the entire brush. Initially, the unpleasant sensations and pain occurred
only at pressure on the elbow or after a long bending. In the more pronounced stage, the pain and numbness were constantly felt. In radial nerve compression syndrome ("spiral canal syndrome"), pain in patients was manifested on the dorsal surface of the shoulder, forearm, as well as in the extensor muscles of the forearm.

Assessing the severity of your pain syndrome, we noted that your primary and control patients had VAS above average (6.62 ± 0.21 and 6.58 ± 0.18 points, respectively). No significant difference between the groups was found, which indicated the homogeneity of the surveyed groups (p> 0.05).

On re-examination, we observed a decrease in pain in both groups, but in the main group, the severity of pain was significantly lower than in the control group, indicating a positive effect of rehabilitation measures used in patients in the main group (p <0.001) (Table 2).

The DN4 Pain Diagnostic Questionnaire we used in our work was designed to determine neuropathic pain in 2005 and still remains relevant for the practicing neurologist and physical therapist since the questionnaire is easy to use and can be used for rapid diagnosis. The authors of the questionnaire are scientists [10] contains 10 points, a positive answer to one of them is counted for 1 point. A score of more than four indicates the neuropathic nature of the patient's pain.

On initial examination, we found that all patients had neuropathic pain in the affected limb (positive answer to the DN4 questionnaire), but the nature of the pain was different. There were no significant differences between the groups (p> 0.05). Re-examination showed that in the main group, the number of positive answers to the question about the presence of different manifestations of pain syndrome significantly decreased compared to the control group (p <0.001) (Table 2).

**Table 2**

| Pain Level | Main group (n=37) | Control group (n=36) | t     | p      |
|------------|------------------|----------------------|-------|--------|
|            | Primary examination | Again examination | Primary examination | Again examination |
| On the VAS scale (points) | 6.62±0.21 | 3.11±0.19 | 6.58±0.18 | 4.21±0.24 | 0.14 | p>0.05* |
|                      | 3.59 | p<0.001** |
| According to the DN4 survey (points) | 7.78±0.15 | 4.63±0.18 | 8.01±0.21 | 5.85±0.17 | 0.89 | p>0.05* |
|                      | 4.93 | p<0.001** |

*: the difference between the indicators of the main and control group in the initial survey

**: the difference between the indicators of the main and control group at repeated examination

Analyzing in detail the responses of the patients of both groups on the DN4 questionnaire, we concluded that the most characteristic manifestations of pain in the examined patients during the initial examination were: burning sensation in the affected limb was noted (59.5% of patients in the main group and 58.3% of the patients in the main group) in the control group), tingling - 64.9% and 61.1% of the persons respectively in the main and control groups, numbness - 56.8% and 55.6% of the patients of the examined groups. Fewer patients had decreased sensitivity to generation - 37.8% and 41.7% of patients, and the feeling of electric shock - 16.2% and 13.8%, respectively, in the main and control groups.

When re-interviewing patients for DN4, we noted a more pronounced decrease in the number of patients with the most characteristic manifestations of pain in the main group, compared with the control group. Thus, burning sensation remained in 10.8% of the population of the main group, in the control group this indicator was higher - 16.7% of patients, tingling - in 18.9% and 30.5%, respectively (Table 3).
Table 3
Results of a primary and re-examination of the DN4 questionnaire for the diagnosis of pain (n=73)

| Питання                                                                 | Main group (n=37) | Control group (n=36) |
|--------------------------------------------------------------------------|-------------------|----------------------|
|                                                                          | Primary examination (%) | Again examination (%) | Primary examination (%) | Again examination (%) |
| Question 1: Does the patient’s pain match one or more of the following definitions? |                    |                      |                       |                     |
| 1. Feeling of burning                                                   | 59,5              | 10,8                 | 58,3                   | 16,7               |
| 2. Painful feeling of cold                                              | 13,5              | 1,9                  | 16,7                   | 8,3                |
| 3. Feeling like a shock                                                 | 16,2              | -                    | 13,8                   | -                  |
| Question 2: Is pain accompanied by one or more of the following symptoms in the area of its localization? |                    |                      |                       |                     |
| 4. Tingling, feeling of crawling ants                                   | 61,8              | 20,8                 | 63,9                   | 27,8               |
| 5. Generation                                                           | 64,9              | 18,9                 | 61,1                   | 30,5               |
| 6. Numbness                                                             | 56,8              | -                    | 55,6                   | 5,6                |
| 7. Itching                                                              | 10,8              | -                    | 13,8                   | -                  |
| Question 3: Localized pain in the same area where the examination reveals one or both of the following symptoms: |          |                      |                       |                     |
| 8. Reduced sensitivity to touch                                         | 26,5              | 13,5                 | 22,2                   | 16,7               |
| 9. Reduced sensitivity to generation                                    | 37,8              | 10,8                 | 41,7                   | 22,2               |
| Question 4: Is it possible to cause or aggravate pain in its localization: |                    |                      |                       |                     |
| 10. Having spent a brush in this area                                   | 16,2              | -                    | 19,4                   | -                  |

Discussion

Therefore, the initial examination of patients with upper limb compression-ischemic neuropathy revealed the presence of pain syndrome of different nature and severity in all patients examined. Our survey confirms the study of other scientists on the presence of neuropathic pain in patients with compression-ischemic neuropathy of the upper extremity [2, 8].

In particular, Sakovets, Bogdanov [4] point out that positive sensory symptoms may appear first in tunneling neuropathies. In the future, negative sensory disturbances (reduction of pain, temperature, tactile sensitivity), which gradually spread in the proximal direction, are joined. Positive sensory symptoms include: persistent pain or in the form of short-term acute painful attacks of 1-2 seconds in the absence of any external influence (burning, cutting, shooting nature, feeling cold, frostbite), paresthesia (feeling numb or numb irritation).

Researchers Polishchuk et al [12] conducted a survey of 186 patients with tunneling neuropathies, who were treated at the Clinic of Rehabilitation Neurosurgery, State Institution "Institute of Neurosurgery. Academician A.P. Romodanov " and the neurosurgery departments of the Kyiv City Clinical Hospital of Emergency Medical Services found that at initial examination all patients with compression-ischemic neuropathies of the peripheral nerves of the upper extremity experienced severe rest pain, which required admission.

Belova [10] in his dissertation he emphasizes that special attention in the examination of persons with carpal tunnel syndrome should be given to complaints of neuropathic pain and autonomic manifestations, as the debut of the disease is not always present, and especially the motor deficit.

According to foreign scientists Treede et al. [13], the pain usually arises from the activation of nociceptive afferents by actually or potentially destroying the tissues of the stimuli. Pain can also occur as a result of activity generated within the nervous system without adequate stimulation of its peripheral sensory endings. For this type of pain, the International Pain Study Association has introduced the term neuropathic pain, defined as "pain initiated or caused by a primary lesion or dysfunction of the nervous system". Similar results were obtained by other researchers [14, 15, 16].

The study confirmed that the use of physical therapy contributes to the reduction of pain in this category of patients. In the works of Davydov, Danilov [17], Tararoshenko [18] it is noted that
timely and complex therapy is the key to successful treatment of pain in compression-ischemic neuropathies.

Tsimbalyuk et al [19], Barinov, Shepelenko [20], Yakhno [21] emphasize that the basis of complex pathogenetic therapy is the combination of the effect of different therapeutic measures on different parts of the pathological process. Such a combination gives a more significant end result compared with the result of the action on individual parts of the pathological process.

Conclusions

1. A primary examination of patients with upper limb compression-ischemic neuropathy revealed that, on the visual analogue pain scale and the DN4 questionnaire, the pain was above average and high in both groups. On re-examination, the pain significantly decreased in the patients of the main group compared to the control group (3.11 ± 0.19 points and 4.21 ± 0.24 respectively in the main and control groups, p <0.001).

2. The results of the DN4 survey have also improved. When re-interviewing patients for DN4, we noted a more pronounced decrease in the number of patients with the most characteristic manifestations of pain in the main group, compared with the control group. Thus, burning sensation remained in 10.8% of the population of the main group, in the control group this indicator was higher - 16.7% of patients, tingling - in 18.9% and 30.5% respectively.

3. The inclusion of kinesitherapy with neurodynamic mobilization, taping, hardware physiotherapy and mechanotherapy in the comprehensive treatment of upper extremity coronary artery ischemic neuropathy contributes to a significant reduction in pain in the main group compared with the control group.

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Conflict of interest

Authors state that there is no conflict of interest.

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