INJ
МІЖНАРОДНИЙ НЕВРОЛОГІЧНИЙ ЖУРНАЛ
INTERNATIONAL NEUROLOGICAL JOURNAL

ОРИГІНАЛЬНІ ДОСЛІДЖЕННЯ
ORIGINAL RESEARCHES

UDC 616.833-009.7 DOI: https://doi.org/10.22141/2224-0713.20.4.2024.1083

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Management of different types of postamputation residual limb pain amid full scale war

For citation: International Neurological Journal (Ukraine).2024;20(4):207-210. doi: 10.22141/2224-0713.20.4.2024.1083

Abstract. ***Background.*** *Up to 50–80 % of military service members suffer from postamputation pain. Residual limb pain significantly postpones prosthetic surgery, recovery, employability, negatively impacts rehabilitation and military duty performance. The purpose was to study residual limb pain types in military personnel after traumatic amputation and efficacy of methods for their treatment.* ***Materials and methods.*** *A randomized cross-sectional study was performed of 231 military service members with residual limb pain after combat traumatic amputation, who underwent surgical treatment in tertiary and quaternary level military medical center between 2022 and 2024 amid full-scale war.* ***Results.*** *Somatic residual limb pain was observed in 36.36 % of enrolled patients, which was mainly caused by heterotopic ossification (30.74 %). 41.13 % of amputees experienced neuropathic pain due to neuromas. Pain syndrome in 22.51 % of patients resulted from both somatic causes and neuromas. Prosthesis-associated pain as a type of somatic pain was observed in 17.32 % of individuals. This study found that the persistence or recurrence of neuropathic pain among patients from the group of lidocaine-alcohol injection for painful neuromas was significantly lower ($P\alpha = 0.013$) at 6-month follow-up compared to the simple neuroma resection group. During 3 months after regenerative peripheral nerve interface, which was performed for 25 terminal neuromas, no pain recurrence was observed.* ***Conclusions.*** *It is important to assume the presence of one or both pain types in a patient with residual limb pain: somatic and/or neuropathic. Simple neuroma resections lead to an undesirably high reoperation rate — 21.79 ± 4.86 % of persistent painful neuromas. Lidocaine-alcohol injections are sufficiently simple and effective (8.70 ± 3.26 % of reinjections) in the treatment of neuropathic pain caused by terminal neuromas. Regenerative peripheral nerve interface is promising in the treatment and prevention of symptomatic neuroma.*

Keywords: *postamputation pain; residual limb pain; stump pain; symptomatic neuroma; heterotopic ossification; neuroma resection; lidocaine-alcohol injection; regenerative peripheral nerve interface; prosthesis-associated pain*

Introduction

Postamputation pain is very common among patients with limb amputation, but still represents a complex clinical problem. This complexity is caused by both diversity and combination of pathogenetic mechanisms of combat trauma.

Chronic postamputation pain severely impacts the quality of life of thousands of wounded service members. According to the United States, 1,573 wounded American soldiers underwent amputations between 2001 and 2013 [1]. According to the literature, from 50 to 80 % of them suffer from chronic pain. In particular, residual limb pain persists for 50 % of Vietnam war veterans with amputations and 63 % of OIF/OEF survey participants [2].

Residual limb pain is one of the types of postamputation pain, also known as stump pain, which is localized in the preserved part of the limb following amputation [3, 4]. Stump pain significantly postpones prosthetics, leads to unsuccessful rehabilitation of the patient, impedes restoration of his employability and military duty performance.

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Pathogenetic causes of residual limb pain can be neuromas, nerve damage, heterotopic ossification, osteophytes, sympathetic dystrophy, causalgia, muscle-tonic syndrome, complex regional pain syndrome, nociceptive, neuropathic, inflammatory, ischemic, arthrogenic, vertebrogenic, prosthetics-associated mechanisms, adhesive scar tissue, excess or deficiency of stump soft tissues.

We divide residual limb pain into 2 main types: somatic and neuropathic, based on Buchheit et al. research [5].

The purpose was to study residual limb pain types in military personnel after traumatic amputation and efficacy of methods for their treatment.

Materials and methods

A randomized cross-sectional study was conducted. The participants were 231 servicemen amputees with residual limb pain following gunshot wounds, combat injuries and underwent surgical treatment at the Military Medical Clinical Center of the Western Region during the enrollment period between 2022 and 2024. The average age of patients is 36.13 ± 8.64 years. All subjects were male.

Patients underwent general clinical and neurological examinations. The average pain intensity in the residual limb was assessed with Defense Veterans Pain Rating Scale, 2010 and initially was 8.41 ± 3.63 [6]. Amputees with mild stump pain that did not require surgical or injection treatment, other types of neuropathic pain — neuralgia, causalgia, complex regional pain syndrome, and the presence of isolated phantom pain and phantom sensations were excluded.

X-ray of a stump can determine presence and progression of osteophytes, identify the excess or deficiency of soft tissues, and diagnose a false stump.

The neuropathic pain was diagnosed with neurological examination and the Leeds Assessment of Neuropathic Symptoms and Signs questionnaire, M. Bennett, 2001 (positive response criterion ≥ 12 points).

Ultrasound exam of the stump is the main method to diagnose and localize terminal neuromas of peripheral nerves, their relationship to soft and bone tissues, involvement in scar tissue, allows to verify the condition of soft tissues, the presence of inflammatory changes, etc. In addition, it is a control tool while neuroma injection is conducted.

Statistical analysis was performed using Microsoft Excel, 2021. The following statistical methods were used: calculation of non-parametric data with Pearson's χ^2 test and Student test for four-field tables with 95% CI (P-value < 0.05).

Results

Somatic residual limb pain was diagnosed in 36.36 % of patients of the sample. 41.13 % of patients had neuropathic pain in the residual limb. Combined pain which was caused by both somatic and neuropathic mechanisms was observed in 22.51 % of amputees (Fig. 1).

Heterotopic ossification was the most frequent cause of somatic residual limb pain among the participants (30.74 %) (Fig. 2). This result justifies the routine appointment of amputated stump X-ray when somatic pain type is diagnosed.

Prosthesis-associated pain, as a type of somatic pain, was observed in 17.32 % of enrolled individuals.

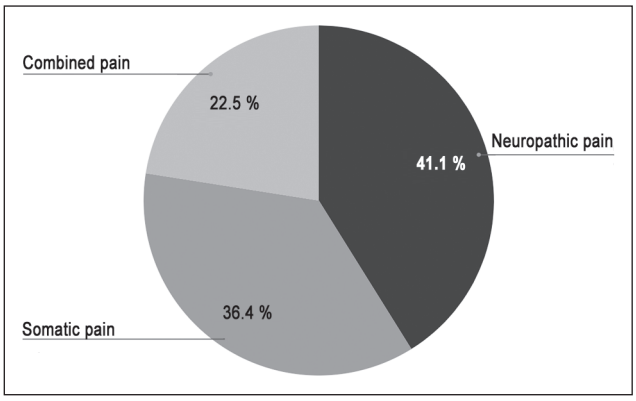

Figure 1. Structure of residual limb pain types among military service members following traumatic amputation, %

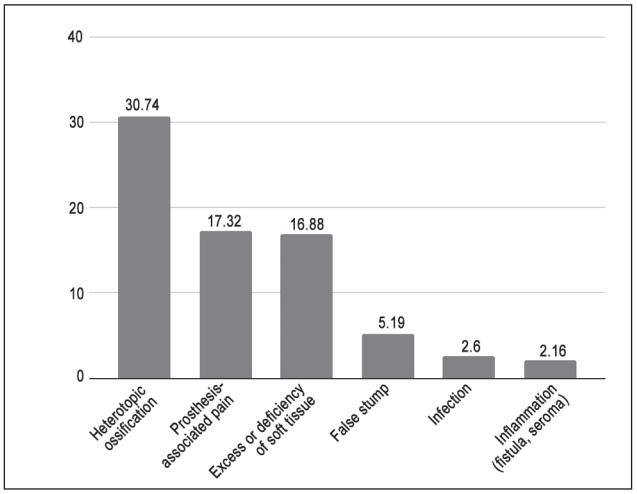

Figure 2. Distribution of causes of somatic pain among military service members following traumatic amputation, %

Table 1. Frequency of surgical interventions for various residual limb pain types among military service members following traumatic amputation performed in 2022–2024, %

Surgical interventions	P, %
Simple neuroma resection	52.38
Resection of heterotopic ossification	30.74
Stump remodeling due to soft tissue excess or deficiency	16.88
Lidocaine-alcohol injection	13.85
Reamputation	5.19
Surgery due to infectious and inflammatory complications	4.76
RPNI	3.90

Primary simple neuroma resections were performed for 280 painful neuromas of 121 patients (Table 1). Depending on severity, one patient of this group underwent resection of 1 to 4 terminal neuromas of peripheral nerves, on average 2.31 (1.26) neuromas. Sensitized neuroma persisted in 21.79 ± 4.86 % of cases (Fig. 3).

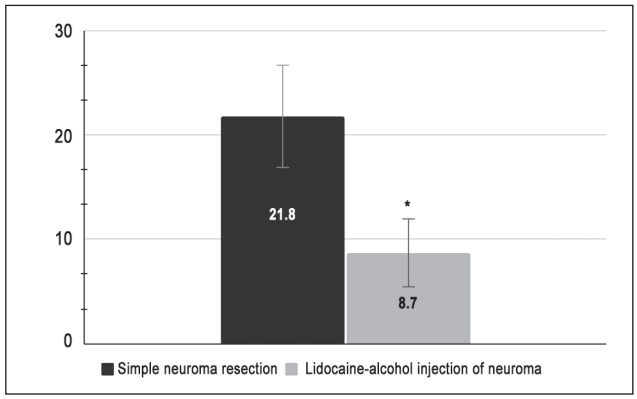

Figure 3. Distribution of painful neuroma recurrence after simple neuroma resection and lidocaine-alcohol injection of neuroma after 3–6 months, %

Note: * — Pα < 0.05.

Lidocaine-alcohol injections were performed for 69 painful neuromas of 32 patients. There were 43 primary injections, 26 injections were secondary to pain recurrence after neuroma resection. On average one patient of this group underwent lidocaine-alcohol injections of 2.12 (1.05) neuromas. 8.70 ± ± 3.26 % of painful neuroma cases required repeated lidocaine-alcohol injections (Fig. 3). Pain level in this group dropped to 2.32 ± 1.04 points in 3 months following the procedure.

The study established that neuropathic pain persistence or recurrence among patients who had underwent lidocaine-alcohol injections of painful neuromas was significantly lower ($P\alpha$ (χ^2, df = 1) = 0.013, $P\alpha$ (t, df = 347) = 0.015) during 6 months of follow-up, compared with the group of simple neuroma resections.

Regenerative peripheral nerve interface (RPNI) was performed while resecting 25 terminal neuromas, on average 2.7 (0.97) neuromas per operation. During 3 months of follow-up, no significant pain recurrence was observed in amputees, pain rated 1.9 ± 0.4 points.

Resections of heterotopic ossification were performed in 30.74 % of patients. Recurrence rate was 5.63 ± 2.63 % of cases.

Discussion

Treatment of persistent residual limb pain with known analgesic agents does not demonstrate satisfactory effectiveness in practice [7]. It creates conditions for active research for preventive treatment strategies.

Based on available evidence, local injection therapy demonstrates efficacy in the treatment of residual limb pain caused by neuromas, mainly due to the significant peripheral pathogenesis of this pain type. When injected around a nerve, alcohol causes chemical neurolysis by dehydration, necrosis, denaturation of proteins, leading to Wallerian degeneration and inhibition of neurotransmission [8]. There are no large, controlled studies on the use of alcohol chemical denervation for symptomatic neuromas among amputees. Local neuroma blocks with lidocaine and corticosteroids often provide immediate relief, however the duration of pain relief is short-term [9]. Thus, there is an active area of research to prolongate the analgesic effect.

According to the available evidence, 77 % of patients after symptomatic neuroma resection demonstrate pain relief and improvement of quality of life, regardless of an excision method. Despite initial successful results, 20–30 % of neuromas remain refractory to surgical treatment [10, 11].

Widely performed technique of simple neuroma resection with retraction of a nerve and implantation of a nerve stump into adjacent muscle spaces is aimed to create a perineural surrounding that will protect a future neuroma from external mechanical stimuli. However, after such operations, which do not prevent secondary neuromas, a high reoperation rate is observed and is up to 65 % [10, 12].

The up-to-date prophylactic surgery for painful neuromas, RPNI, was originally developed to amplify a nerve signal from the amputated limb to the neuroprosthesis [13]. According to this method, an autologous free muscle graft is wrapped around the terminal nerve stump, therefore, preventing the formation of painful neuroma [14, 15].

This study underlines prosthesis-associated pain among other causes of somatic residual limb pain type in order to optimize treatment management, as it requires improvement of a prosthesis and rehabilitation process. Such patients should be prescribed anti-inflammatory drugs and physiotherapeutic treatment.

Conclusions

It is important to assume the presence of either one or both pain types in a patient with residual limb pain: somatic and/or neuropathic, in order to select the precise examination and treatment. Furthermore, according to the results of this randomized study, the number of amputees with neuropathic pain prevails, and most of them meet diagnostic criteria for neuromas.

Based on the available evidence and the results of our study, simple neuroma resection leads to an undesirably high reoperation rate. Thus, amputees with mild or moderate pain are recommended to undergo local lidocaine-alcohol injection for painful neuromas. We recommend performing preventive surgical treatment — RPNI for patients complaining of severe and persistent neuropathic pain.

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Received 03.04.2024
Revised 13.04.2024
Accepted 22.04.2024

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Conflicts of interests. Authors declare the absence of any conflicts of interests and own financial interest that might be construed to influence the results or interpretation of the manuscript.

Information about funding. No Funding. The study was conducted as part of the clinical and research work of the Military Medical Clinical Center of the Western Region of the Ministry of Defense of Ukraine.

Authors' contribution. Ivan Bohdan — conceptualization, review, final editing; Anastasiya Bohdan — results of study, original draft; Zakhar Plakhtyr — data gathering and editing.

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Лікування різних типів постампутаційного болю в резидуальній кінцівці в умовах повномасштабної війни

Резюме. ***Актуальність.*** На постампутаційний біль страждають від 50 до 80 % військовослужбовців. Больовий синдром у куксі є вагомим фактором відтермінування протезування, недостатньо ефективної реабілітації пацієнта, затримки відновлення його працездатності й повернення до виконання службових обов'язків. ***Мета:*** вивчити типи постампутаційного болю в куксі серед військовослужбовців після травматичної ампутації та ефективність методів їх лікування. ***Матеріали та методи.*** Проведено рандомізоване крос-секційне дослідження 231 військовослужбовця з больовим синдромом у резидуальній кінцівці після ампутацій внаслідок вогнепальних поранень, бойових травм, які проходили хірургічне лікування у військово-медичному клінічному центрі III–IV рівня впродовж 2022–2024 років в умовах повномасштабної війни. ***Результати.*** У 36,36 % пацієнтів вибірки спостерігався соматичний біль у куксі, основною причиною якого була гетеротопічна осифікація (30,74 %). 41,13 % ампутантів мали нейропатичний тип болю внаслідок невром. У 22,51 % пацієнтів больовий синдром був викликаний як соматичними причинами, так і невромами. Протез-асоційований біль як різновид соматичного типу виявлений у 17,32 % осіб. У результаті цього дослідження встановлено, що персистенція чи рецидив нейропатичного болю серед пацієнтів групи, якій проводили лідокаїн-алкогольну ін'єкцію болючих невром, вірогідно нижчі ($P\alpha = 0{,}013$) через 6 місяців спостереження порівняно з групою після простих резекцій невром. Через 3 місяці після формування регенеративного периферичного невронального інтерфейсу (RPNI), виконаного при резекції 25 термінальних невром, рецидиву значущого болю не спостерігалось. ***Висновки.*** Важливо припускати у хворого з болем у куксі наявність одного чи обох типів болю: соматичного і/або нейропатичного. Прості резекції невром призводять до небажано високого рівня повторних операцій — $21{,}79 \pm 4{,}86$ % стійких болючих невром. З метою лікування нейропатичного болю, викликаного термінальними невромами, лідокаїн-алкогольні ін'єкції достатньо прості та ефективні ($8{,}70 \pm 3{,}26$ % повторних втручань). Перспективною є методика RPNI для лікування і профілактики симптомних невром.

Ключові слова: постампутаційний біль; біль у резидуальній кінцівці; біль у куксі; симптомна неврома; гетеротопічна осифікація; резекція невром; лідокаїн-алкогольна ін'єкція; RPNI; протез-асоційований біль