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CURRENT STATE OF KNOWLEDGE REGARDING LOWER LIMB AMPUTATIONS: NEW ADVANCES IN SURGERY

Abstract. Against the background of the growing number of local and international armed conflicts, in particular the full-scale war in Ukraine, cases of severe injuries accompanied by traumatic loss of lower limbs are increasingly being recorded. In peacetime, the main causes of amputations were vascular pathologies, diabetes mellitus and malignant neoplasms, however, combat trauma is now becoming increasingly important. Amputation of the lower limb, regardless of etiology, is a surgical intervention with a high risk of complications, significant functional consequences and the need for complex rehabilitation. In this context, it is extremely relevant to study the current state of knowledge in the field of amputation surgery, in particular regarding the latest techniques, predicting complications and ensuring the quality of life of patients. The aim of the study is to summarize current scientific information on surgical approaches to lower limb amputations, associated complications and prospects for improving the quality of life of patients. Materials and methods. To achieve the goal, a systematic review of publications in leading scientometric databases (PubMed, Scopus, Web of Science) over the past 10 years was conducted. The review covered studies devoted to surgical techniques, reconstructive technologies, postoperative complications and social adaptation of persons with amputated limbs. Results of the study. Today, considerable attention is paid to the use of gentle amputation techniques taking into account the preservation of the functional capabilities of the hip and knee joints, which significantly facilitates future prosthetics. The latest surgical strategies are being implemented in practice, such as targeted muscle reinnervation, osseointegrated prostheses, bioelectric control and 3D printing of individual components. At the same time, the frequency of complications such as phantom pain, soft tissue infections, stump healing disorders, depression and post-traumatic conditions remains high. The quality of life after amputation largely depends on access to modern prosthetics, early initiation of physical rehabilitation, psychological support, and social integration. Conclusion. Modern amputation surgery is rapidly evolving due to the introduction of technological innovations and interdisciplinary approaches. Effective postoperative management and comprehensive

rehabilitation are key factors in reducing disability and improving the quality of life of patients.

Keywords: reconstructive interventions, prosthetic and orthopedic rehabilitation, postoperative complications, innovative approaches in traumatology, quality of life after surgery.

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АКТУАЛЬНИЙ СТАН ЗНАНЬ СТОСОВНО АМПУТАЦІЙ НИЖНІХ КІНЦІВОК: НОВІ ЗДОБУТКИ ХІРУРГІЇ

Анотація. На тлі зростання кількості локальних та міжнародних збройних конфліктів, зокрема повномасштабної війни в Україні, усе частіше фіксуються випадки важких поранень, що супроводжуються травматичною втратою нижніх кінцівок. У мирний час основними причинами ампутацій були судинні патології, цукровий діабет і злоякісні новоутворення, однак нині дедалі більшого значення набуває бойова травма. Ампутація нижньої кінцівки, незалежно від етіології, є хірургічним втручанням із високим ризиком ускладнень, значними функціональними наслідками та потребою в складній реабілітації. У цьому контексті надзвичайно актуальним є вивчення сучасного стану знань у сфері хірургії ампутацій, зокрема щодо новітніх технік, прогнозування ускладнень та забезпечення якості життя пацієнтів. Метою дослідження є узагальнення актуальної наукової інформації про хірургічні підходи до ампутацій нижніх кінцівок, пов’язані з ними ускладнення та перспективи покращення якості життя пацієнтів. Матеріали та методи. Для досягнення мети було проведено систематичний огляд публікацій у провідних наукометричних базах (PubMed, Scopus, Web of Science) за останні 10 років. Огляд охопив дослідження, присвячені хірургічним методикам, реконструктивним технологіям, післяопераційним ускладненням та соціальній адаптації осіб з ампутованими кінцівками. Результати дослідження. На сьогодні значна увага приділяється використанню щадних технік ампутації з урахуванням збереження функціональних можливостей культі та колінного суглоба, що істотно полегшує майбутнє протезування. У практику впроваджуються новітні хірургічні стратегії, такі як таргетна м’язова реіннервація, остеоінтегровані протези, біоелектричне керування та 3D-друк індивідуальних компонентів. Водночас залишається високою частота таких ускладнень, як фантомні болі, інфекції м’яких тканин, порушення загоєння кукси, депресія та посттравматичні стани. Якість життя після ампутації значною

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мірою залежить від доступу до сучасного протезування, раннього початку фізичної реабілітації, психологічної підтримки та соціальної інтеграції. Висновок. Сучасна хірургія ампутацій демонструє швидкий розвиток завдяки впровадженню технологічних інновацій та міждисциплінарних підходів. Ефективне післяопераційне ведення та комплексна реабілітація є ключовими факторами зниження інвалідизації та покращення якості життя пацієнтів.

Ключові слова: реконструктивні втручання, протезно-ортопедична реабілітація, післяопераційні ускладнення, інноваційні підходи в травматології, якість життя після хірургічного втручання.

Statement of the problem. Lower limb amputation remains a major global health problem, with a variety of causes, including complications of diabetes, vascular disease, trauma, and combat injuries. The prevalence of diabetes-related amputations has continued to increase over the past decade. According to a systematic review and meta-analysis conducted in 2010-2020, the global annual incidence of diabetes-related amputations is approximately 8.2 cases per 100,000 population, with the highest rates in Southeast Asia and Africa. The significant decline in amputation rates in countries with developed health systems is attributed to improvements in diabetes prevention and control [1].

In the European Union, there has been a gradual decline in the lower limb amputation rate over the period 1990-2017. In more than 15 EU countries, the average rate ranged from 12 to 15 cases per 100,000 population in the early 1990s and has decreased to 8 to 10 cases per 100,000 population in recent years. These positive changes are associated with improvements in vascular surgery, early detection and treatment of ischemic lower limb disease [2].

Canada shows a stable incidence of lower limb amputations at 15 cases per 100,000 population per year. However, mortality in patients after amputation remains high – about 20% during the first year after surgery. There is also considerable variability in the causes of amputation, including diabetic complications, vascular diseases and trauma [3].

Traumatic amputations associated with combat, natural disasters, and road traffic accidents constitute a significant share of the global health burden. It is estimated that more than 120,000 cases of traumatic lower limb amputations were recorded in 2020 in 204 countries, with the highest prevalence in regions with conflict and low levels of medical care [4].

Military injuries of the lower limbs from explosive devices are particularly dangerous due to the complexity of the lesions, which combine mechanical damage to bones, soft tissues, and blood vessels. The characteristics of such injuries indicate a high risk of infectious complications and the need for complex reconstructive surgeries, which significantly complicates the recovery process of patients [5]. Analysis of civilian cases of trauma caused by terrorist bombings during the period 1970-2016 also confirms the trend of increasing number of severe amputations with multisystem lesions, requiring the use of innovative surgical approaches and rehabilitation programs [6].

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Thus, modern surgery of lower limb amputations is developing under the influence of both chronic diseases and acute traumatic injuries. Improvements in surgical techniques, early diagnosis and multidisciplinary approach to treatment contribute to reducing the incidence of complications and improving the quality of life of patients.

The aim of the study is to summarize current scientific information on surgical approaches to lower limb amputations, their complications, and their impact on patients' quality of life, taking into account the latest advances in the field of surgery.

Research objects and methods. An analysis of scientific publications devoted to modern surgical approaches to lower limb amputations was carried out, with an emphasis on the latest techniques, postoperative complications and restoration of patients' quality of life. The main criterion for selecting literature sources was the date of publication no later than 15 years ago. Searches were carried out using the Google Scholar database. Of the 43 identified sources, 20 were selected for a systematic review. The process of organizing and selecting sources was carried out in accordance with international requirements for creating review publications using the PRISMA methodology and the PRISMA flowchart to clearly demonstrate the sequence of inclusion of materials [7].

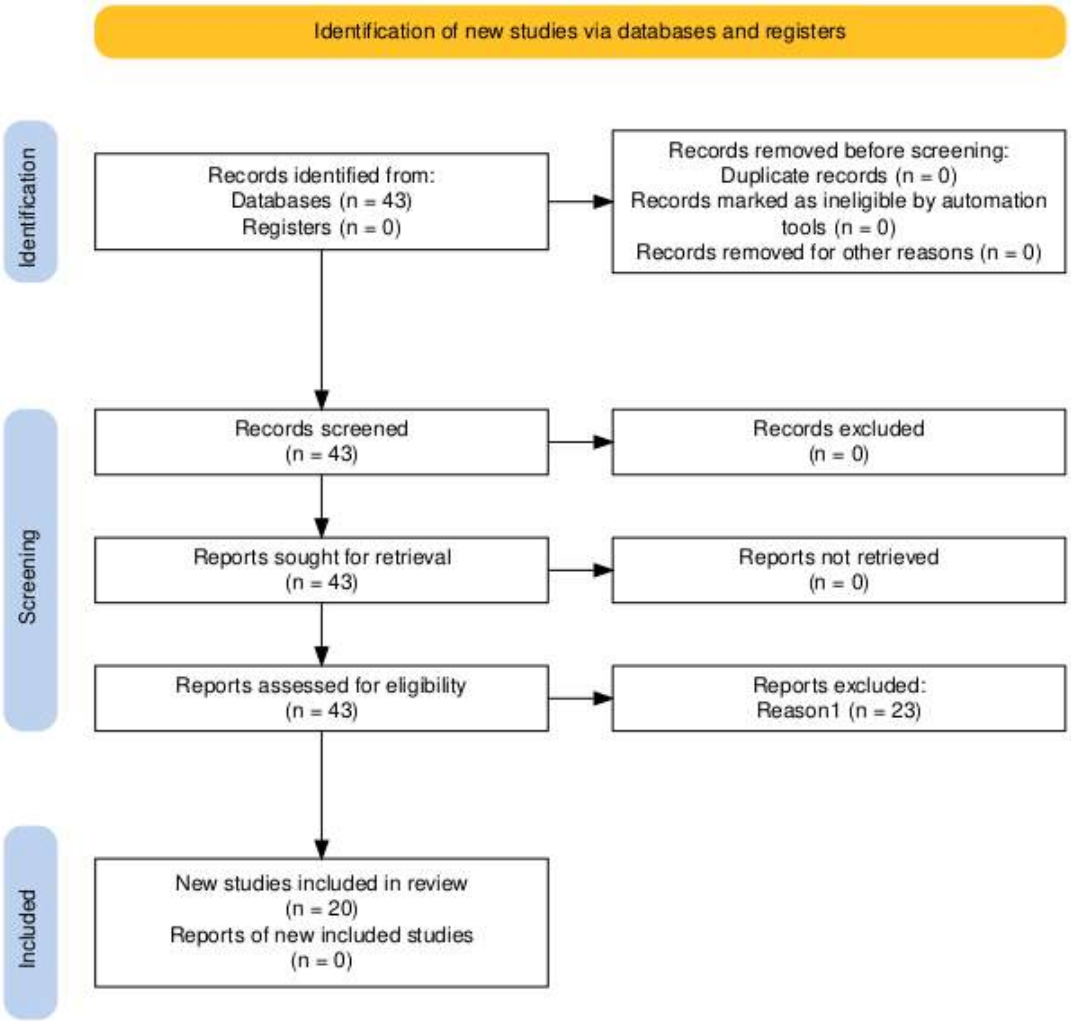

Fig. 1. The PRISMA flow diagram of literary sources search results.

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Presentation of the main material.

Research results and their discussion. Lower limb amputation is one of the most serious surgical procedures performed when limb preservation is impossible or life-threatening. More than a million amputations are performed worldwide each year, and the number is increasing. The most common causes are diabetes mellitus, atherosclerosis, critical limb ischemia, trauma, and complications after infections. According to clinical analysis, critical limb ischemia and diabetic angiopathy are the leading factors leading to the need for amputation, accounting for more than 60% of all cases. Most amputations occur in men over 60 years of age, and more than 26% of patients experience postoperative complications, the most common of which are soft tissue infections, stump healing disorders, necrosis, and thrombosis [8].

Postoperative mortality in patients with lower limb amputation remains high. A meta-analysis of more than 40 studies involving more than 5000 patients showed that the 1-year mortality after major amputation is approximately 22%, the 3-year mortality is 43%, and the 5-year mortality is almost 48%. The most important factors that increase the risk of mortality are considered to be advanced age, the presence of coronary heart disease, impaired renal function, previous vascular interventions, and high level of amputation (above the knee). Patients with transfemoral amputation have a significantly lower chance of survival and functional rehabilitation than those with amputation at the level of the lower leg [9].

Despite the complexity of the clinical situation, positive dynamics in treatment outcomes have been observed over the past decade. The development of vascular surgery, the active implementation of endovascular technologies, a multidisciplinary approach to patient management, and standardized rehabilitation protocols have contributed to a decrease in the level of disability and an improvement in the functional prognosis. In one prospective study, the five-year survival rate after amputation was 55-60% in clinics that implemented modern approaches to care [10].

One of the most pressing issues is the prevention of postoperative complications and rehospitalization. The rate of unplanned readmissions to the hospital after lower limb amputation reaches 30%, and in 12% of cases, patients require repeated surgical intervention due to infections or impaired stump healing. The main predictors of complications are the presence of chronic obstructive pulmonary disease, anemia, chronic renal failure, obesity, and the lack of adequate support in the outpatient period [11].

The intensive development of surgical technologies in recent years has led to the emergence of new surgical techniques that improve functional outcomes. One of these is targeted muscle reinnervation, which reduces phantom pain and creates a more controlled base for prosthetics. Another modern technology, osseointegration, consists in implanting a metal pin into the femur or tibia, which provides a direct connection to the prosthesis. This approach avoids rubbing of the stump, improves sensory feedback and promotes faster rehabilitation [12].

International clinical guidelines state that preparation for amputation, surgery and postoperative care should be based on interdisciplinary cooperation. Optimal

treatment includes assessment of functional potential, adaptation of the stump to prosthetics, psychological preparation of the patient and training in self-care techniques. One of the important elements of patient management is the prevention of contractures, physical therapy, formation of a stable stump and psychological adaptation [13].

A 15-year analysis of trends in the US Medicare system shows a steady decrease in the number of amputations in patients with critical lower limb ischemia. This was facilitated by preventive programs, increased public awareness of risk factors, timely diagnosis of vascular diseases, and the availability of endovascular procedures [14].

3D technologies play a special role in modern surgery. Personalized 3D-printed implants and orthopedic components are actively used in complex cases of stump reconstruction after traumatic amputations. 3D printing allows you to model implants taking into account the individual anatomy of the patient, increasing the accuracy of the fit and reducing the risk of rejection. This approach contributes not only to physical recovery, but also to improving the aesthetic and functional characteristics of the prosthesis [15, 16].

Quality of life after amputation is a multifaceted category that depends on both medical factors and social, psychological, and economic conditions. Clinical studies have shown that up to 60% of patients experience significant reductions in physical activity, difficulties with self-care, and dependence on outside help. However, those who had access to modern rehabilitation programs, high-quality prostheses, and psychological support demonstrated significant improvements in functional capacity within 6–12 months after amputation [17].

Quality of life is also influenced by a number of non-clinical factors. The main social determinants include education, financial status, access to health services, family support and social adjustment. A systematic review has shown that patients with lower socioeconomic status are more likely to experience limitations in daily activities, depression and isolation [18, 19]. A study conducted in the West of Scotland found that socioeconomic deprivation significantly reduces mobility, social participation and subjective well-being among lower limb amputees. Patients with higher living standards were more likely to receive modern prostheses, be able to engage in physical activity and return to work [20].

Conclusions. Modern approaches to lower limb amputation surgery demonstrate significant progress through the introduction of minimally invasive techniques, reconstructive interventions, and integrated prosthetic technologies. At the same time, the problem of complications after amputations, including phantom pain, infections, and psychoemotional disorders, remains relevant. Comprehensive postoperative management, multidisciplinary rehabilitation, and access to modern prosthetics are key factors in improving the quality of life of patients. Further research should focus on personalized treatment approaches and long-term recovery outcomes.

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