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RESULTS OF SURGICAL TREATMENT OF PATIENTS WITH CRITICAL ISCHAEMIA OF THE LOWER EXTREMITIES USING BIFURCATION SELECTIVE PROFUNDOPLASTY WITH REVERSED AUTOVENOUS GRAFTING

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Abstract

This article discusses the problems of surgical tactics in critical ischaemia of the lower extremities and its complications, both in the early postoperative period and in the long term. High limb amputation rates are prompting surgeons to search for the optimal surgical treatment method to achieve the best results. Amputation below the knee joint is considered preferable, as preserving the knee joint significantly improves functional outcomes, in particular the possibility of successful prosthetics and restoration of limb support. However, stump survival, the risk of postoperative complications, and the potential for prosthetics depend to a large extent on adequate blood supply in the amputation area.

Aim: To improve the results of surgical treatment of patients with critical lower limb ischaemia using bifurcation selective profundoplasty with reversed autovenous grafting.

Materials and Methods: This study involved 63 patients who underwent surgery between 2022 and 2024 in the city of Semey, Abai region. The study examined the general characteristics of surgical interventions performed on patients with critical lower limb ischaemia using the treatment methods we proposed to improve the final results.

Results: The analysis showed that patients who underwent lower leg amputation combined with bifurcation profundoplasty had better postoperative outcomes compared to the group that underwent isolated amputation. In the second group, complications from the stump were significantly less common, the ability to undergo prosthetic replacement was higher (71.9% vs. 45.2%, $p < 0.05$), and patency of the deep femoral artery was maintained in 81.3% of cases during 12 months of follow-up.

Conclusions: The data obtained confirm that preservation of the knee joint during amputation, combined with optimisation of collateral blood flow through profundoplasty, contributes to better functional outcomes and improved quality of life for patients. The proposed combined approach can be considered an effective alternative to isolated amputation in patients with severe vascular pathology and limited possibilities for direct revascularisation.

Keywords: *Critical limb ischaemia, atherosclerosis, amputation, profundoplasty.*

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Резюме

РЕЗУЛЬТАТЫ ХИРУРГИЧЕСКОГО ЛЕЧЕНИЯ БОЛЬНЫХ С КРИТИЧЕСКОЙ ИШЕМИЕЙ НИЖНИХ КОНЕЧНОСТЕЙ С ПРИМЕНЕНИЕМ БИФУРКАЦИОННОЙ СЕЛЕКТИВНОЙ ПРОФУНДОПЛАСТИКИ С РЕВЕРСИРОВАННОЙ АУТОВЕНОЙ

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В данной статье рассматриваются проблемы хирургической тактики при критической ишемии нижних конечностей и ее осложнениях, как в раннем послеоперационном периоде, так и в отдаленном периоде. Высокие показатели ампутации конечности подталкивают хирургов на поиски оптимального метода хирургического лечения для получения лучших результатов. Уровень ампутации ниже коленного сустава считается предпочтительным, так как при сохранении коленного сустава значительно улучшаются функциональные результаты, в частности — возможность успешного протезирования и восстановления опороспособности конечности. Однако выживаемость культи, риск послеоперационных осложнений и потенциал для протезирования в значительной степени зависят от адекватного кровоснабжения в зоне ампутации.

Цель исследования: Улучшить результаты хирургического лечения больных с критической ишемией нижних конечностей с применением бифуркационной селективной профундопластики с реверсированной аутовеной.

Материалы и методы: В данном исследовании приняли участие 63 пациента, которым проведено хирургическое вмешательство с 2022 по 2024 года в городе Семей, области Абай. В исследовании были изучены общие характеристики хирургических вмешательств, выполненных больным с критической ишемией нижней конечности с использованием предложенными нами методов лечения для улучшения конечных результатов.

Результаты: Проведённый анализ показал, что у пациентов, перенёсших ампутацию голени в сочетании с бифуркационной профундопластикой, отмечались лучшие послеоперационные исходы по сравнению с группой, где выполнялась изолированная ампутация. Во второй группе достоверно реже встречались осложнения со стороны культи, выше была способность к протезированию (71,9% против 45,2%, $p < 0,05$), а также сохранялась проходимость глубокой бедренной артерии в 81,3% случаев в течение 12 месяцев наблюдения.

Выводы: Полученные данные подтверждают, что сохранение коленного сустава при ампутации в сочетании с оптимизацией коллатерального кровотока за счёт профундопластики способствует лучшим функциональным исходам и повышению качества жизни пациентов. Предлагаемый комбинированный подход может рассматриваться как эффективная альтернатива изолированной ампутации у пациентов с выраженной сосудистой патологией и ограниченными возможностями к прямой реваскуляризации.

Ключевые слова: Критическая ишемия конечности, атеросклероз, ампутация, профундопластика.

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Түйіндеме

РЕВЕРСИЯЛАНҒАН КӨКТАМЫРМЕН СЕЛЕКТИВТІ БИФУРКАЦИЯЛЫҚ ПРОФУНДОПЛАСТИКА ӘДІСІН ҚОЛДАНА ОТЫРЫП, АЯҚТЫҢ КРИТИКАЛЫҚ ИШЕМИЯСЫ БАР НАУҚАСТАРҒА ЖАСАЛҒАН ХИРУРГИЯЛЫҚ ЕМДЕУДІҢ НӘТИЖЕЛЕРІ

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Бұл мақалада аяқтың критикалық ишемиясы кезіндегі хирургиялық тактика мен оның асқынулары, ерте және кеш отадан кейінгі кезеңдердегі ерекшеліктері қарастырылған. Аяқты ампутациялау көрсеткіштерінің жоғарылығы хирургтарды жақсы нәтижелерге қол жеткізу үшін тиімді әдістерді іздеуге итермелейді. Тізеден төмен деңгейде ампутация жасау қолайлы болып саналады, себебі тізе буынының сақталуы функционалды нәтижелерді едәуір

жақсартады, атап айтқанда – сәтті протездеу мүмкіндігін және аяқтың тірек қабілетін қалпына келтіруді қамтамасыз етеді. Алайда, тұқылдың (культяның) тез жазылуы, операциядан кейінгі асқынулар қаупі және протездеу ампутация аймағындағы қанмен қамтамасыз етілу деңгейіне айтарлықтай байланысты.

Зерттеудің мақсаты: Реверсияланған көктамырмен орындалатын бифуркациялық селективті профундопластика қолдану арқылы аяқтың критикалық ишемиясы бар науқастарды хирургиялық емдеу нәтижелерін жақсарту.

Материалдар мен әдістер: Зерттеуге 2022–2024 жылдар аралығында Абай облысының Семей қаласында ота жасалған 63 науқас қатысты. Зерттеу барысында аяқтың критикалық ишемиясы бар науқастарға қолданылған хирургиялық емдеу әдістерінің жалпы сипаттамалары мен соңғы нәтижелері талданды.

Нәтижелер: Талдау көрсеткендей, сирақ ампутациясын бифуркациялық профундопластикамен бірге өткізген науқастарда, оқшауланған ампутация жасалған топпен салыстырғанда, операциядан кейінгі нәтижелер жақсы болды. Екінші топта тұқылдың (культя) асқынулар сенімді түрде аз кездесті, протездеу мүмкіндігі жоғары болды (71,9% қарсы 45,2%, $p < 0,05$), сондай-ақ терең жамбас артериясының өткізгіштігі 12 айлық бақылау кезеңінде 81,3% жағдайда сақталды.

Қорытынды: Алынған деректер тізе буынын сақтау және профундопластика арқылы коллатералды қан айналымын жақсарту функционалды нәтижелерді күшейтіп, науқастардың өмір сапасын арттыратынын дәлелдейді. Ұсынылған кешенді тәсіл айқын тамырлық патологиясы бар әрі тікелей ревааскуляризация жасау мүмкіндігі шектеулі науқастарда оқшауланған ампутацияға тиімді альтернативі ретінде қарастырылуы мүмкін.

Түйінді сөздер: Аяқтың критикалық ишемиясы, атеросклероз, ампутация, профундопластика.

Дәйексөз үшін:

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Introduction

Every 30 seconds, a non-traumatic lower limb amputation occurs worldwide, amounting to more than 2,500 cases daily. According to various data, the annual incidence of major amputations ranges from 120 to 500 per million inhabitants [7]. This represents not only a medical but also a significant socio-economic problem, directly impacting patients' quality of life, work capacity, and life expectancy. Contemporary epidemiological data show that up to 90% of all non-traumatic amputations are associated with vascular diseases, primarily chronic critical limb ischemia (CLI) caused by progressive atherosclerosis of the lower extremity arteries.

Despite the severe detrimental effects of CLI on health, public awareness remains low. In many cases, patients seek medical help only at advanced stages characterized by significant trophic disturbances - gangrene or ischemic ulcers - which limits the possibilities for effective revascularization and increases the risk of amputation. Early detection and timely intervention are essential for successful treatment outcomes.

The most common anatomical localization of atherosclerotic lesions is the femoropopliteal segment. Isolated lesions in this area account for up to 65% of all recorded cases of lower limb arterial disease [9]. In cases of superficial femoral artery (SFA) occlusion, the deep femoral artery (DFA), which does not directly continue into the popliteal artery, plays a key role as a source of collateral blood flow. The extensive branching of the DFA allows for the formation of collaterals that partially compensate for blood supply to the distal parts of the limb. However, the presence of hemodynamically significant stenosis of the DFA markedly reduces the efficiency of this compensatory mechanism, which may lead to progression of ischemia, tissue necrosis in the foot and lower leg, and the necessity of amputation [4, 8].

Given the role of the DFA in collateral circulation, its functional status is critically important in patients with CLI. In some cases, reconstruction of the deep femoral artery (profundoplasty) improves perfusion in distal limb segments, even when full revascularization of more distal arteries is not feasible. Recent studies confirm that open reconstruction of the DFA not only promotes ulcer healing and amputation prevention but also increases the likelihood of successful prosthetic fitting after below-knee amputation.

Currently, two main approaches are used to restore blood flow in chronic femoropopliteal occlusions: open surgical interventions (including bypass surgery and profundoplasty) and endovascular methods - percutaneous transluminal angioplasty and stenting. Endovascular treatment is considered the first-line strategy for lesions of the superficial femoral and popliteal arteries [10]. However, in cases involving the common femoral artery (CFA) and the ostium of the deep femoral artery, open endarterectomy with patch angioplasty remains the gold standard [1].

In cases where revascularization is impossible or ineffective, amputation is performed. However, even in these situations, the condition of the DFA remains clinically significant: adequate blood flow to the stump is critical for wound healing, prevention of infectious complications, and successful prosthetic rehabilitation. Therefore, assessment of the status and reconstructive options of the DFA should be an integral part of preoperative planning in patients with severe limb ischemia.

The aim of the study is to improve the results of surgical treatment of patients with critical ischaemia of the lower extremities using bifurcation selective profundoplasty with reversed autovenous grafting.

Materials and methods

The study included 63 patients with critical lower limb ischaemia (CLLI) stage IV according to the Rutherford classification, who were scheduled for lower limb amputation at the shin level. All patients were treated in the cardiovascular surgery department of the University Hospital NCJSC 'SMU' from 2022 to 2024. The average age of the patients was 65.2 years (range 57 to 73 years). Of the total number of patients examined, 47 (74.6%) were men and 16 (25.4%) were women.

Inclusion criteria: patients with critical lower limb ischaemia who are indicated for limb amputation with significant stenosis of the deep femoral artery on the affected side.

Exclusion criteria: patients with critical ischaemia without indications for lower limb amputation, absence of significant stenosis of the deep femoral artery in patients.

The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the State Medical University of Semey (Protocol 5 dated January 25, 2022, y).

Patients were divided into two groups:

- Group 1 (n = 31): Lower leg amputation without reconstructive surgery;
- Group 2 (n = 32): Lower leg amputation combined with bifurcation selective profundoplasty using a reversed autovenous graft.

Table 1.

Distribution of patients by groups and demographic characteristics.

Indicator	Group 1 (n=31)	Group 2 (n=32)	Total (n=63)
Average age (years)	64,8 ± 4,2	65,6 ± 3,9	65,2 ± 4,0
Age range (years)	57–73	58–72	57–73
Men, n (%)	24 (77,4%)	23 (71,9%)	47 (74,6%)
Women, n (%)	7 (22,6%)	9 (28,1%)	16 (25,4%)

Pre- and postoperative assessment included:

- Clinical examination (pain syndrome, viability of stump tissues);
- Ultrasound with Doppler imaging;
- In some cases – CT angiography;
- Assessment of suture integrity and wound healing quality;
- Deep femoral artery patency (in the second group);
- Prosthetic potential (stump bearing capacity).

The duration of observation was 12 months. Follow-up examinations were conducted at 1, 3, 6, and 12 months.

Statistical analysis

Intergroup comparison of quantitative characteristics was performed using the Mann-Whitney U test. Comparison of frequency indicators in independent samples was performed using Fisher's exact test. Differences were considered statistically significant at p < 0.05.

Results

A comprehensive analysis of 63 patients was conducted. The comorbidities of both groups are presented below (Table 2).

Table 2.

Prevalence of comorbidities in patients in both groups.

Associated disease	Group 1 (n=31)	Group 2 (n=32)	Total (n=63)	p-value
History of acute cerebrovascular accident	9 (29,0%)	7 (21,9%)	16 (25,4%)	0,48
Arterial hypertension	25 (80,6%)	26 (81,3%)	51 (81,0%)	0,94
Ischemic heart disease	18 (58,1%)	16 (50,0%)	34 (54,0%)	0,51
Chronic kidney disease (CKD)	11 (35,5%)	8 (25,0%)	19 (30,2%)	0,38
Obliterating atherosclerosis of the BCA	9 (29,0%)	7 (21,9%)	16 (25,4%)	0,48
Chronic heart failure	10 (32,3%)	9 (28,1%)	19 (30,2%)	0,72
Obesity (BMI ≥ 30 kg/m ²)	6 (19,4%)	5 (15,6%)	11 (17,5%)	0,66

A high incidence of concomitant chronic diseases was observed among the patients examined. Arterial hypertension was detected in the majority of patients (81.0%), ischaemic heart disease in 54.0%, and chronic kidney disease in 30.2%. A history of acute cerebrovascular accident was present in 25.4% of patients, and obesity (BMI ≥ 30 kg/m²) in 17.5%. The distribution of concomitant pathology between the groups was comparable, with no statistically significant differences recorded (p > 0.05 for all indicators). The combination of severe vascular pathology with somatic diseases forms a high-risk group, which requires special attention when choosing treatment tactics and in postoperative observation.

Surgical procedure:

In the first group, standard amputation of the lower leg at the mid-third level was performed using the

generally accepted technique. In the second group, a combined procedure was performed: amputation of the lower leg at the mid-third level combined with bifurcation selective profundoplasty. The indication for profundoplasty was stenosis of the deep femoral artery (DFA) with unaffected inflow pathways and surface occlusion. When performing isolated profundoplasty, we used regional (epidural or spinal) anaesthesia. A reversed great saphenous vein borrowed from the contralateral or ipsilateral limb was used for reconstruction. Surgical access was achieved through a medial femoral incision. Revision of the common, superficial, and deep femoral arteries was performed. Anastomoses were performed between the venous shunt and the main branches of the deep femoral artery, ensuring improved collateral blood flow to the stump (Figure 1).

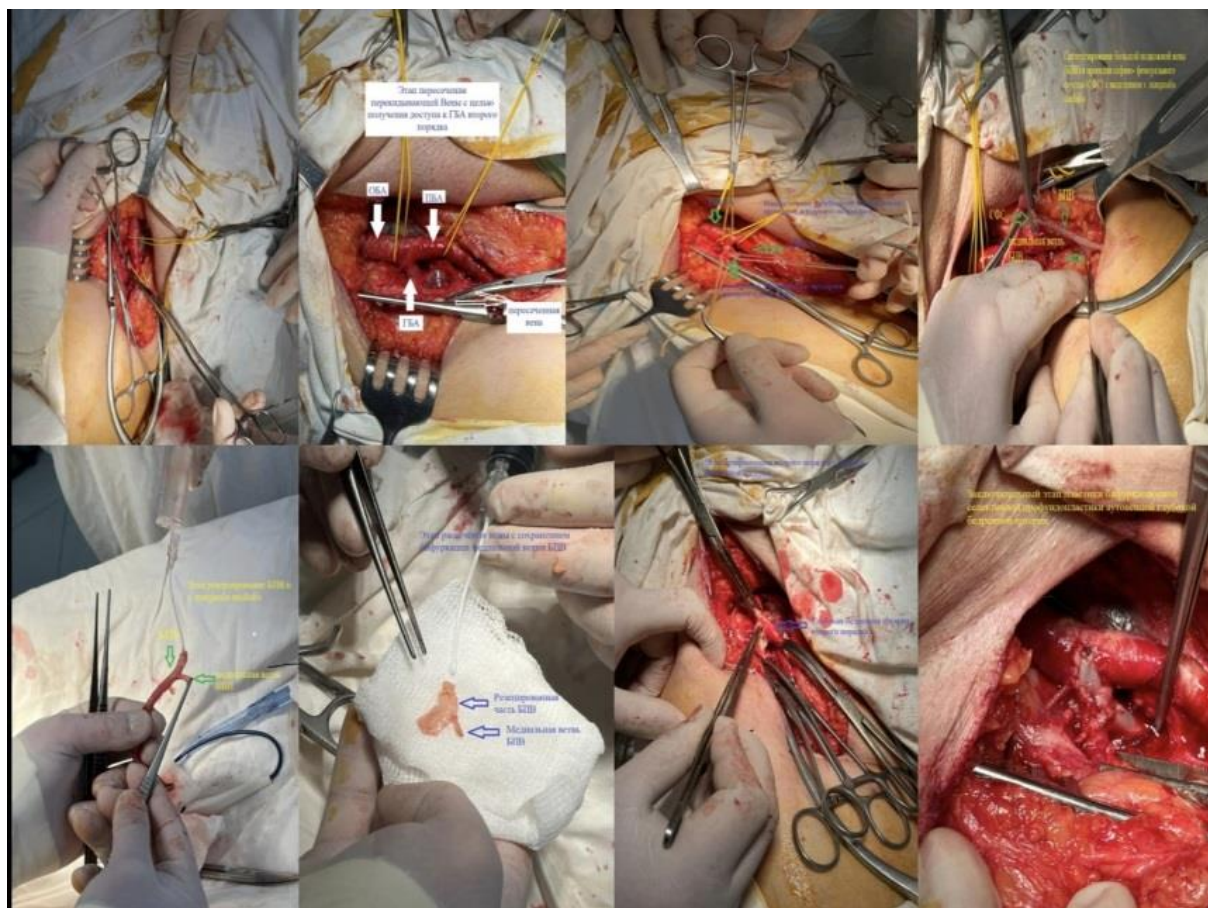


Figure 1. 1. Isolation of the common, deep and superficial femoral arteries. 2. Crossing of the perforating vein. 3. Isolation of the second-order DFA. 4. Harvesting of the GSV with the medial branch. 5. Reversal of the GSV with the medial branch. 6. Incision of the vein with preservation of the bifurcation of the medial branch. 7. Arteriotomy of the second-order DFA. 8. General view after selective bifurcation plasty of the second-order DFA.

This surgical treatment method has been granted patent No. 36887 by the Republic of Kazakhstan in 2023.

Patients in the second group showed more favourable indicators of stump tissue viability and wound healing quality in the postoperative period. Delayed complications (stump necrosis, wound infection, suture dehiscence) were statistically significantly less frequent in the second group compared to the first ($p < 0.05$). The ability to undergo prosthetic replacement after 12 months of observation was significantly higher in the second group: 71.9% of patients ($n = 23$) successfully underwent primary prosthetic replacement and achieved satisfactory stump bearing capacity, while in the first group the corresponding figure was 45.2% ($n = 14$) ($p = 0.03$).

Discussion

Below-knee amputation in cases of critical limb ischemia (CLI) remains a relevant and sometimes the only feasible surgical treatment for patients with severe, irreversible arterial circulation disorders. However, the success of such surgery is determined not only by patient survival but also by functional outcomes, particularly the load-bearing capacity of the stump and the potential for prosthetic rehabilitation. At the same time, inadequate blood supply in the amputation area significantly increases the risk of postoperative complications such as tissue necrosis,

infection, wound dehiscence, and formation of an unstable stump requiring revision surgery [2].

The study demonstrated that the use of selective profundoplasty at the bifurcation in patients with isolated stenosis of the profunda femoris artery and occlusion of the superficial femoral artery significantly improved the outcomes of below-knee amputation. In the second group, where this technique was applied, there was a significant reduction in the incidence of local complications and an increase in the proportion of patients eligible for prosthetic rehabilitation compared to the group that underwent isolated amputation [3, 5].

Given that in some CLI patients the profunda femoris artery remains the only source of collateral blood supply to the distal limb, its reconstruction becomes especially important. The performed profundoplasty contributed to improved tissue perfusion in the stump area, which, in turn, positively affected wound healing and final functional outcomes. The authors also emphasize that the diameter of the profunda femoris artery is a critical factor in achieving favorable results [6]. Furthermore, it is important to note that the combined procedure did not increase hospital mortality or the rate of serious systemic complications, indicating its safety when appropriate preoperative patient selection is applied. Additionally, the use of an autogenous venous graft

(reversed great saphenous vein) provided high graft patency over a 12-month follow-up period.

Moreover, the reconstruction of the profunda femoris artery as part of a comprehensive approach to CLI treatment not only improves immediate surgical outcomes but also enhances patients' quality of life in the postoperative period. A more stable stump and the potential for early prosthetic fitting significantly increase the chances of social and domestic reintegration, especially in elderly patients with multiple comorbidities. This is particularly relevant considering the disabling nature of lower-limb amputations and the need for rapid functional recovery.

The reduced incidence of local postoperative complications—such as soft tissue necrosis, wound dehiscence, and secondary infection—also contributes to shorter hospital stays and less frequent need for reoperations, which has both clinical and economic significance. These benefits are especially valuable in resource-limited healthcare settings, where achieving maximum treatment efficiency is essential.

Comparison with other studies also supports the rationale for using profundoplasty. Several authors [3, 8] have previously emphasized the importance of maintaining or restoring blood flow through the profunda femoris artery in patients with superficial femoral artery occlusion. Our findings confirm these conclusions and demonstrate their practical feasibility even in cases where only an amputation was initially planned.

Nevertheless, it is essential to highlight that the success of this intervention largely depends on proper patient selection. Key criteria include the anatomical patency and adequate diameter of the profunda femoris artery, availability of suitable autologous vein grafts, and the patient's overall condition. Therefore, individualized treatment planning and involvement of a multidisciplinary team (including a vascular surgeon, anesthesiologist, and rehabilitation specialist) are crucial factors in decision-making and optimizing clinical outcomes.

In conclusion, the results confirm that below-knee amputation combined with profunda femoris artery reconstruction can be an effective and justified approach in patients with severe ischemia, where revascularization via the superficial femoral artery or below is not possible or ineffective. However, despite the encouraging results, the limited sample size and retrospective nature of the study must be taken into account. Future randomized prospective studies with larger patient cohorts and longer follow-up periods are warranted to more accurately assess the efficacy of this technique and define its place in clinical guidelines.

Conclusions

The results of the study demonstrate the clinical feasibility and effectiveness of bifurcation selective profundoplasty combined with lower leg amputation in patients with stage IV critical lower limb ischaemia in the presence of deep femoral artery stenosis. Performing reconstructive surgery in the context of amputation improves blood supply to the stump, reduces the frequency of postoperative complications, increases tissue viability, and significantly increases the proportion of patients who are eligible for prosthetics and restoration of limb function. The data obtained confirm that preservation of the knee joint during amputation, combined with optimisation of

collateral blood flow through profundoplasty, contributes to better functional outcomes and improved quality of life for patients. The proposed combined approach can be considered an effective alternative to isolated amputation in patients with severe vascular pathology and limited possibilities for direct revascularisation.

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