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Repeated Revascularizing Osteotrepanation in Patients with Critical Ischemia of the Upper and Lower Extremities with Distal Lesions of the Arteries

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Abstract

Purpose: To study the results of repeated revascularizing osteotrepanation in patients with critical ischaemia of the upper and lower extremities in order to prevent major amputations. ***Material and methods:*** The etiological cause of the development of CI was thromboangiitis obliterans (OT) in 9 patients, Raynaud's syndrome (disease) in 4 patients, obliterating atherosclerosis in 5 patients, obliterating atherosclerosis with concomitant type 2 diabetes mellitus in 9 patients. According to the Fontaine-Pokrovsky classification, 10 patients had stage III of chronic ischemia, and 17 patients had stage IV of chronic ischemia. The terms of repeated revascularizing osteotrepanation are from 3 months. up to 2 years after the first ROT. ***Results:*** Repeated operation of oral rotation of the ulna and radius was performed in 15 extremities with stage IV chronic ischemia. In 3 (20.0%) extremities, the necrotic wound on the fingers healed, in 5 (33.3%) soft tissue necrectomy was performed, in 7 (46.7%) cases - minor amputations at the level of the fingers. Amputation at the level of the forearm was not performed. Repeated operation of tibial rot was performed in 24 limbs with stage IV chronic ischemia. In 7 (25.9%) limbs, the necrotic wound healed, in 6 (22.2%) limbs, soft tissue necrectomy was performed, in 9 (33.3%) limbs - minor amputations, in 5 (18.5%) - due to the progression of critical ischemia, amputation was performed at the level of the upper third of the tibia (major amputation). In 22 (81.5%) cases with stage IV chronic ischemia, the supporting function of the limb was preserved. ***Conclusion:*** With repeated ROT, the frequency of high amputations of the upper and lower extremities decreases. Out of 22 limbs with stage IV of chronic ischemia of the lower extremities, 15 (81.5% of cases) managed to preserve the supporting function. In all 20 cases with stage IV chronic ischemia of the upper extremities, it was possible to maintain the functional state of the limb.

Keywords: arterial steno-occlusion; critical ischemia; stimulation of regional circulation; re-vascularizing osteotrepanation

Introduction

Peripheral arterial obliterating disease occurs in 3-5% of the population. In 35-65% of patients with chronic obliterating diseases, critical ischemia of the lower extremities (CILE) develops [1-4].

The main methods of treatment for CILE are direct methods of revascularization: open reconstructive surgery, endovascular storage (stenting, balloon angioplasty), and hybrid operations [5, 6]. Despite the high efficiency of percutaneous balloon transluminal angioplasty, it is not always possible to perform direct methods of revascularization in distal lesions of the arteries, and in such cases, indirect methods of revascularization are successfully used: revascularizing osteotrepanation (ROT), lumbar sympathectomy (LSE), gene therapy, autologous bone marrow cell transplantation, spinal neurostimulation [7-14]. Despite the ambiguous attitude to the

revascularization capabilities of the operation, ROT can be used as an attempt to prevent high limb amputation. The combined use of ROT with reconstructive surgery, endovascular receptacles, lumbar sympathectomy, and gene therapy significantly improves treatment outcomes [9, 11, 14-16]. Clinical, morphological, biochemical, and Doppler studies indicate the pathogenetic validity of the use of ROT in the treatment of patients with CILE with distal arterial lesions [16, 17, 20, 21]. There are isolated reports of the efficacy of repeated rot in patients with lower and upper limb CILE [18, 19].

Objective

To study the results of repeated revascularizing osteotrepanation in patients with critical ischaemia of the upper and lower extremities in order to prevent major amputations.

Material and Methods

The study was carried out in 27 patients with critical ischemia (CI) of the lower and upper extremities who were on inpatient treatment in the Department of Vascular Surgery of the Scientific Center of Surgery named after Academician M.A. Topchubashev. The age of the patients ranged from 27 to 76 years. 12 women and 15 men. The etiological cause of the development of CI was thromboangiitis obliterans (OT) in 9 patients, Raynaud's syndrome (disease) in 4 patients, obliterating atherosclerosis in 5 patients., obliterating atherosclerosis with concomitant type 2 diabetes mellitus in 9 patients. According to the Fontaine-Pokrovsky classification, 10 patients had stage III of chronic ischemia, and 17 patients had stage IV of chronic ischemia. The terms of repeated revascularizing osteotrepanation are from 3 months. up to 2 years after the first ROT.

The criteria for inclusion in the studies were [18, 19]: 1. Presence of a necrotizing wound in the distal part of the limb; 2. The presence of contraindications to open and endovascular methods of revascularization; 3. Lack of indications for high amputation of the limb. The exclusion criteria were: 1. The need to perform a high amputation; 2. The presence of indications for direct methods of revascularization; 3. Age over 75 years.

To diagnose and determine the degree of critical ischemia, as well as to assess the effectiveness of repeated ROT, clinical ultrasound examination in the form of duplex angioscanning, multispiral computer-tomographic (MSCT), peripheral angiography was performed, rheographic index (RI), skin oxygen saturation (SOC) was determined. The causes of the development of CI in the upper extremities were OT, Raynaud's syndrome (disease) and atherosclerosis with concomitant type 2 diabetes mellitus. And in the lower extremities - OT, atherosclerosis and atherosclerosis with concomitant type 2 diabetes mellitus.

Results

In all the examined patients, there was no pulsation of the arteries of the lower leg and forearm on the affected limb during the examination in a typical place. According to the data of ultrasonic Doppler ultrasound, all examined patients had pronounced disorders of blood flow through the arteries of the lower leg and forearm. monophasic Doppler curve with a significant decrease in the peak systolic velocity of blood flow.

MSCT-peripheral angiographic examination revealed mainly polysegmental hemodynamically significant stenosis and occlusions and distal disorders of blood flow in the affected limb.

In order to stimulate regional circulation in the upper extremities, a second operation of ROT of the ulna and radius was performed in 11 patients in both upper extremities diagnosed with thromboangiitis obliterate (4), atherosclerosis on the background of type 2 (3) diabetes mellitus, Raynaud's disease (4) (22 limbs). In 7 (31.8%) limbs, stage III was diagnosed and in 15 (68.2%) limbs – stage IV of chronic ischemia. Three osteotrepanation holes with a diameter of 3 mm were made in the radius and ulna. In 4 patients, repeated rotation was performed 3 times as the critical ischemia progressed again at different times after the previous rot. Upper extremity ROT surgery was performed under general anesthesia. During inpatient treatment, skin temperature increased by 27.3% ($p< 0.05$), skin

oxygen saturation by 24.6% (p<0.05) and rheographic index by 32.7% (0.005), and ischemic pain relief in all patients. In 3 (20.0%) extremities, the necrotic wound on the fingers healed, in 5 (33.3%) soft tissue necrectomy was performed, in 7 (46.7%) cases - minor amputations at the level of the fingers. Amputation at the level of the forearm was not performed and thus the functional state of the upper extremities was preserved (Table 1).

Limb / ***Outcomes***	***Upper limb (n=15)***	***Lower limb (n=27)***
Wound healing	3(20,0%)	7(25,9%)
Necrectomy	5(33.3%)	6(22,2%)
Minor amputations	7(46,7%)	9(33,3)
Amputation of the forearm / lower leg	-	5(18,5%)

Table 1: Results of repeated revascularizing osteotrepanation in patients with stage IV chronic ischemia of the upper and lower extremities.

To stimulate collateral blood flow in the lower extremities in 16 patients (thromboangiitis obliterans-5, atherosclrosis -5, atherosclerosis with concomitant diabetes mellitus type 2-6) in both lower extremities (32 limbs), a second operation of tibial rot was performed. In 5 (15.6%) limbs, stage III was diagnosed and in 27 (84.4%) limbs – stage IV of chronic ischemia. The operations were performed under spinal anesthesia. Standard trauma drills were used for the operation. Along the anterolateral and anteromedial surfaces of the tibia, 6 transcortical holes with a diameter of 5 mm were drilled to the medullary canal. Repeated tibial rotation was performed 2 times in 4 patients, 3 times in 3 patients, and 4 times in 2 patients at different times after the primary rot During the period of inpatient treatment, an increase in skin temperature by 25.6% (p< 0.05), skin oxygen saturation by 32.4% (p<0.05) and rheographic index by 34.3% (0.05), and relief of ischemic pain in all patients were noted. In 7 (25.9%) limbs, the necrotic wound healed, in 6 (22.2%) limbs, soft tissue necrectomy was performed, in 9 (33.3%) limbs - minor amputations (amputation of fingers, disarticulation of the fingers with resection of the distal part of the metatarsal, metatarsal amputation), in 5 (18.5%) - due to the progression of critical ischemia, amputation was performed at the level of the upper third of the tibia (major amputation). In 22 (81.5%) cases with stage IV chronic ischemia, the supporting function of the limb was preserved.

In addition to repeated ROT and surgical debridement of necrotic foci, all examined patients received drug treatment, which was complex and pathogenetically substantiated.

The results obtained showed that repeated ROT 3 months to 2 years after the previous operation provides a more stable and long-lasting revascularizing effect than ROT performed once. But this effect is noted in those patients who do not have gross trophic disorders of soft tissues and therefore have a certain reserve for the growth of vascular collaterals.

Discussion

In order to explain the learned results, the following assumption can be made: With mechanical action on the bone, first of all, the vascular network of the damaged area is activated due to intensive invasion of vessels both into the medullary spaces and into the vascular channels of the cortical plate, then the growth of blood vessels in the nearby soft tissues of the limb is noted. Bone injury leads to an increase in the formation of a number of osteotropic hormones and cyclic nucleotides, f also to intensify all types of metabolism in the tissues of the limb and increase the efficiency of the immune system. Stimulation of regenerative processes in the tubular bones of the lower leg and forearm leads to an increase in muscle revascularization due to an increase in the volume of the microcirculatory bed and the growth of new collaterals. [17, 21] The effectiveness of all these processes is significantly limited in the presence of pronounced trophic disorders in the soft tissues of the limb.

The results obtained confirm the opinion expressed in the literature that all of the above effects are enhanced by repeated rotation of the tibial and forearm bones in patients with CI [19, 20].

It should be noted that the revascularized effect of ROT develops slowly, but can be maintained at a sufficient level for a long time if patients have reserve capabilities of collateral blood flow. Over time, after revascularization, patients continue to increase collateral circulation [21].

Conclusion

1. Repeated rotation of the tibia, radius and ulna provides an improvement in the effectiveness of complex treatment of patients with recurrent critical ischaemia by reducing the frequency of high amputations of the upper and lower extremities. Out of 22 limbs with stage IV of chronic ischemia of the lower extremities, 15 (81.5% of cases) managed to preserve the supporting function extremities.
2. Repeated rotation of the tibia, radius and ulna should be carried out taking into account the reserve capabilities of collateral blood flow without deep, irreversible changes in soft tissues.

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