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LEVEL SELECTION OF NON-TRAUMATIC LOWER EXTREMITY AMPUTATIONS IN PATIENTS WITH CRITICAL ISCHEMIA

Вибір рівня нетравматичної ампутації нижньої кінцівки у пацієнтів з критичною ішемією

Abstract

Purpose of the study. To evaluate the informativeness of ultrasound scanning of the lower limb arteries and angiography in patients with critical ischemia for choosing the optimal level of extremity amputation.

Materials and methods. Treatment of 289 patients with obliterative diseases of the arteries of the lower extremities of various genesis with the indications for amputation of the damaged lower extremity was analyzed.

Results. Ultrasound scanning of arteries could not always characterize the severity of collateral circulation, but indicated only the level of occlusion. However, the severity of chronic ischemia of the lower limb is determined not only by the level of occlusion, but also by the severity of collateral blood flow at the same level of damage. That is why, in our opinion, the results of an ultrasound examination of the lower limb arteries cannot be decisive when choosing the level of amputation. Angiography made it possible to characterize not only the level of occlusion or stenosis, but also the state of collateral circulation, which had a decisive influence on the choice of the method of limb amputation.

Conclusion. Ultrasound examination of the lower extremity vessels allows to establish the level of occlusion, but is uninformative for the assessment of collateral anastomoses, which is an important factor in choosing the level of non-traumatic amputation of the lower extremity. In patients with critical ischemia, transtibial amputations should be avoided, as they show worse results. The operation of choice should be a transfemoral amputation or non-traumatic through-knee amputation.

Реферат

Мета роботи. Оцінити інформативність ультразвукового сканування артерій нижніх кінцівок та ангіографії у пацієнтів з критичною ішемією для вибору оптимального рівня ампутації кінцівки.

Матеріали та методи. Ми провели аналіз лікування 289 пацієнтів з облітерувальними захворюваннями артерій нижніх кінцівок різного генезу, які потребували ампутації ураженої нижньої кінцівки.

Результати. Ультразвукове сканування артерій не завжди могло схарактеризувати вираженість колатерального кровообігу, а вказувало тільки на рівень оклюзії. Однак, тяжкість хронічної ішемії нижньої кінцівки визначається не тільки рівнем оклюзії, а й вираженістю колатерального кровотоку при однаковому рівні ураження. Саме тому, на нашу думку, результати ультразвукового обстеження артерій нижньої кінцівки не можуть бути визначальними при виборі рівня ампутації. Ангіографія дозволяла схарактеризувати не тільки рівень оклюзії чи стенозу, а й стан колатерального кровообігу, що визначально впливало на вибір методу ампутації кінцівки.

Висновки. Ультразвукове обстеження судин нижніх кінцівок дозволяє встановити рівень оклюзії, однак є неінформативним для оцінки колатеральних анастомозів, що є важливим чинником вибору рівня нетравматичної ампутації нижньої кінцівки. У пацієнтів з критичною ішемією слід уникати проведення транстибальних ампутацій, які демонструють гірші результати. Операцією вибору повинна бути

Keywords: *ultrasound examination, angiography, transfemoral amputation, below-knee amputation, through-knee amputation.*

трансфеморальна ампутація або нетравматична наскрізна ампутація коліна.

Ключові слова: *ультразвук, ангіографія, трансфеморальна ампутація, транстібіальна ампутація, наскрізна ампутація коліна.*

INTRODUCTION

One of the most difficult issues in lower extremity surgery is the selection of the level of amputation in patients with critical ischemia due to diabetes or obliterative atherosclerosis. It should be mentioned that in case of injuries of the lower limb the level of primary amputation is determined individually, with an assessment of tissue damage, the probability of the patient's survival and the possibility of his subsequent prosthetics. However, when determining the level of non-traumatic amputation, it is necessary to take into account many more indicators (the clinical picture of ischemia, the results of various special research methods, regional vascular reserve, trunk and collateral blood circulation in the limbs, microcirculation and tissue trophic). The final level of amputation in these patients is often established only intraoperatively, after a visual assessment of the degree of blood supply to the crossed muscles [1, 2].

It should be noted that a significant proportion of patients with critical ischemia treated in surgical hospitals are people with widespread gangrene or intermuscular phlegmons of the distal parts of the lower limbs, which often makes it impossible to perform operations ideal for healing the postoperative wound and subsequent prosthetics.

Hence, the importance of developing methods allows for objectifying the choice of the optimal level of amputation with the aim of maximally reducing this level without increasing the risk of early purulent-necrotic postoperative complications is understood [3, 4]. These complications are the result of excessively «economical» amputation, when the line of excision of the limb falls on tissues with impaired tissue metabolism and insufficient oxygenation, therefore, it is important to develop diagnostic methods which would help determine the «ideal» level of amputation [5, 6].

PURPOSE OF THE STUDY

To assess the informativeness of ultrasound scanning of the lower limb arteries and angiography in patients with critical ischemia for choosing the optimal level of limb amputation.

MATERIALS AND METHODS

We analyzed the treatment of 289 patients with obliterative diseases of the arteries of the lower extremities of various genesis with the

indications for amputation of the damaged lower extremity (Table 1). The criteria for the inclusion of patients in the study were: informed consent of the patients, age 18 years and over, clinical and instrumental signs of tissue necrosis of the lower extremity, consultation of a vascular surgeon stating the impossibility of performing open or endovascular revascularization, the expected level of limb amputation above the foot. Exclusion criteria were: malignant neoplasms, breastfeeding or pregnancy, acute complications of diabetes, severe chronic renal dysfunction, neurasthenia, inappropriate behavior. Patients underwent the following necessary examinations: general blood test, biochemical analysis, coagulogram, electrocardiogram with the consultation of a therapist, ultrasound and X-ray examination of the arterial bed of the lower extremities, consultation of a vascular surgeon.

RESULTS

The preoperative choice of the level of amputation was based on the data of the ultrasound research method. This made it possible to determine the level of segmental occlusion, severity of stenosis of main vessels and regional blood flow disorders. In most patients, multifocal and polysegmental lesions of the arteries of the lower extremities with a probable ($< 0,001$) predominance of the tibial segment were noted (Table 2). Single plaque ($< 25\%$) probably ($p = 0,003$) occurred more often in aa. profunda femoral (B5) and superficial femoral (B6). Multiple stenosis ($\leq 50\%$) was not probably diagnosed more often, multiple stenosis ($> 50\%$) more often ($p = 0,026$) and occlusion was diagnosed more often from level a. popliteal (B7) and below. All examined patients probably ($p < 0,001$) had blood flow disorders in aa. popliteal, anterior tibial, peroneal and posterior tibial (B7–10).

It is known that chronic arterial ischemia of various segments of the arterial system of the lower extremities always leads to the formation of compensatory collateral intrasystemic anastomoses (between the branches of one large artery) and intersystemic anastomoses (between the branches of several large arteries). Ultrasound scanning of arteries could not always characterize the severity of collateral circulation, but indicated only the level of occlusion. However, the severity of chronic ischemia of the lower limb is determined not only by the level of occlusion, but also by the severity of collateral blood flow at the same level

of damage. That is why, in our opinion, the results of an ultrasound examination of the arteries of the lower limb cannot be decisive when choosing the level of amputation.

In order to determine preoperatively the likely level of amputation, a computed tomography study of the arterial bed of the lower limb was additionally performed. This examination, unlike ultrasound angioscanning, made it possible to characterize not only the level of occlusion or stenosis, but also the state of collateral circulation, which fundamentally influenced the choice of the method of limb amputation.

Discussion. Based on the clinical examination and analysis of ultrasound and angiographic examination results, the following tactical approaches were proposed.

With occlusion or hemodynamically significant stenosis of the abdominal aorta and aa. common iliac, external iliac, internal iliac (B1, B2, B3, B4), collateral blood flow in patients was provided through intersystemic anastomoses between the branches of these arteries and the arteries that departed from a. internal iliac. Transfemoral (above-knee) amputation was performed in patients with such blood flow changes.

With occlusion of a. profunda femoral (B5), below the level of its bifurcation, branches of a. profunda femoral were anastomosed with the branches of aa. popliteal, anterior tibial, peroneal and posterior tibial, which made it possible to fully compensate for blood flow at the level of the thigh, and choose through-knee amputation, achieving good wound healing, even if a. popliteal pulsation is absent.

With occlusion of a. popliteal (B7), intersystemic anastomoses were formed between the vessels of the knee joint and a. anterior tibial. The posterior tibial muscle group in these patients retained a blood supply from the collateral network between

the knee joint arteries and the branches of a. profunda femoral. In these patients, the operation of choice should be through-knee amputation.

With occlusion of all arteries of the distal part of the tibial segment (B8, B9, B10), blood flow in the arteries of the foot was also not noted. Given the peculiarities of the collateral blood flow in the lower leg, the operation of choice in these patients remained a through-knee amputation.

Our experience of performing amputations in conditions of impaired blood flow in the lower limb allows us to assert the impracticality of performing below-knee amputation in patients with critical ischemia. Anastomoses in the middle and lower third of the lower leg in case of damage to the tibial vessels (B8, B9, B10) in the upper third were much weaker than anastomoses in the middle and lower third of the thigh in case of damage to the femoral artery (B5, B6). Analysis of angiograms showed that with occlusive lesions of the tibial segment, ischemia of the distal parts of the leg and foot is severe, and collateral blood flow does not allow adequate perfusion. Regardless of the method of below-knee amputation (Ertl technique, Burgess-Romano, Roehampton, guillotine, etc.), the ischemic skin flap in these patients does not allow wound healing by primary tension. There is a high risk of suture failure in below-knee amputation in case of impaired blood flow in the arteries below the knee, which causes the appearance of chronic wounds of the amputation stump, prolongs the terms of inpatient and outpatient treatment, requires re-amputations and makes prosthetics of the patient impossible for a long time. In these conditions, through-knee amputation is a more optimal operation than below-knee amputation. However, Spittler, Albino or Mazet methods are quite traumatic and we are inclined to VPA procedure, which does not involve removing the knee cap and the articular surface of the femur.

Table 1

Characteristics of patients included in the study (n = 289)

Demographic and clinical markers	Indicator (n = 289)
Men/Women	54/235
BMI > 30	36 (12,5%)
Diabetes	173 (59,9%)
HIER	181 (62,6%)
CHD	209 (72,3%)
AH	231 (79,9%)
CE	147 (50,8%)
ASA-I	35 (12,1%)
ASA-II	144 (49,8%)
ASA-III	101 (34,9%)
ASA-IV	9 (3,1%)

Note: BMI – body mass index; HIER – history of ineffective revascularization; CHD – coronary heart disease; AH – arterial hypertension; CE – circulatory encephalopathy; ASA – classification for assessing the physical status of a patient by the American Society of Anesthesiologists (ASA), 2020

Characteristic of damage to the lower extremity arteries according to ultrasound examination (n = 289) and computer angiography (n=175) (according to the Bollinger classification)

	B1-4	B5-6	B7-10	χ^2 (p)
SP (US)	12 (19,1%)	17 (14,5%)	10 (5,6%)	11,25 (0,003)
SP (CT)	22 (12,5%)	21 (12,0%)	18 (10,3%)	0,48 (0,785)
χ^2 (p)	10,17 (0,001)	4,64 (0,031)	7,79 (0,005)	
MS \leq 50% (US)	18 (28,6%)	25 (21,4%)	46 (25,6%)	1,28 (0,528)
MS \leq 50% (CT)	13 (7,4%)	11 (6,3%)	18 (10,3%)	2,02 (0,364)
χ^2 (p)	0,10 (0,756)	0,55 (0,456)	2,45 (0,117)	
MS > 50% (US)	11 (17,5%)	43 (36,7%)	56 (31,1%)	7,23 (0,026)
MS > 50% (CT)	25 (14,3%)	57 (32,6%)	68 (38,8%)	27,94 (< 0,001)
χ^2 (p)	15,29 (< 0,001)	19,15 (< 0,001)	20,14 (< 0,001)	
O (US)	21 (33,3%)	32 (27,3%)	68 (37,7%)	3,46 (0,177)
O (CT)	40 (22,9%)	43 (24,6%)	71 (40,6%)	16,12 (< 0,001)
χ^2 (p)	21,86 (< 0,001)	13,68 (< 0,001)	14,29 (< 0,001)	

Note: SP – single plaque (< 25%); MS – multiple stenosis; O – occlusions; US – ultrasound; CT – computer tomography; χ^2 – Pearson's chi-squared test; p – p-level (significant level); B1-10 – Bollinger level

CONCLUSION

1. Ultrasound examination of the lower extremity vessels allows to establish the level of occlusion; however, it is uninformative for the assessment of collateral anastomoses, which is an important factor in choosing the level of non-

traumatic amputation of the lower extremity.

2. In patients with critical ischemia caused by impaired blood flow in the arteries below the knee, below-knee amputation should be avoided due to poorly defined collateral blood flow system. The operation of choice should be transfemoral (above-knee) amputation or through-knee amputation.

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