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ULTRASOUND EXAMINATION CRITERIA FOR THE CHOICE OF SURGICAL TREATMENT IN PATIENTS WITH OBLITERATING ATHEROSCLEROSIS OF THE LOWER EXTREMITIES

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Abstract. *Introduction.* Critical ischemia of the lower extremities is a major indication for primary reconstructive surgery, since only restoration of the main blood flow can preserve the limb and improve the quality of life of patients [1, 3]. But in 17 - 70% of patients with critical ischemia, due to the lesion of the distal vascular bed, there are no conditions for performing reconstructive operations, which causes a high frequency of primary limb amputation - up to 25 - 90% [6, 9].

Purpose. To study and analyze ultrasound duplex scan data of the lower extremity arteries in order to select the optimal method for deep femoral artery reconstruction.

Materials and methods. The results of a comprehensive examination and surgical treatment of 182 patients who were operated at the vascular surgery department of the Zakarpattya Regional Clinical Hospital named after Andriy Novak were studied and analyzed (from 2000 to 2017), regarding critical ischemia based on the obliterating atherosclerosis of the lower extremities vessels.

Results. Based on the data obtained by ultrasound duplex scan of the lower extremity arteries, the main diagnostic criteria of the pathology were identified. The indications for the implementation of various methods of profundoplasty were determined.

Conclusions. Ultrasound duplex scan of the lower extremity arteries is the optimal non-invasive method for determining the indications for various methods of profundoplasty. The main ultrasound criteria include the degree, extent of stenosis, plaque density, and deep-popliteal index, which allow us to select patients for profundoplasty and to choose the optimal method for reconstruction of the deep femoral artery.

Keywords: lower extremity vessels obliterating atherosclerosis, deep femoral artery, ultrasound duplex scan of lower extremity arteries, profundoplasty.

Ультразвукові критерії дослідження для вибору оперативного лікування хворих із приводу облітеруючого атеросклерозу судин нижніх кінцівок

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Резюме. *Вступ.* Критична ішемія нижніх кінцівок є основним показом до первинної реконструктивної операції, оскільки лише відновлення магістрального кровоплину може зберегти кінцівку та покращити якість життя пацієнтів [1, 3]. Але у 17 – 70% хворих із критичною ішемією, внаслідок ураження дистального судинного русла, немає умов до виконання реконструктивних операцій, що обумовлює високу частоту первинної ампутації кінцівки – до 25 – 90% [6, 9].

Мета дослідження Вивчити та проаналізувати дані ультразвукового дуплексного сканування артерій нижніх кінцівок для вибору оптимального методу реконструкції глибокої артерії стегна.

Матеріали та методи. У роботі вивчено та проаналізовано результати комплексного обстеження та хірургічного лікування 182 хворих, яких прооперовано у відділенні судинної хірургії Закарпатської обласної клінічної лікарні ім. Андрія Новака від 2000 до 2017 року з приводу критичної ішемії при облітеруючому атеросклерозі судин нижніх кінцівок.

Результати досліджень. На основі отриманих даних ультразвукового дуплексного сканування артерій нижніх кінцівок були виділені основні діагностичні критерії патології та визначені покази до виконання різних методик профундопластики.

Висновки. Ультразвукове дуплексне сканування артерій нижніх кінцівок є оптимальним неінвазивним методом для визначення показань до різних методів профундопластики. До основних ультразвукових критеріїв слід віднести ступінь, протяжність стенозу, щільність бляшки та величину глибокостегно-



во-підколінного індексу, що дає змогу відібрати пацієнтів для профундопластики та вибрати оптимальний спосіб реконструкції глибокої артерії стегна.

Ключові слова: облітеруючий атеросклероз нижніх кінцівок, глибока стегнова артерія, ультразвукове дуплексне сканування артерій, профундопластика.

Introduction

Critical ischemia of the lower extremities is a major indication for primary reconstructive surgery, since only restoration of the main blood flow can preserve the limb and improve the quality of life of patients [1, 3]. But in 17 - 70% of patients with critical ischemia, due to the lesion of the distal vascular bed, there are no conditions for performing reconstructive operations, which causes a high frequency of primary limb amputation - up to 25 - 90% [6, 9]. Absence of conditions for the reconstruction of atherosclerotic occlusion-stenotic lesions of the femoral and popliteal segment causes the surgeons to develop and implement indirect surgical techniques aimed for improving of the collateral sympathectomy, decompression osteoperforation of the tibia, tissue transplantation on the vascular leg [7, 8].

Purpose

To study and analyze ultrasound duplex scan data of the lower extremity arteries in order to select the optimal method for deep femoral artery reconstruction.

Materials and methods

The results of a comprehensive examination and surgical treatment of 182 patients who were

operated at the vascular surgery department of the Zakarpattya Regional Clinical Hospital named after Andriy Novak were studied and analyzed (from 2000 to 2017), regarding critical ischemia based on the occlusive-stenotic lesions of the femur-popliteal-tibial segment caused by obliterating atherosclerosis of the lower extremities vessels. All patients underwent ultrasound duplex scanning (ultrasound) of the lower extremity arteries with color mapping of blood flow prior to surgery. Studies were performed on the devices: ALOKA 3500 (Japan) with linear transducer 8-10 MHz, ESAOTE MY LAB 50 (Italy) with linear transducer 8 - 12 MHz and ZONARE (USA) with linear transducer 8 - 10 MHz, TOSHIBA APLIO 400 (Japan) with linear transducer 8 - 10 MHz.

The ultrasound protocol included visualization of the lower extremity arteries (general, superficial and deep thigh arteries, subclavian artery, descending knee artery anterior and anterior tibial arteries and tibial artery), establishment of the diameter of the arteries, complex media; presence of atherosclerotic plaque, its length; degree of stenosis; cartogram of blood flow (color flow corresponds to the true diameter of the vessel) and spectrogram of blood flow (Fig.1).

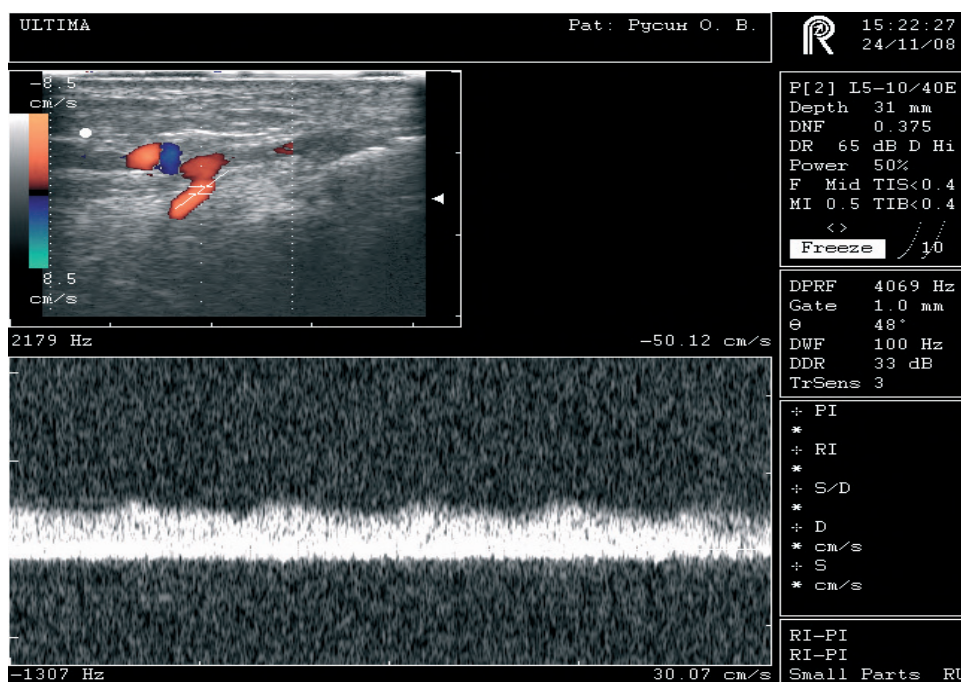


Fig. 1. Ultrasound duplex scan of the popliteal artery

The collateral blood flow along the descending artery of the knee with occlusion of the popliteal artery was preserved.

Quantitative blood flow parameters were obtained by spectral Doppler study. The following tests were evaluated:

1. peak systolic velocity (PSV) of blood flow;
2. peak end-diastolic velocity (PEDV)
3. resistance index(RI);
4. pulsatility index (PI);
5. systolic-diastolic correlation (SDC)
6. flow velocity(FV)

Functionality of revascularization of the deep femoral artery was determined by the Profuna popliteal collateral index (PPCI) using the following formula:

$$PPCI = \frac{AN - BN}{BN}$$

PPCI= regional systolic pressure in the popliteal artery above the knee , AN - regional systolic pressure in the popliteal artery above the knee, BN - pressure in the popliteal artery below the knee.

In case of maintained patency of the popliteal and tibial arteries, the value of this indicator is in the range of 0.2-0.3, and with occlusion of these arteries, it significantly increases. A PPCI value above 0.4 indicates an increase in the resistance of the circulatory system and weak functional reserves of deep femory atery [7, 10].

The degree of stenosis in the lower extremity arteries was determined by the diameter of the vessel. The level of stenosis was determined using

the Sossman et al. Velocity criteria in violation of atherosclerotic plaque imaging (2007 y.).

These criteria are based on the measurement of PSS at the site of stenosis and the ratio of PSV at the stenosis location and velocity at a point located 1-2 cm more proximal of the site of stenosis in the unaffected segment.

Ultrasound scanning necessarily assessed the suitability of a large subcutaneous vein for plastic. Investigation should be performed in the transverse and longitudinal scanning planes. The vein patency was evaluated by its compression, color mapping and registration of the Doppler curve. The diameter of the vein on the thigh and lower leg was measured. The large subcutaneous vein was considered suitable for shunting with a diameter of ≥ 4 mm, without varicose transformation, with the condition of patency of the deep veins of the lower extremity.

Results

PSV in critical stenosis in the deep artery of the hip should be greater than 400 cm / s, according to Sossman et al., which we cannot agree with [4]. The normal PSV index in the deep thigh artery is 52.6 ± 11.3 cm / s [5]. At deep femoral artery stenosis, more than 75% of PSV at the stenosis location should be > 200 cm / s (Fig. 2). At the same time, according to AA Guch, at hemodynamically significant stenosis of femoral deep artery the PSV date begins with 180 cm / s and more in the stenosis zone [2].

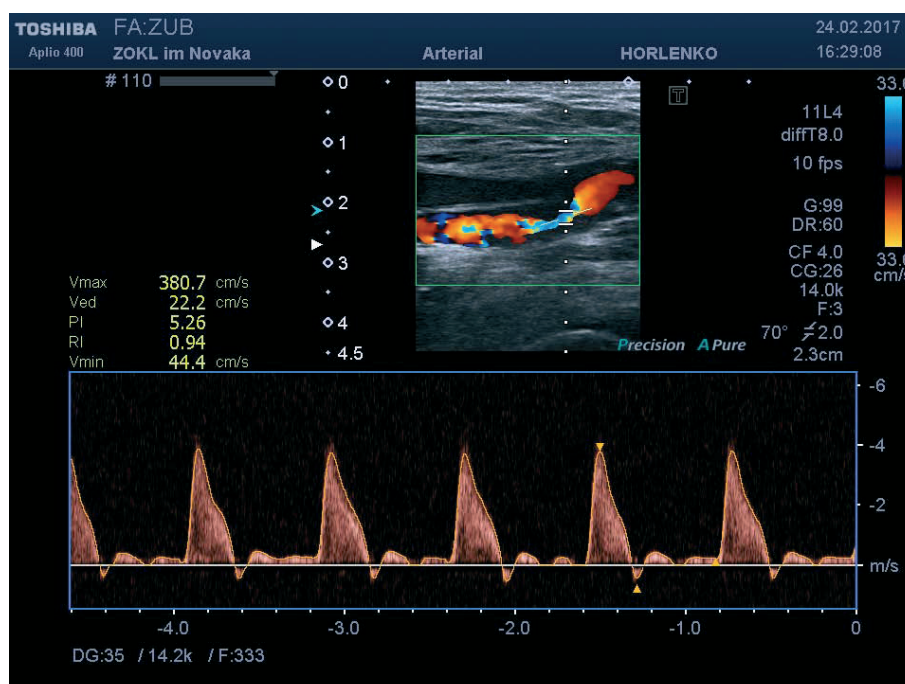


Fig. 2. Ultrasound duplex scan of the deep hip artery



Spectral analysis: peak systolic velocity increase and stenosis greater than 70% over 1.5 cm in length.

In determining the hemodynamically significant disorders of the distal blood flow, the greatest decrease of all parameters has been established (PSV, PPCI) along with increase

in the blood flow volumetric rate in grade IV ischemia of the lower extremity. Decrease of the above indicators testified to decompensation of collateral flow in the tibial arteries (anterior and posterior rotating tibial arteries, ATA, PTA) at a critical ischemia of the lower extremities (Table 1).

Table 1

Changes in ultrasound data depending on the degree of lower extremity ischemia

Parameter	ATA		PTA	
	ischemia degree		ischemia degree	
	III-B	IV	III-B	IV
V_{ps} , cm/c	$18,5 \pm 2,4^{1)}$	$14,2 \pm 1,8^{2)}$	$20,1 \pm 2,5^{2)}$	$17,2 \pm 2,4^{1)}$
V_{ed} , cm/c	$3,8 \pm 1,2^{1)}$	$3,3 \pm 1,4^{2)}$	$4,5 \pm 1,4^{2)}$	$3,7 \pm 1,3^{1)}$
PI, cond. unit	$2,92 \pm 0,6^{1)}$	$3,58 \pm 0,5^{2)}$	$2,9 \pm 0,6^{2)}$	$3,6 \pm 0,5^{1)}$
V_{vol} , ml/min	$15,2 \pm 3,3^{1)}$	$20,1 \pm 2,7^{1)}$	$15,3 \pm 3,3^{2)}$	$19,8 \pm 2,7^{2)}$
PPCI	$0,28 \pm 0,11^{3)}$	$0,23 \pm 0,1^{3)}$	$0,29 \pm 0,11^{3)}$	$0,26 \pm 0,1^{3)}$

Note: ¹⁾ $p \leq 0,05$; ²⁾ $p \leq 0,01$; ³⁾ $p \leq 0,01$;

We considered the results of the examination of the prosthodontic surgery, based on the results of the ultrasound examination:

- the presence of local occlusion of the occlusion or stenosis of the deep femoral artery more 70 %;
- occlusion of superficial femoral artery, diffuse occlusal-stenotic lesion of the popliteal artery and arteries of the tibia;
- increase in PSV in the stenosis site above 200 cm / s according to ultrasound of the arteries lower extremity
- profunda popliteal collateral index within 0,2-0,3;
- **PPCI** less than 0,45;
- Deep hip artery diameter not less than 4 mm with patency of distal parts and presence of collateral connections with the popliteal artery and the arteries of the leg and foot

In our opinion, the following are the general criteria for the choice of the method of profundoplasty: 1) degree of stenosis; 2) length of stenosis; 3) density of atherosclerotic plaque; 4) patency of the descending knee artery; 5) patency of the arteries of the foot, where the individual criteria are the length, degree of stenosis, and atherosclerotic plaque density.

The adequate endarterectomy cannot be performed in order to be safe to perform bypass surgery with dense atherosclerotic plaques.

One of the important problems in planning the type of reconstruction in occlusal-stenotic lesions of the arteries of the femur-popliteal-tibial segment is the assessment of blood flow on collateral branches and the condition of the arteries of the leg, occlusion which creates obstacles for adequate blood flow to the distal divisions of the extremities and is the cause of the negative results of the bypass surgery.

The deep femoral artery is an important arterial branch that provides collateral flow in occlusal-stenotic lesions of the arteries of the thigh-popliteal and tibial segment. In this segment of the lesion to the main collaterals can be attributed to the descending branch of the lateral bony artery of the hip and piercing arteries of the deep artery of the hip. They anastomose with the upper and lower knee arteries, the calf arteries, the anterior and posterior rotating tibial arteries (ATA, PTA). Therefore, we think that prolonged profundoplasty to the third piercing artery (distal 10 cm from the inflow) in elderly patients is justified. The methods of profundoplasty include the following techniques:

1. Open endarterectomy with an autovenous patch.
2. Open endarterectomy with auto-arterial patch.
3. Open endarterectomy with allopatch.
4. Hip - femoral and femoral autovenous prosthesis.
5. Hip - femoral and femoral allo prosthesis or shunting.
6. Profundoplasty with an arterial insertion by Waibel;
7. Distal femoral artery bifurcation with thrombendarterectomy and intravenous patch or without.

Spectral Doppler study provides objective quantitative information on the presence and nature of changes in local and systemic geodynamics, state of backbone and collateral bloodflow. Ultrasound duplex scan of the main arteries is a non-invasive method of diagnosis, which is worthy of competition with angiography. The qualitative and quantitative indicators of blood flow are evaluated in the analysis of outcomes. The qualitative characteristics of the Doppler spectrum include the shape of the envelope of the Doppler

spectrum, the localization of the maximum of the spectral distribution, the presence and expression of the spectral window. Thus, it is possible to determine the type of artery (with low or high peripheral resistance), the degree of functional activity of the organ supplying the artery, the presence, nature and degree of local hemodynamic shift and systemic hemodynamic disorders in vascular lesions, type of flow (laminar, turbulent) the presence of local disorders of hemodynamics. The hemodynamically significant stenosis of the deep artery of the hip corresponds to a level of more than 75% and the PPCI at the place of stenosis should be more than 200 cm / s.

Conclusion

Ultrasound duplex scanning of the lower extremity arteries is the optimal non-invasive method for determining indications for various methods of profundoplasty. The main ultrasound criteria include the degree, extent of stenosis, plaque density, and deep-popliteal index, which allow us to select patients for profundoplasty and to choose the optimal method for reconstruction of the deep femoral artery.

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