Research Article

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The Algorithm for the Study of Deep Femoral Vessels Using Ultrasound Duplex Angioscanning

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ABSTRACT The deep femoral vessels are the main branches/donor vessels of the femoral vessels. Their branches penetrate the entire array of muscles of the posteromedial group and descend almost to the popliteal region, so they are able to both largely compensate for blood flow disorders in obliterating atherosclerosis of the arteries of the lower extremities, and in the presence of an anastomosis with the popliteal vein, influence the course of acute and chronic vein diseases. The modern standard for studying the vascular system of the lower extremities is duplex scan, but it allows deep femoral vessels to be examined only in the ostium segment up to 5–6 cm.

AIM OF STUDY To determine the patency and state of blood flow in the deep femoral vessels throughout the entire length using ultrasound duplex angioscanning.

MATERIAL AND METHODS The analysis of the results of 30 computed tomograms and 100 ultrasound scans of patients (aged 20 to 85 years) who underwent routine examination of the vascular system of the lower extremities in a polyclinic setting was carried out. The study was performed according to the original method (Patent for invention No. 2751819).

RESULTS In the upper third of the thigh, the deep femoral vessels are located most superficially, 2.3±0.15 cm from the skin surface and 0.5±0.08 cm from the posterior wall of the femoral artery. In the middle third of the thigh, the depth of the deep femoral vessels is 3.5±0.9 cm from the skin surface and 4.3±0.24 cm from the posterior wall of the femoral artery.

The deep femoral vessels are located between the vastus medialis and adductor longus muscles closer to the femur. In the lower third of the thigh, deep femoral vessels are located at a distance of 4.3±0.4 cm from the skin surface and 1.8±0.5 cm from the posterior wall of the femoral artery. Therefore, for ultrasound examination, a linear probe is first used, which is placed along the projection line of the femoral vessels in the upper third of the thigh, and then the orifice of the deep femoral vessels is visualized. Next, a convex probe is used, and in the middle and lower third of the thigh, it is drawn along a line located 2 cm medially to the projection line of the femoral vessels, while the probe itself deviates posteriorly by ~ 15°.

CONCLUSION The research algorithm helps increase the length of the areas of the deep femoral artery and vein available for research and help the physician choose the optimal method of treating the patient.

Keywords: algorithm, ultrasound duplex angioscanning, deep femoral vessels, deep femoral artery, deep femoral vein, computed tomography

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DFA - deep femoral artery
DFV - deep femoral vein
CT - computed tomography
CFA - common femoral artery
CD - color Doppler

INTRODUCTION

In the structure of all venous thrombosis, thrombosis in the system of the inferior vena cava accounts for more than 90% of cases [1]. Venous thrombosis of this location is the main source of pulmonary embolism, which occurs with a frequency of one case per 1000 population in the developed countries of the world and occupies one of the leading places in mortality among cardiovascular diseases, therefore, high-quality diagnostics is extremely important [2].

Thrombosis can occur anywhere in the deep veins of the lower extremities, but there are areas of typical and atypical location. In more than half of cases, thrombosis is localized in the deep veins of the leg, from where it can spread to the popliteal and femoral veins. This often happens when there are conditions for a violation of the hemodynamic factor in the form of a cessation of contraction of the calf muscles [3]. Parts of the venous system that are not involved in active venous return, such as the anterior tibial, fibular, plantar veins, and the deep femoral vein (DFV), can be classified as atypical location areas.

Another problem of vascular surgery is arterial thrombosis/embolism of the lower extremities, which surgical treatment is not always successful [3], due to the complexity of assessing the state of peripheral vessels, including the deep femoral artery (DFA).

The deep femoral artery (DFA) is the main branch of the common femoral artery (CFA) that originates from it 3–5 cm below the inguinal ligament [4]. Its diameter is 5–7 mm and sometimes it is not smaller than femoral artery. Its branches are the medial and lateral arteries that envelop the femur, as well as the perforating arteries. The last two end branches anastomose with the popliteal artery, therefore, surgical interventions on the DFA in vascular surgery are of great importance and their effectiveness largely depends on an adequate assessment of the patency of the vessel [3, 5].

The deep femoral vein (DFV) is the main tributary of the femoral vein and is located 8–9 cm below the level of the inguinal ligament [4]. In venous return, its value is so great that it is equated with the value of the work of the femoral vein, and in the presence of floating thrombi in the femoral vein, its resection below the level of the confluence of the DFV is acceptable [6]; at the same time, it itself can be a source of blood clots [7].

The modern standard in the treatment of the vascular system of the lower extremities is ultrasound duplex scan [8–10]. However, with the help of ultrasound duplex scan, diagnostic algorithms have not been developed for all areas of the lower extremities; in addition, variant anatomy often complicates diagnosis [11]. It is believed that the DFV and DFA can only be examined in the near-ostium segment for 5–6 cm [12–15], while the total length of the vessels reaches 23–28 cm [1, 5, 16].

Therefore, **the aim of the study** was to determine the possibilities of ultrasound in diagnosing the state of deep femoral vessels and to create an algorithm for determining the patency and state of blood flow in the deep femoral vessels using ultrasound throughout.

MATERIAL AND METHODS

The analysis of the results of 30 computed tomographic (CT) angiograms and 100 ultrasound scans of patients (70 women and 60 men aged 20 to 85 years) who underwent a standard examination of the vascular system of the lower extremities in a polyclinic setting. The study was carried out according to the original method (Patent for Invention No. 2751819), which is described below. The ultrasound was performed on *Samsung Sonoace X*8, *Siemens Acuson Cypress*, *Siemens Acuson Sequoya* 512, *Saoyte My Lab Alfa devices*. We used linear transducers with a frequency of 7–13 MHz and convex transducers with a frequency of 2–5 MHz.

RESULTS AND DISCUSSION

In the topography of the deep femoral vessels three sections relative to the position of the femoral artery are normally distinguished:

1) Area of the femoral triangle: deep femoral vessels go in the vascular-muscular gap between the femoral vein from the inside and the iliopsoas with the initial part of the medial vastus muscle of the thigh, located outside. When the DFA origins from the posterior surface of the CFA, which occurs most often (60% of observations), it descends down, being located strictly below it. Only at the apex of the femoral triangle, it shifts outwards. In the rarest variant of DFA origin from the medial surface of the femoral artery (10% of cases), it is located between the CFA and the vein and behind them, then along the posterior wall of the CFA moves outward and exits at the top of the femoral triangle from under it. At the level of the apex of the femoral triangle, the deep femoral artery and vein are located closest — 2.3±0.15 cm to the skin surface and 0.5±0.08 cm from the posterior wall of the femoral artery (Fig. 1).

2) The anterior sulcus is a canal bounded on the inside by the vast medial muscle of the thigh, and on the outside by the long adductor muscle, and covered anteriorly by the sartorius muscle. The deep femoral vessels are located here under the femoral vessels and the sartorius muscle, between the vast medial muscle and the long adductor muscle of the thigh closer to the femur. The depth of the deep femoral vessels was 3.5±0.9 cm from the skin surface and 4.3±0.24 cm from the posterior wall of the femoral artery (Fig. 2).

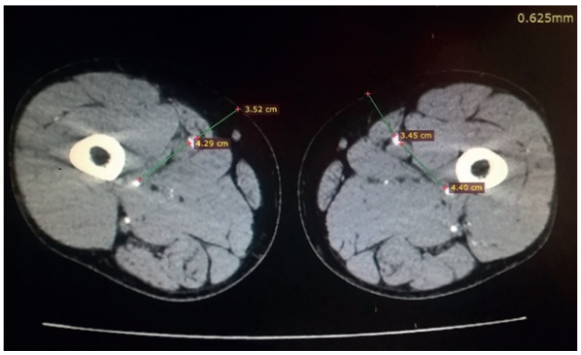

Fig. 1. CT angiogram, transverse section at the level of the upper third of the thigh

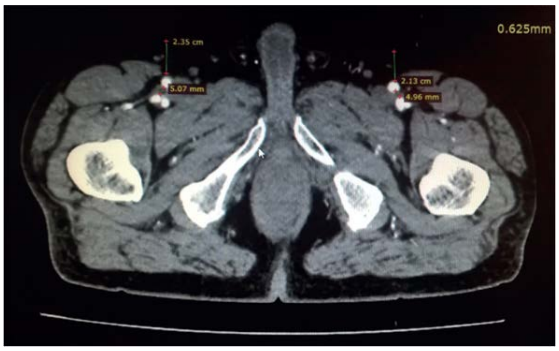

Fig. 2. CT angiogram, transverse section at the level of the middle third of the thigh

3) The final section of the deep femoral vein artery is the third or fourth perforating vessels located between the tendons of the long and large adductor muscles. The depth of the deep femoral vessels is 4.3±0.4 cm from the skin surface and 1.8±0.5 cm from the posterior wall of the femoral artery (Fig. 3).

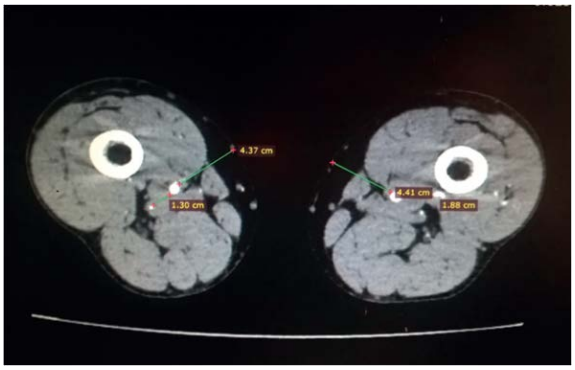

Fig. 3. CT angiogram, transverse section at the level of the lower third of the thigh

Thanks to this topography, the deep femoral vessels, the artery and vein, are protected from external influences, so they are much less likely to be affected [4], but it is precisely this that creates difficulties in diagnosing, since the depth of the vessels does not allow using the standard algorithm for diagnosing deep femoral vessels [7, 8, 11].

The standard technique for ultrasound of the femoral arteries and veins involves the use of a linear probe. DFA and DFV are well located only directly in the area up to 5 cm adjacent to the bifurcation of the femoral vessels [8–10]. When analyzing the literature in *the eLibrary*, *Pubmed* and *Scopus* databases, we did not find any works that would assess the state of blood flow in the deep femoral vessels below this level using ultrasound.

However, the need for this is confirmed by cases of thrombosis of the popliteal vein without the possibility of visualizing the proximal border of a thrombus in the superficial femoral vein and emboli at the level of branches of the second and third order in the DFA [1, 17, 18].

Therefore, on the basis of the obtained CT angiograms and comparison with the data of topographic anatomy, an algorithm for studying the state of blood flow in the deep femoral vessels using ultrasound was built (Patent for invention No. 2751819). The study of deep vessels of the thigh is carried out in the position of the patient lying on his back. First, a linear sensor is placed along the projection line of the femoral vessels in the upper third of the thigh, the mouth of the deep femoral arteries and veins is visualized (the place where the DFA origins from the CFA and the place where the DFV flows into the femoral vein). Next, a convex sensor is used, in the upper third of the thigh, scanning is carried out along the projection line of the femoral vessels, and in the middle and lower third of the thigh, the sensor is scanned along a line located ~2 cm medially to the projection line of the femoral vessels, while the sensor itself is deflected posteriorly by ~15° (Fig. 4). The veins are compressed, the patency of the arteries is assessed (Fig. 5).

This algorithm makes it possible to visualize deep femoral vessels, firstly, through the use of a convex probe, which makes it possible to examine structures at a depth of up to 20 cm, and secondly, due to its location in the intermuscular space medially from the sartorius muscle, which allows increasing the penetrating power of ultrasound .

Using this method for assessing the state of blood flow through the deep femoral vessels, 100 patients were examined; it was possible to assess the state of blood flow in the deep femoral arteries and veins in all cases: according to the results of the examination, hemodynamically significant stenoses in the DFA were detected in 6 patients, emboli distal to the mouth of the DFA were revealed in 2 cases, DVT thrombosis was revealed in 7 patients.

Fig. 4. The position of the convex probe when examining deep femoral vessels in the middle and lower third of the thigh

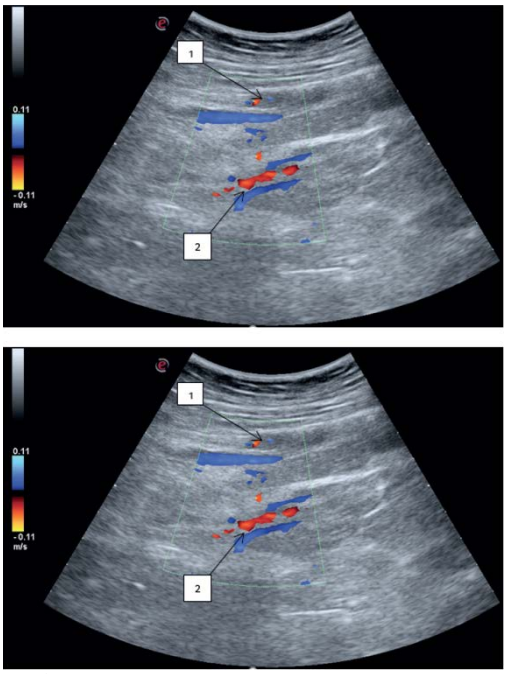

Fig. 5. Angioscanogram of the femoral and deep femoral vessels (color Doppler mapping mode). 1, superficial femoral vessels; 2, deep femoral vessels at the level of branches of the second level

Clinical case 1

Patient A., 58 years old, came to see a vascular surgeon with complaints of swelling of the left lower limb. Upon examination: the left tibia is +3 cm, the thigh is +1 cm relative to the diameters of the right tibia and femur, positive symptoms of Moses, Homans are determined. According to ultrasound: on the left side, the femoral vein, the great saphenous vein, the small saphenous vein are patent, the compression is full.

In the lumen of the posterior tibial veins and the popliteal vein, hypoechoic thrombotic masses are determined. Due to the fact that the proximal border of the thrombus ended at the level of location of the anastomoses with the DFV, it was decided to evaluate its patency. During the examination, a thrombus was detected in the DFV with a proximal border at the level of the middle third of the thigh with signs of flotation over a length of 22.6 mm (Fig. 6).

Due to the fact that the patient had venous thrombosis with signs of flotation, he was hospitalized in the Department of Vascular Surgery.

Clinical case 2

Patient A., 59 years old, consulted a vascular surgeon with complaints of pain in the right lower limb when walking more than 200 meters. In history, a year ago, he underwent a femoropopliteal bypass above the knee joint gap with a synthetic prosthesis on the right. After the operation, the pulse was determined on the anterior and posterior tibial arteries, the pain-free walking distance was more than 500 m. About 3 months ago, the walking distance decreased to 200 meters, and he did not go to the hospital. Upon examination: the pulse is determined on CFA on the right, peripheral pulse on the left. According to ultrasound: CFA patency, blood flow through the femoral-popliteal shunt is not determined, heterogeneous thrombotic masses in the lumen.

In the DFA, 8 cm distal to the mouth, at the level of the branches of the second level, hemodynamically significant stenosis was determined in the main trunk of the DFA (Fig. 7). The diagnosis was: “Obliterating atherosclerosis of the arteries of the lower extremities. Post-thrombotic occlusion of the femoral-popliteal shunt, II b stage”. In connection with the identified changes in the DFA, X-ray endovascular dilatation of the DFA stenosis 8 cm distal to the mouth was indicated.

Fig. 6. Angioscanogram (B — mode and mode of color Doppler mapping): floating thrombus in the deep vein of the thigh with the proximal border of the thrombus at the level of the middle third of the thigh. floating part length ~ 22mm

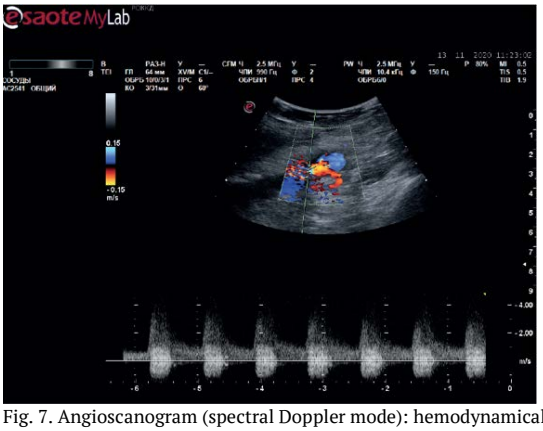

Fig. 7. Angioscanogram (spectral Doppler mode): hemodynamically significant stenosis at the level of the second branch of the deep femoral artery

CONCLUSIONS

1. The proposed algorithm helps increase the length of the areas of deep femoral vessels accessible for examination — the deep femoral artery and deep femoral vein.

2. The data obtained can significantly adjust the tactics of patient management.

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