REVIEW PAPERS

Popliteal artery aneurysm

Tętniak tętnicy podkolanowej

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KEYWORDS:

- popliteal artery
- aneurysm
- limb ischemia

ABSTRACT

Popliteal artery aneurysms are the most common peripheral artery aneurysms and occur significantly more commonly in men than in women. Popliteal aneurysms often coexist with other vascular pathologies – especially with aneurysms of a different location. The most common etiopathogenesis is atherosclerosis, rarely are caused by connective tissue diseases (Marfan's syndrome, Becket's disease) or infection. Uncomplicated popliteal aneurysms are often asymptomatic, only large-diameter aneurysms can be palpated as a pulsating tumor in the popliteal fossa. Complications of a popliteal artery aneurysm are a significant problem – most often thrombosis of the popliteal artery or peripheral embolism causing ischemia or compression on adjacent structures (popliteal vein, tibial nerve), while popliteal artery aneurysm rupture is very rare. Treatment of popliteal artery aneurysms includes endovascular implantation of a covered stent/stentgraft and open reconstruction with the use of an artificial vascular prosthesis made or the patient's native vessel. The method of surgical treatment depends on many factors – the diameter, length, and location of the aneurysm, neck kinking, the presence of a thrombus, compression on the adjacent structures, and patency of the outflow arteries and is selected individually. The results of planned operations of popliteal aneurysms are good and depend on the anatomical configuration of the aneurysm, coexisting vascular pathologies. Albeit the risk of limb amputation in the case of popliteal artery aneurysms triggering acute ischemia is significant and reaches 20%.

SŁOWA KLUCZOWE:

- tętnica podkolanowa
- tętniak
- niedokrwienie kończyny

STRESZCZENIE

Tętniak tętnicy podkolanowej są najczęstszym tętniakiem tętnic obwodowych i występują znacząco częściej u mężczyzn niż u kobiet. Tętniaki tętnicy podkolanowej często współwystępują z innymi patologiami naczyniowymi – najczęściej tętniakami o innym umiejscowieniu. Najczęstszą etiopatogenezą tętniaków tętnicy podkolanowej jest miażdżyca, znacznie rzadziej spowodowane są chorobami tkanki łącznej (zespół Marfana, choroba Becketa) lub zakażeniem. Niepowikłane tętniaki tętnicy podkolanowej często są bezobjawowe, jedynie tętniaki o dużej średnicy mogą być wyczuwalne jako tętniący guz w dole podkolanowym. Istotnym problemem są powikłania tętniaka tętnicy podkolanowej – najczęściej zakrzepica tętnicy podkolanowej lub zator obwodowy powodujące niedokrwienie lub ucisk na przylegające struktury (żyła podkolanowa, nerw piszczelowy),natomiast pęknięcie tętniaka występuje bardzo rzadko. Leczenie tętniaków tętnicy podkolanowej obejmuje wewnątrznaczyniowe wszczepienie stentu krytego oraz otwarte rekonstrukcje z wykorzystaniem protezy naczyniowej z tworzywa sztucznego lub własnego naczynia chorego. Sposób leczenia operacyjnego zależy od wielu czynników – średnicy i długości tętniaka, zagięcia szyi, obecność skrzepliny, ucisku na przylegające struktury, drożności tętnic podudzia i dobierany jest indywidualnie. Wyniki planowych operacji tętniaków tętnicy podkolanowych zależne są od konfiguracji anatomicznej tętniaka, współistniejących patologii naczyniowych, są dobre i zależą od konfiguracji anatomicznej tętniaka, współistniejących patologii naczyniowych. Jednak ryzyko amputacji kończyny w przypadków tętniaków powodujących ostre niedokrwienie jest znaczne i sięga 20%.

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Published and financed by Centre of Postgraduate Medical Education; https://doi.org/10.36553/wm.145.

Introduction

The popliteal artery supplies arterial blood to the lower leg and is a continuation of the superficial femoral artery. It begins at the level of the adductor hiatus and ends at the bifurcation into the posterior tibial artery and the tibioperoneal trunk. A popliteal artery aneurysm is defined as a focal artery dilation of more than 1.5 to 2 times. As the diameter of the popliteal artery ranges from 0.5 cm to 1.1 cm, it has been assumed that an aneurysm is diagnosed when the diameter of the artery exceeds 2 cm.

Treatment modalities for popliteal artery aneurysms have evolved over the centuries. The oldest surgical treatment technique was developed by a Greek physician, Antyllus, who lived in the 3rd century. He recommended opening and draining the contents of the aneurysm and then ligation of the popliteal artery above and below the lesion. A famous British surgeon, Bradford Wilmer, wrote in 1779 that he knew no successful case of such a procedure. In the second half of the 18th century, another English surgeon, Percivall Pott, recommended early amputation of the limb in cases of symptomatic popliteal artery aneurysms (1). Most historically described surgical techniques for a popliteal artery aneurysm were based on the assumption that, in some cases, collateral circulation may be sufficient to provide blood supply to the tissues of the lower leg and that radical management may prevent a patient's death. Hence, aneurysm ligation was recommended, yet there were some arguments about its technique. Pierre Joseph Desault performed distal ligation of an aneurysm, which was thought to increase the chances of leaving sufficient collateral circulation to preserve blood supply to the limb. Matrick Murrey, on the other hand, advocated ligation of the artery above an aneurysm. We have no reports confirming the performance of this type of surgery in the 18th century. The only reference comes from a lecture by a Scottish surgeon, John Hunter, who in 1785 performed 5 surgeries involving ligation of a popliteal artery in the proximal segment within unchanged tissue. Three patients survived the surgery (2). An analysis of 68 cases of a popliteal artery aneurysm dating back to the 19th century shows a mortality rate of 15%. At the end of the 19th century, the next step in the surgical treatment of popliteal artery aneurysms was the proposal by Rudolf Matas to open the aneurysm through a large incision and underpin collateral vessels "from the inside". At that time, surgeries were performed without anesthesia and disregarding antiseptic principles, deep in the tissues of the popliteal fossa, which was associated with a significant number of complications, wound infections, amputations and a high mortality rate. For this reason, various conservative treatment techniques were attempted. The aim of such treatment was to bring about the formation of a thrombus inside the aneurysm to reduce the risk of its growth or rupture. Various techniques were used to achieve this. The first one consisted of prolonged flexion of the limb at the hip and knee, which probably allowed for thrombus formation in the aneurysm lumen and preservation of the limb in about 50% of cases. Similar results were obtained with a proximally applied Esmarck bandage and direct compression of a popliteal artery aneurysm. What is noteworthy is a long period of limb flexion position or compression, which lasted an average of 12 days (1-49) (2).

Due to a high risk of inducing increased limb ischaemia in the case of popliteal artery aneurysm thrombosis, attempts were made in the 20th century to operate on it while leaving the popliteal artery unobstructed. In 1906, Rudolf Matas described 19 cases of successful aneurysmorrhaphy, a surgery involving the excision of a large portion of the aneurysm wall and its suturing (3). This laid the foundation for modern reconstructive surgery techniques. The saphenous vein was used to bypass the popliteal artery after an aneurysm incision, as described by Jose Goyanes in 1906 (Fig. 1) and James Pringle in 1915 (4). The first plastic vascular prosthesis was used by Clarence Crawford in 1957. The next step in the treatment of popliteal artery aneurysms was the introduction of endovascular techniques. The first endovascular management of a popliteal artery aneurysm was described by Michael Marin in 1994 (5).

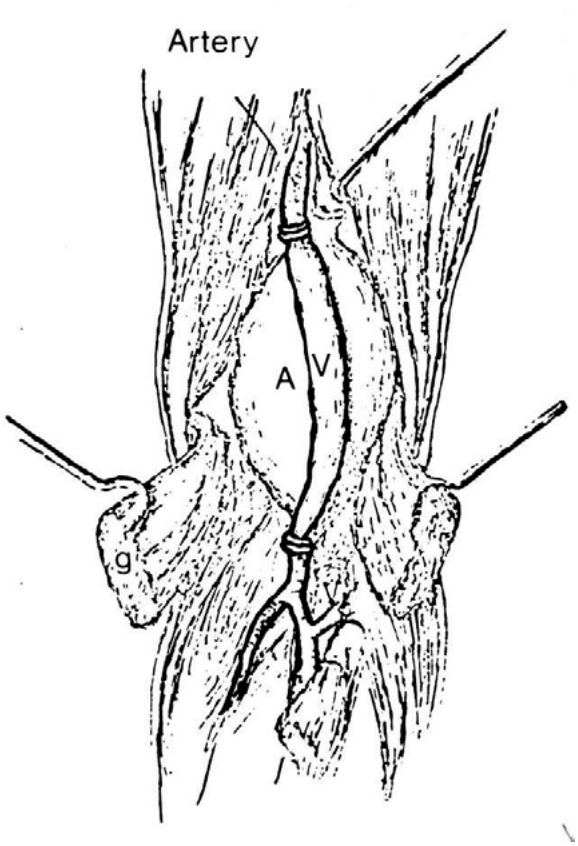


Figure 1. Management of a popliteal artery aneurysm with venous bypass – illustration from a 1906 publication by Jose Goyanes (4).

Epidemiology

Popliteal artery aneurysms are quite rare; nevertheless, they account for 70%-85% of all peripheral aneurysms. They are diagnosed almost 20 times more frequently in men than in women and affect approximately 1% of the male population aged 65-80 years (6). The incidence of popliteal artery aneurysms, like abdominal aortic aneurysms, appears to increase with the age of patients, but there are no screening studies describing this relationship in more detail. Popliteal artery aneurysms are divided into fusiform and saccular (asymmetric) aneurysms. Popliteal artery aneurysms most often co-occur with aneurysms of other locations and less frequently with other arterial pathologies. Analysis of ultrasound examinations of 251 men with abdominal aortic aneurysms (AAA) showed that 14% of them had concomitant femoral or popliteal artery aneurysms. No popliteal artery aneurysms were found among the 62 women with AAA (7). In his retrospective study, Thomas Dent found that 86% of patients with peripheral aneurysms had aneurysms

in another location. In this group of patients, 78% of patients with popliteal artery aneurysms were found to have coexisting aneurysms in another location – abdominal aortic aneurysms or iliac aneurysms in 64% and contralateral popliteal artery aneurysms in 47%. The incidence of abdominal aortic aneurysms in patients with popliteal artery aneurysms has been estimated at 40-50% in many reports (8, 9).

Aetiopathogenesis

The most common cause of popliteal artery aneurysms is atherosclerotic lesions. Aneurysms due to Marfan syndrome, Behcet's disease or infection occur rarely. Aetiopathogenesis of popliteal artery aneurysm formation is unknown. Results of molecular tests indicate concomitance of genetic defects, inflammatory processes and blood flow disorders, often associated with the presence of atherosclerotic stenosis of the popliteal artery. Reduced strength of the popliteal artery wall and increased blood pressure can lead to aneurysm formation.

Natural history and symptoms

Popliteal artery aneurysms cause impaired blood flow which promotes the formation of mural thrombi. It is estimated that the average increase in diameter of a popliteal artery aneurysm is 2.4 mm per year. The rate of increase in popliteal artery aneurysm diameter is significantly influenced by the coexistence of an abdominal aortic aneurysm. Average increase in popliteal artery aneurysm diameter in patients with concomitant AAA is 3.5 mm/year (range 2.9-4.9) and in patients without AAA it is 0.8 mm/year (range 0.1-1.5) (10). Like in the case of AAA, popliteal artery aneurysms with a larger diameter were characterized by a faster increase in size. Concomitant atrial fibrillation and the presence of a mural thrombus in the aneurysm sac have also been shown to be risk factors for a more rapid increase in diameter (11).

In most cases, popliteal artery aneurysms, especially those of small diameter, do not cause clinical symptoms. Larger diameter aneurysms may be palpable as an arterial lump in the popliteal fossa. Clinical symptoms appear when complications occur. These are usually the consequences of local compression of the growing tumor or ischaemia of the lower leg or foot. Rupture of a popliteal artery aneurysm is very rare. Compression symptoms include swelling of the limb caused by compression or thrombosis of the popliteal vein and paresthesias or pain in the limb caused by compression of the tibial nerve. Symptoms of limb ischaemia caused by the presence of a popliteal artery aneurysm may result from narrowing of the arterial lumen due to the growth of a mural thrombus and peripheral embolism caused by the thrombus or thrombosis of the aneurysm. The nature of ischaemic symptoms – acute or chronic – depends on the severity of the lesions, dynamics of their progression and presence of collateral circulation vessels. A characteristic symptom of the embolism of popliteal artery aneurysms is blue toe syndrome, resulting from embolisation of the arteries of the toe with fragments of mural thrombus released from the aneurysm sac. The onset of acute limb ischaemia as a result of popliteal artery aneurysm thrombosis or massive peripheral embolism produces the typical symptoms of acute limb ischaemia: pain, cooling, paleness of the limb, and absence of a pulse on the peripheral arteries. In advanced cases of ischaemia, muscle paralysis and the appearance of retrograde changes in the foot may occur. Acute ischaemia of the limb due to complications of a popliteal artery aneurysm has a poor prognosis due to a low number of collateral circulation vessels at the level of the knee joint, which are an alternative route of blood supply, and the loss of patency of the peripheral arteries. The risk of limb amputation in such a situation is estimated to be as high as 20% (12).

Asymptomatic popliteal artery aneurysms are thought to become symptomatic in 14% of patients per year (13). Only 32% of patients treated conservatively avoid complications during the 5-year follow-up period (14). The main

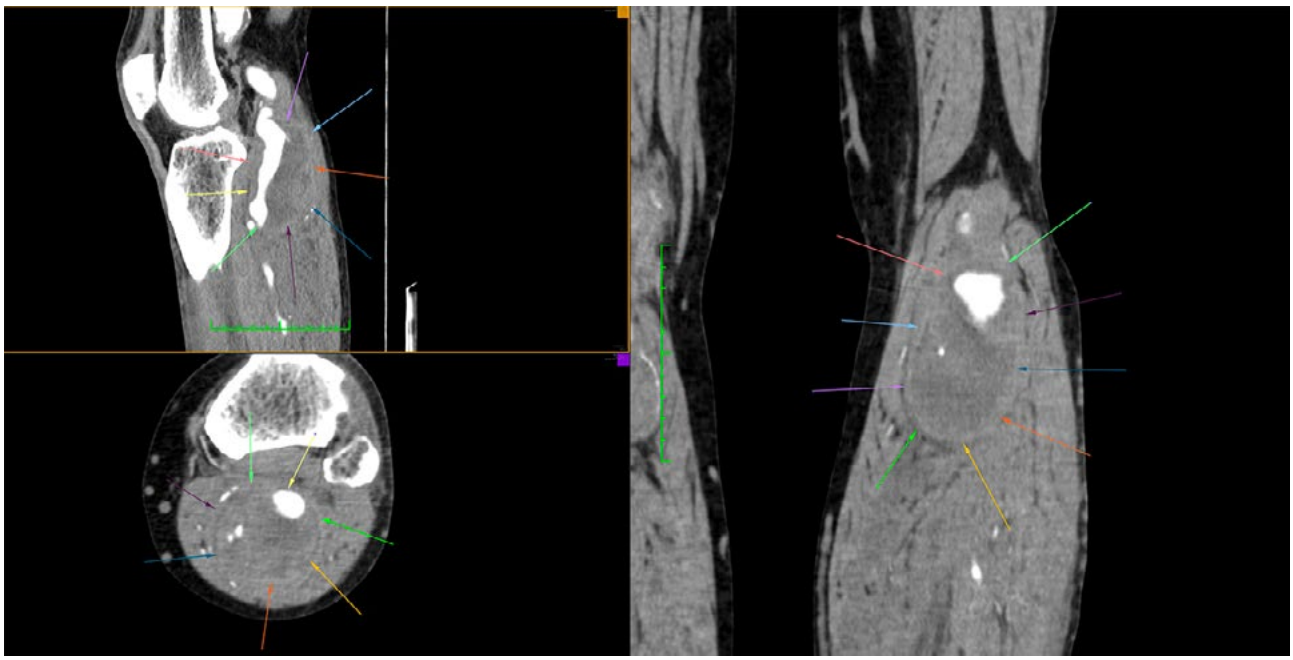


Figure. 2 Popliteal artery aneurysm in computed tomography angiography (arrows indicate the aneurysm wall).

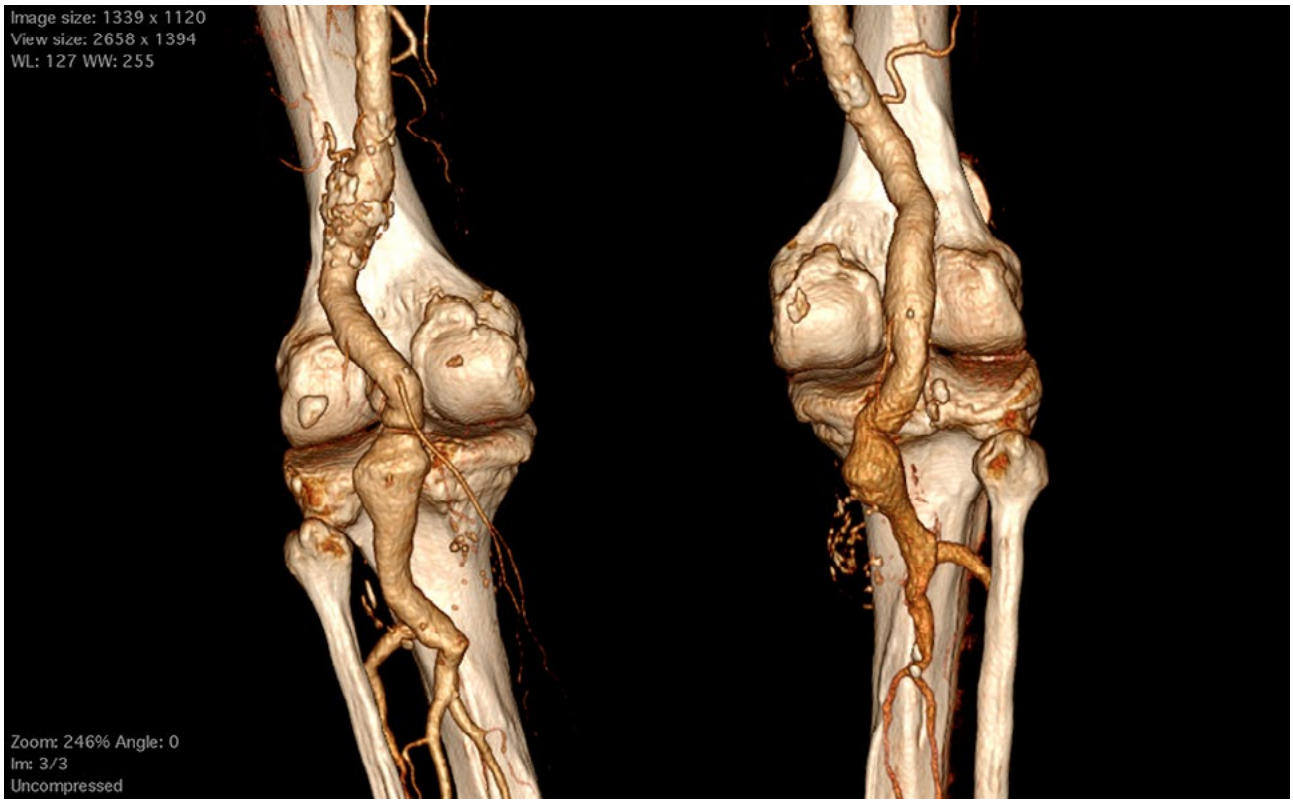


Figure. 3 Popliteal artery aneurysms. Computed tomography angiography.

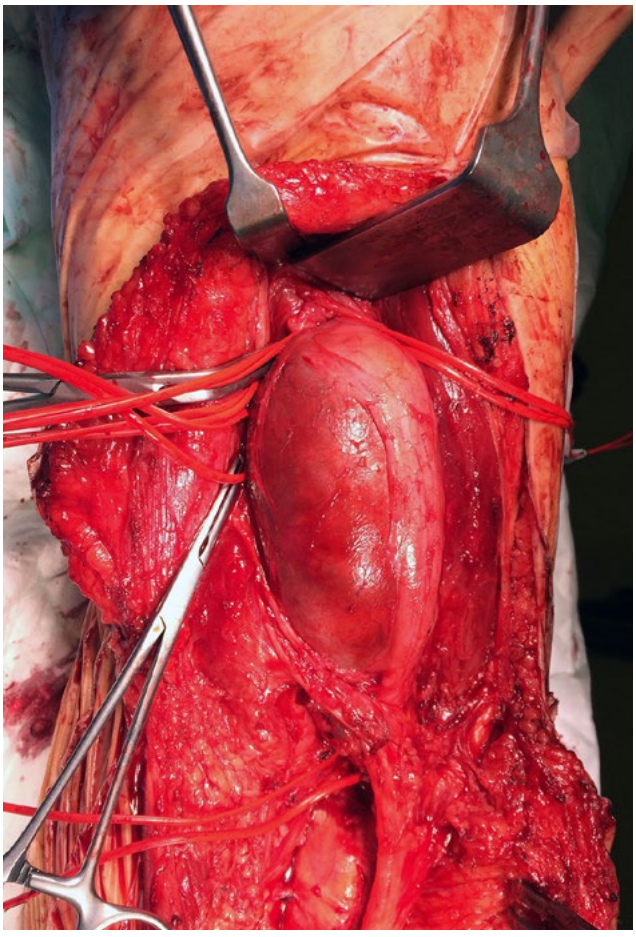


Figure. 4 Popliteal artery aneurysm intraoperative image.

Figure. 5 Intraoperative image. Status after the management of a popliteal artery aneurysm with insertion of a reinforced vascular prosthesis in polytetrafluoroethylene.

factors associated with the development of complications due to limb ischaemia are the diameter of an aneurysm and the degree of kinking of its neck. A median diameter for asymptomatic aneurysms is 2 cm (1.5-4.8 cm), for those causing acute ischaemia is 3 cm (1.4-4.6), and for those causing compression symptoms, it is 3.45 (3.0-5.6). It has not been possible to demonstrate whether the diameter of the aneurysm affects the likelihood of arterial thrombosis. The neck of proximal and distal popliteal artery aneurysms are usually immobile, and as the diameter of the aneurysm increases, its length and, thus, the degree of kinking increases. For asymptomatic aneurysms, a median degree of kinking is 0° (0°-90°); in patients with acute limb ischaemia, it is 60° (0°-180°), and in those with compression symptoms, it is 45° (45°-90°). As an aneurysm diameter gets bigger, the thickness of the mural thrombus in the aneurysm sac increases. However, it has not been possible to demonstrate a relationship between thrombus size and the likelihood of peripheral embolisation.

Diagnosis

On clinical examination of patients with suspected popliteal artery aneurysms, a pulsating tumor is sensed in the popliteal fossa. In all cases, the pulse on the posterior tibial artery and the dorsal artery of the foot must also be evaluated. Physical examination may detect popliteal artery aneurysms of medium and large diameter with a sensitivity of up to 60%. Differential diagnosis should include Becker's cyst, enlarged lymph nodes, varicose veins and cystic adventitial degeneration. Doppler ultrasonography is the imaging method of choice that can confirm the presence of a popliteal artery aneurysm. This examination can accurately determine the diameter of the aneurysm, its length, presence and size of a thrombus, neck kinking, possible stenosis of the artery and patency of popliteal arteries. Computed tomography angiography and, less commonly, magnetic resonance angiography should be performed on every patient qualified for surgery, as the images obtained make it possible to accurately assess an aneurysm and plan the procedure (Fig. 2, 3). The role of classical angiography in the imaging of popliteal artery aneurysms is currently limited only to pre- and intra- and post-operative assessment during endovascular procedures.

Treatment of popliteal artery aneurysms

Elective surgery of a popliteal artery aneurysm is indicated when the diameter exceeds 2 cm. Urgent and emergency indications include thrombus and aneurysm rupture.

Currently, surgical treatment of popliteal artery aneurysms includes endovascular implantation of a covered stent and open reconstructive surgery using prosthetic vascular prostheses or the patient's own vein. A surgical treatment method is selected, taking into account such factors as the diameter of the aneurysm, neck kinking, thrombus presence, the degree of compression of the surrounding tissues of the popliteal fossa and the length of the aneurysm. The first surgery performed on a patient with a popliteal artery aneurysm is femoropopliteal bypass via the medial approach described by Edwards in 1969. This technique, unfortunately, does not allow for full elimination of tissue compression of the popliteal fossa. Therefore, in the case of large aneurysms, posterior approach surgery is recommended (Fig. 4, 5). For both approaches, either the patient's native vein or a prosthetic vascular prosthesis can be used to bypass the popliteal arteries (15). Immediate and long-term results of the surgery show the advantage of bypasses from native vessels (16). The use of the saphenous vein ensures longer patency of the artery and also reduces the risk of infection (Fig. 6). In patients with symptoms of acute limb ischaemia, who are found to have aneurysmal thrombosis on clinical assessment and imaging exams, thrombolytic treatment can be used. Favorable results of initial thrombolytic treatment compared to bypass alone have been shown in patients with acute limb ischaemia and peripheral arterial thrombosis (17, 18). Endovascular treatment can be considered in aneurysms with preserved good blood flow to the arteries of the shin, with little neck kinking, a moderate diameter and long zones of an unchanged vessel. The zones of proximal and distal stent landing should be not less than 1.5 cm. The use of endovascular treatment brings substantial benefits in terms of shorter hospitalization time, shorter recovery and fewer complications (19). However, this technique does not eliminate tissue compression of the popliteal fossa. The early primary patency rate after popliteal artery aneurysm endovascular surgery is 84%, 60% at 5 years and 50% at 10 years of follow-up. Secondary patency is 98%, 71% and 60%, respectively. Unfortunately, after endovascular surgery with covered stent implantation, many complications in ling-term observation are observed. The most common include vascular access site complications, arterial thrombosis and stent migration and rupture (20). Endovascular treatment of popliteal artery aneurysms has also used a special type of multilayer stent that causes modulation of blood flow and reduction of blood pressure in the aneurysm sac. In a study describing this method of surgery, Ucci et al. demonstrated 100% technical success of the procedure. Aneurysm thrombosis was reported in 92.9% of cases, and inhibition of aneurysm diameter enlargement in 100% of cases. A decrease in aneurysm diameter was observed in 66% of patients. Primary patency was 95.7% after 1 month, 77% after 1 year and 70.1% after 2 years. Secondary patency was 100%, 90.3% and 90.3%, respectively (21) Tab. 1.

A comparison of the results of endovascular treatment with classical surgery shows that endovascular treatment

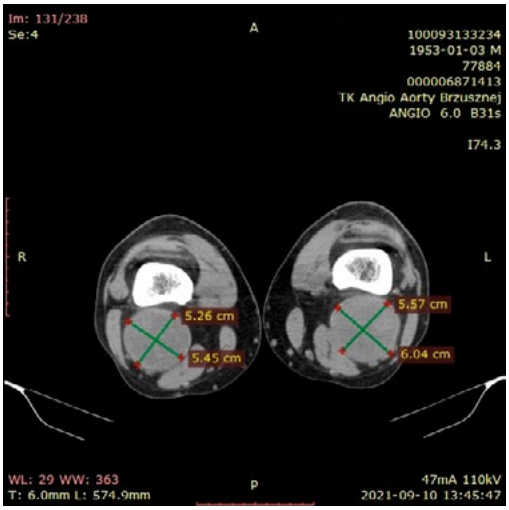
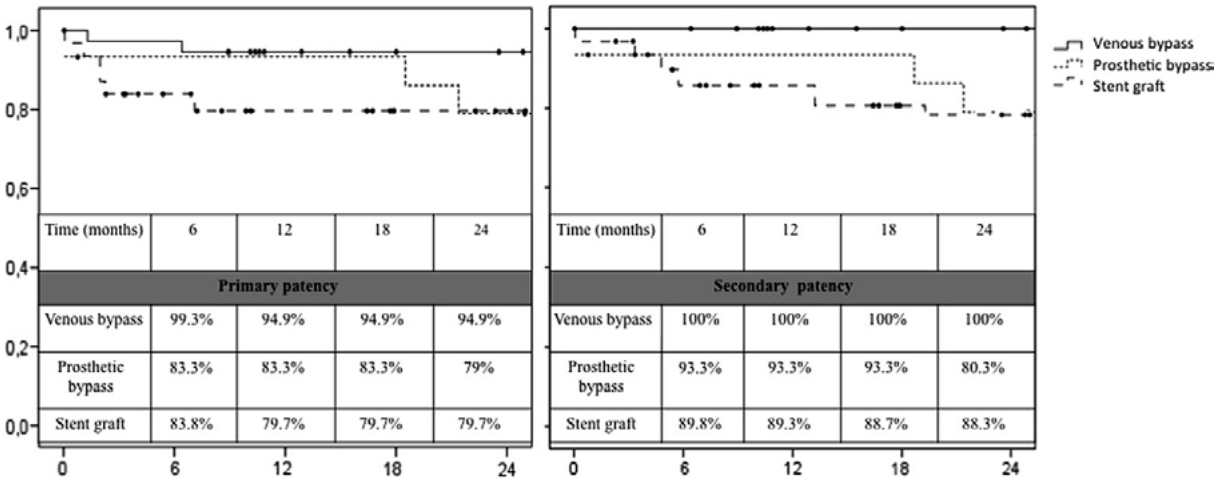


Figure. 6 Bilateral popliteal artery aneurysms. Computed tomography angiography.



Time (months)	6	12	18	24
Primary patency				
Venous bypass	99.3%	94.9%	94.9%	94.9%
Prosthetic bypass	83.3%	83.3%	83.3%	79%
Stent graft	83.8%	79.7%	79.7%	79.7%

Time (months)	6	12	18	24
Secondary patency				
Venous bypass	100%	100%	100%	100%
Prosthetic bypass	93.3%	93.3%	93.3%	80.3%
Stent graft	89.8%	89.3%	88.7%	88.3%

Table.1 Kaplan-Meyer Curve primary and secondary patency venous bypass, prosthetic bypass and stentgraft (24).

is associated with fewer local complications of wound healing and a shorter hospitalization period, at the expense of shorter primary patency but similar secondary patency over a 3-year follow-up period (22, 23).

The main risk factor for arterial thrombosis after popliteal artery aneurysm surgery is lower leg artery obstruction and impaired outflow from the popliteal artery (24). It seems to be particularly relevant in the case of using endovascular techniques. Therefore, in cases of poor anatomical conditions – aneurysm encompassing the outflow of the lower leg arteries, obstruction of one or two lower leg arteries – classical surgery is chosen as a treatment method.

Summary

Popliteal artery aneurysms are the most common peripheral artery aneurysms and occur significantly more commonly in men than in women. Popliteal aneurysms often coexist with other vascular pathologies – especially with aneurysms of a different location. The most common etiopathogenesis is atherosclerosis, rarely are caused by connective tissue diseases (Marfan's syndrome, Becket's disease) or infection. Uncomplicated popliteal aneurysms are often asymptomatic, only large-diameter aneurysms can be palpated as a pulsating tumor in the popliteal fossa. Complications of a popliteal artery aneurysm are a significant problem – most often thrombosis of the popliteal artery or peripheral embolism causing ischemia or compression on adjacent structures (popliteal vein, tibial nerve), while popliteal artery aneurysm rupture is very rare. Treatment of popliteal artery aneurysms includes endovascular implantation of a covered stent/stentgraft and open reconstruction with the use of an artificial vascular prosthesis made or the patient's native vessel. The method of surgical treatment depends on many factors – the diameter, length, and location of the aneurysm, neck kinking, the presence of a thrombus, compression on the adjacent structures, and patency of the outflow arteries and is selected individually. The results of planned operations of popliteal aneurysms are good and depend on the anatomical configuration of the aneurysm, coexisting vascular pathologies. Albeit the risk of limb amputation in the case of popliteal artery aneurysms triggering acute ischemia is significant and reaches 20%.

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