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Complications associated with the treatment of chronic limb-threatening ischemia

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The aim of the work is to review current national and foreign specialized literature on various complications associated with the treatment of chronic limb-threatening ischemia.

Atherosclerotic lesion of the lower limb arteries is the most common cause of tissue perfusion deficiency of the lower limbs and can lead to their loss. A radical method of treatment for chronic limb-threatening ischemia (CLTI) remains revascularization. Despite the modern possibilities of surgical treatment and many years of experience in such treatment, the percentage of surgical complications is still substantial.

The level of providing qualitative care to patients with CLTI consists in the successful correction of the mentioned complications. That is why the analysis of this problem is an urgent issue of modern angiosurgery.

Conclusions. Most complications after surgical treatment of atherosclerotic lower limb lesions could cause both a limb loss and a severe systemic disorder development in general. The presented data of the professional literature review of clinical and experimental studies justify the need for an early management of complications associated with surgical treatment of chronic limb-threatening ischemia. It would contribute not only to the limb preservation, but also prevent the occurrence of severe general somatic complications.

Ключові слова: хронічна загрозлива ішемія нижніх кінцівок, атеросклероз, інфекція ділянки хірургічного втручання, псевдоаневризма.

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Ускладнення, пов’язані з лікуванням хронічної загрозливої ішемії нижніх кінцівок

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Мета роботи – огляд сучасної вітчизняної та закордонної фахової літератури щодо різних ускладнень, пов’язаних із лікуванням хронічної загрозливої ішемії нижніх кінцівок.

Атеросклеротичне ураження артерій нижніх кінцівок – найчастіша причина дефіциту перфузії тканин нижніх кінцівок, що може спричинити їх втрату. Радикальним методом лікування критичної ішемії нижніх кінцівок залишається реваскуляризація. Незважаючи на сучасні можливості хірургічного лікування та багаторічний досвід такого лікування, відсоток ускладнень хірургічних втручань залишається високим. Рівень надання якісної допомоги пацієнтам із хронічною загрозливою ішемією нижніх кінцівок полягає у вдалій корекції названих ускладнень. Тому аналіз порушеної проблеми залишається актуальним у сучасній ангіохірургії.

Висновки. Більшість ускладнень хірургічного лікування атеросклеротичного ураження артерій нижніх кінцівок можуть стати причинами і втрати кінцівки, і виникнення тяжких системних розладів. Наведені в цьому огляді фахової літератури результати клінічних та експериментальних досліджень обґрунтовують необхідність своєчасного лікування ускладнень, пов’язаних із хірургічним лікуванням хронічної загрозливої ішемії, що сприятиме не лише збереженню кінцівки, але й запобігатиме виникненню тяжких загальносоматичних ускладнень.

Atherosclerotic lesions of major arteries in different basins and topographic areas can be the cause of various clinical manifestations of cardiovascular insufficiency. The following cardiovascular events can be distinguished in atherosclerosis: acute myocardial infarction (AMI) due to coronary artery lesions, ischemic type of acute cerebrovascular accident (ACA) due to carotid artery lesions, and chronic limb-threatening ischemia (CLTI) due to the occlusive-stenotic lesions of the major lower limb arteries. The prevalence of the latter pathology is approximately 11 % of the overall world population [1], and its social significance is due to the danger of mortality, disability as a result of amputations, and a considerable deterioration of the quality of life.

According to the 2D European Consensus, the criterion for diagnosing CLTI is the presence of pain at rest with a systolic pressure in the distal third of the lower leg of less than 50 mmHg and/or the presence of a toe systolic pressure of less than 30 mmHg, or with trophic changes in the soft tissues of the foot or toes with the same indicators of systolic blood pressure [2,3]. Atherosclerotic lesions of the lower limb arteries in more than 97 % of cases are the cause of the CLTI development [4,5]. Other causes of development include diabetic foot syndrome, peripheral thrombosis and embolism in atrial fibrillation, mitral valve defects, aneurysms of the aorta and iliac arteries, the consequences of mechanical trauma to the arteries, obliterating endarteritis, nonspecific aortoarteritis (Takayasu’s disease), obliterating thromboangiitis (Buerger’s disease) [6].

The clinical course of stages 4, 5, and 6 of CLTI according to the Rutherford classification (1986, 1997) requires surgical treatment by revascularization as soon as possible, as it reflects critical changes in tissues induced by ischemia. CLTI is an absolute indication for operative treatment, however, the possibility of preserving an ischemic limb is available in only half of patients with this diagnosis [7]. More than 75 % of CLTI patients undergo amputations or surgically restore adequate blood supply to the lower limbs during the first year after the diagnosis [8,9]. Reconstructive surgery makes it possible to preserve a limb with chronic threatening ischemia in 85 % of patients within a year after the operation. At present, the main highly effective method of surgical treatment, which allows to preserve the limb viability in patients with CLTI, is revascularization [10]. The most common types of revascularization include reconstructive surgery using autologous and synthetic materials, direct aortic reconstructions, and extraanatomic bypass surgery. Mini-invasive methods of reconstructive interventions are percutaneous balloon angioplasty and stenting [11]. Deep venous arterialization is considered as a rare type of reconstruction [12].

The choice of the revascularization method is determined by the peripheral artery condition: direct blood flow restoration through at least one of the distal arteries can ensure sufficient blood supply and quickly eliminate ischemia [13,14,15]. The arterial reconstruction success rate is greatly influenced by a lesion multifocality, a vascular damage degree, a degree of ischemia as an indication before surgery, a surgical intervention technique, a level of the distal anastomosis, and materials for bypass [16,17].

Modern angiosurgery can offer a wide arsenal of treatment methods to a patient with CLTI [18]. The majority of medical institutions in Ukraine and all over the world provide urgent and scheduled surgical care to patients with chronic pathology of the major arteries. Therefore, different clinical cases can be solved by different methods or a combination of them [19,20]. Anand Dayama and co-authors evaluated the treatment results of patients with damaged popliteal segment of the lower limb arteries using open surgery in comparison with endovascular surgery [21]. In turn, a group of authors from Helsinki University Hospital published the results of hybrid interventions in patients with multilevel damage and demonstrated excellent limb preservation rates at 30 days – 92 %, after 1 year – 91 %, and after 5 and 10 years – 86 % [22]. Without timely reconstructive surgery, the rate of high amputations is approximately 25 % within a year after diagnosis [1].

Despite the fact that the results of reconstructive vascular operations with modern capabilities have high efficiency indicators, complications that may occur after surgical interventions significantly worsen the early and long-term treatment results [18]. A large study by M. Kehlet and co-authors, which included 3202 operative procedures, has demonstrated that 921 patients (30 %) had complications of various genesis within 30 days. Among them, 583 people (19 %) developed complications in the wound area, 193 (6 %) – surgical complications, and 320 (10 %) – systemic complications [23].

Well-known complications of open reconstructive procedures are thrombosis and bleeding after reconstruction [24]. These complications are dangerous both for saving the limb and the patient's life and require immediate correction. Peripheral nerve damage and surgical site infection (SSI) should be mentioned as less dangerous complications of open intervention methods. Hence, results of a publication by Luke M. Stewart and co-authors are indicative of the risk factors for the development of local infectious complications after reconstructive surgical interventions for chronic threatening ischemia [25].

In the case of bleeding and increasing limb ischemia due to thrombosis following reconstruction, the patient is indicated for repeated reconstructive surgical intervention or an affected limb amputation in the absence of conditions for surgery [24]. In addition to surgical complications from reconstruction such as thrombosis and bleeding, among surgical complications of other genesis in patients after arterial reconstructive surgical interventions, peripheral nerve damage, intestinal obstruction, and visceral ischemia are documented [23].

Systemic complications include cardiac (AMI, severe arrhythmias, congestive heart failure), pulmonary (accompanied by respiratory failure and requiring medical correction), acute renal failure (which may require replacement therapy by hemodialysis), transient ischemic attack or ACA, deep vein thrombosis and multiple organ failure syndrome [26,27].

Postoperative wound complications are grouped into non-infectious and infectious genesis.

Lymphatic and ischemic complications are among the non-infectious complications of the postoperative wound. Lymphatic complications include lymphocele and lymphorrhea, and ischemic complications comprise marginal necrosis of the postoperative wound [28,29]. Authors describe various local types of surgical wound complications. Thus, S. East (2013) highlights seroma, marginal skin necrosis, superficial wound infiltrate, superficial wound suppuration, lymphorrhea, lymphocele, infected hematoma, wound margin failure, and deep wound suppuration [30].

A structure analysis of the postoperative complications by the time of occurrence has shown more characteristic complications in the early postoperative period (1–5 days) such as marginal necrosis, superficial wound suppuration, and lymphorrhea [31]. The formation of a hematoma in the wound area followed by infection is associated with a hemostasis violation [32]. Improper care of the wound-edge skin and its intraoperative traumatization in conditions of tissue ischemia can cause the development of marginal skin necrosis [33]. Lymphatic complications after reconstructive operations on the lower extremity arteries range from 1.5 % to 8.1 % [34]. Lymphorrhea develops as a result of lymph node or vessel injuries in surgeries and is observed, mainly, after interventions on the femoral artery, which is associated with the localization of large lymphatic collectors in the groin region [28]. In postoperative lymphorrhea, there are acute (the first 7 postoperative days), subacute (up to 3 weeks) and chronic stages with the formation of a lymphocele itself, the main difference of which is the presence of a lymphatic cavity with a connective tissue capsule [34].

As a result of significant traumatization to soft tissues, in particular, a dissection of lymphatic vessels, a straw-colored serous fluid accumulates in the wound within the subcutaneous adipose tissue followed by the formation of seroma [35]. Clinical features of seroma manifest within 2–3 days post-surgery, patients complain of unpleasant sensations in the wound area, sometimes the appearance of slight pain and low-grade fever; an almost painless infiltrate is detected to palpation [36].

The surface infiltrate of a postoperative wound is formed after 3–6 days resulting from a prolonged phase of hydration, which is manifested by accumulation of serous or serous-fibrinous effusion in tissues with a painful mass formation. The borders of the infiltrate reach 5–10 cm from the wound edges [37]. A frequent complication is a wound edge failure which significantly prolongs the postoperative period, thereby delaying wound healing [27].

Both superficial and deep wound suppuration in most patients is caused by critical ischemia of calf and foot tissues (necrosis, trophic ulcers, gangrene) [9,38].

In the long term, the most frequent complications are lymphocele, local infiltrate and deep infection of the postoperative wound site with a damage to the synthetic vascular reconstruction and the development of erosive bleeding. All cases of erosive bleeding were noted within 1 to 24 months [39]. Deep suppuration of a wound involving a vascular prosthesis is one of the most serious complications and often has an unpredictable outcome [40].

Clinical signs of superficial suppuration of wounds are multi-vectored, but common to them is limitation of the infectious process by soft tissues to the fascia of the thigh or lower leg [41]. Deep suppuration of the wound, spreading deeper than the fascia, is characterized by more pronounced clinical symptoms. In addition to the noticeable general clinical picture, a tense, hyperemic and painful area of the postoperative wound is observed locally [42].

Insufficiently controlled hemostasis and an overdose of anticoagulants cause the formation of postoperative hematomas, which become a good breeding ground for microorganisms, especially in conditions of blood accumulation in the subcutaneous fat tissue with subsequent formation of infected hematomas [43].

With the advent of modern methods of surgical treatment for CLTI, new complications have appeared in the vascular surgeons practice [44]. Thus, the most frequent complications of endovascular procedures are artery wall dissection with resulting artery thrombosis or artery perforation with hematoma development [45]. A frequent local complication of minimally invasive interventions on the lower extremity arteries is the development of a pseudoaneurysm in the area of femoral artery puncture [46]. Dzijan-Horn M. and co-authors have noted an increase in the number of pseudoaneurysms up to 6 % and associated such a high rate with a significant increase in minimally invasive interventions, as well as with an increased availability of diagnostic methods allowing the detection of such complication [47]. A group of authors from Magdeburg, led by Maria Stolt, urges not to underestimate pseudoaneurysms as the latter pose a significant risk to patients [48].

Addressing the complications of minimally invasive interventions often requires hybrid solutions. In particular, artery dissection can be eliminated by stent implantation or by open surgical reconstruction. Thrombotic complications also require restoration of blood flow through revascularization. Extravasation of blood with the development of a hematoma requires drainage [49].

An approach to the management of patients with a pseudoaneurysm in the area of arterial puncture is somewhat varied [50]. There are conservative methods of eliminating the mentioned complication: ultrasound-guided local compression of pseudoaneurysms, false lumen embolization, endograft placement in an artery defect area, and ultrasound-guided thrombin injection into pseudoaneurysms. The latter method requires strict control, because the injection of a thrombin solution into the artery lumen will lead to arterial thrombosis. Thus, a group of authors from Kielce has described the experience of treating 353 patients with postpuncture pseudoaneurysms, among them, 53 patients (15 %) had microembolization of the distal arterial bed, followed by further development of acute ischemia, and one patient (0.3 %) had venous thromboembolism [51].

Ultrasound-guided pseudoaneurysm compression is a simple, cost-effective, and safe method of treating postcatheterization pseudoaneurysms of the femoral artery. The rate of successful pseudoaneurysm lumen thrombosis has been reported to be approximately 75–98 % [50]. Until recently, this method was the first choice for iatrogenic pseudoaneurysms of the femoral artery. Under ultrasound control, the neck and pseudoaneurysm can be observed during compression. The location of the pseudoaneurysm neck should be carefully assessed before compression. The ultrasound probe must be held over the arterial defect, and compression must stop blood flow in the pseudoaneurysm. However, moderate compression should not limit perfusion of the limb. After 10–20 minutes, it is necessary to assess the pseudoaneurysm and the peripheral pulse using a duplex Doppler ultrasound. If there is no blood flow in the neck and cavity, the procedure is considered successful. If blood flow in the pseudoaneurysm persists, the procedure can be repeated three or four times, up to 1 hour in total. This technique can be used in superficial arteries such as femoral, axillary, and brachial. Anticoagulant therapy, pseudoaneurysm size (better results have been described for elimination of pseudoaneurysms smaller than 2 cm) and excess body weight are factors that negatively affect the success of compression [52]. In some studies, the complication rate of this method is about 2.4–4.3% [50]. Possible complications include rupture, skin necrosis, venous thrombosis, and distal embolization. Infection, ischemia, and surgical grafts are contraindications to ultrasound guided compression [50]. Ultrasound-guided compression is not recommended for pseudoaneurysms above the inguinal ligament due to the risk of pseudoaneurysm rupture.

An operative method to remove a pseudoaneurysm is suturing the arterial wall defect. Surgical treatment has some disadvantages, such as a long hospital stay, the need for general anesthesia, and poor wound healing in patients with comorbidities. In addition, surgical intervention has higher morbidity and mortality rates compared to interventional radiological treatment options. Complications of surgery include bleeding, infection, lymphocele, radiculopathy, myocardial infarction, and death.

Over the past few years, with the development of technologies, interventional radiological methods of treatment have come to the fore in the management of pseudoaneurysms. Despite this, surgery is still the gold standard for the treatment of infected pseudoaneurysms, ischemia, neuropathy, and failed endovascular repair [50].

Endogaft placement should be noted among endovascular interventions. The defect zone of the artery, which is the pseudoaneurysm entrance, is closed from the artery lumen by implanting an endograft. This procedure has certain disadvantages. Among others, endograft implantation should be performed in an area away from joints, because endografts are contraindicated in arterial bending or stretching as that can lead to "endograft fracture". Sirignano P. and co-authors have reported satisfactory results of their experience in superficial femoral artery pseudoaneurysm endografting, as demonstrated by follow-up multispiral CT one year after the procedure [53]. Another endovascular method of pseudoaneurysm repair is the StarClose Vascular Closure System. The basis of the method is a pseudoaneurysm puncture, a delivery tube deployment into the arterial lumen within an introducer sheath; the StarClose system grasps the arteriotomy edges using a clip and pulls the vessel walls together [54].

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