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## **Iatrogenic damage to blood vessels: diagnostics and methods of surgical treatment**

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**Abstract:** Surgical treatment of iatrogenic injuries and their consequences is an urgent and largely unresolved problem. The complexity and severity of the disease are exacerbated by multiple risk factors and comorbidities, especially in the context of the ongoing COVID-19 pandemic. This pathology worsens the relatively stable course of the iatrogenic aneurysm, causing increasingly rapidly developing, severe thrombotic complications. In addition, a new coronavirus infection dictates the need to revise the tactics for treating patients with cardiovascular pathology. The paper reviews articles on the surgical treatment of patients with iatrogenic injuries and their consequences. Unfortunately, there are still no approved regimens for the treatment and use of anticoagulant drugs, which not only take into account the peculiarities associated with the infection but also meet the requirements for the safety and effectiveness of the treatment of this disease.

**Keywords:** iatrogenic injury, iatrogenic aneurysm, COVID-19, thrombosis, diagnosis, endovascular, surgical treatment and anticoagulant therapy.

The intensive development of methods for examining a patient, a significant increase in a variety of medical manipulations for diagnosis and treatment has led to the emergence of so-called iatrogenic (jatros - Greek for doctor) diseases [1,2]. It is generally accepted that iatrogenic vascular injury leads to severe consequences requiring surgical intervention. With their unfavorable outcomes, there are often complex moral and legal situations for the attending physicians. The problem of the development of modern diagnostics and tactics of surgical treatment of patients with iatrogenic vascular injuries and their consequences, as researchers emphasize, remains one of the topical and controversial tasks of modern angiosurgery [3,4,5,6].

The share of iatrogenics accounts for 1 to 10% of hospital mortality. Currently, the literature describes iatrogenic vascular injuries in almost all areas of surgery [7]. According to A.V. Khmeleva, referring to the same ICD-10, the term "iatrogenic" refers to "any undesirable or adverse consequences of preventive, diagnostic and therapeutic interventions or procedures that lead to impaired body functions, limitation of habitual activities, disability or death; complications of medical measures that have developed as a result of both erroneous and correct actions of the doctor" [8].

The true frequency of iatrogenic vascular injury (JVI) is unknown, which is associated with the complexity of their systematization and calculation, depending on the number of operations for various diseases. Most of the cases, for known reasons, are obviously not published [9].

Iatrogenic damage to the peripheral arteries of the upper limb, which occurs, as a rule, due to trauma to the arteries with sharp instruments during diagnostic and therapeutic procedures. As a result, all layers of the vascular wall are damaged and the blood goes beyond the vascular bed [10]. Iatrogenic vascular injury of vessels during laparoscopic and robot-assisted operations require open conversions with complex reconstructive and restorative operations in some cases [11,12,13]. The narrowness of the surgical field is of great importance in the genesis of JPS, which is primarily associated with an inadequate choice of surgical approach, tumor prevalence, repeated operations, and other reasons [14]. It should be noted, and the risk of damage to blood vessels during trauma operations [15]. However, the treatment of vascular (JVI) is possible with the use of rentgenendovascular methods [16]. In recent years, the number of reports on iatrogenic injury of the great vessels that occurs during lumbar discectomy has also increased: 1 injury per 1249 procedures, or 0.08% of cases [17].

False iatrogenic aneurysm of the main arteries of the extremities, complicated by arrosive bleeding in patients suffering from drug addiction. This is a severe disease in which mortality and amputation rates exceed 50%.

According to Asfour V. et al [18] (2018), the incidence of complications and deaths ranges from 6 to 13%. The most common JVI occurs during placement of the Veress needle or primary trocar [12,18]. However, it is not always possible to establish the degree of vessel involvement in the tumor process, even using computed tomography [19]. Patel A. et al [20], erroneous puncture of an artery during implantation of a catheter into a central vein can range from 4.2 to 9.3%. This requires experience and knowledge of implantation from the doctor, as this complication can be accompanied by severe and life-threatening bleeding. The literature also describes cases of damage to the subclavian artery during catheterization of the vein of the same name [11,22]. JVI has also been described during orthopedic surgeries, in particular during operations on the hip and knee joints [15].

Researchers [15,23] examined 97 patients with iatrogenic vascular injuries of various nature and localization. Of these, it was found: thrombosis - 66.5%; pulsating hematomas and false aneurysms - 24.5%; others - 9% of patients. In order to restore adequate blood supply to the ischemic pools, on an emergency or urgent basis, surgical interventions were performed. A total of 97 patients were operated on. In 72 (74.3%) patients, thrombectomy and suturing of the vascular wall defect were performed. However, the proximity of the superior gluteal neurovascular bundle to the entry point of the iliosacral screws causes a risk of iatrogenic damage to the superior gluteal artery [24].

Of all the iatrogenic complications, pseudoaneurysms (A pseudoaneurysm is a false aneurysm. This occurs when the wall of the blood vessel is damaged) occur in more than 60% of cases. Most often, they occur after endovascular interventions on the heart, based on anticoagulant or thrombolytic therapy [25]. Bleeding complications are a significant source of morbidity and mortality in patients undergoing cardiac catheterization. Numerous studies, including the recently



published large RIVAL study, have compared the results of transfemoral and transradial approaches. The current study aimed to investigate whether the transradial approach would be superior to the transfemoral approach in patients with ST-segment elevation myocardial infarction[2]. Some scientists believe that the traditional treatment of iatrogenic false aneurysm is associated with a high risk of developing various types of complications - wound infection, rough scar, pain in the wound area [26].

The intensive development of endovascular methods and orthopedic operations contributes to the emergence of iatrogenic, that is, complications induced by a doctor (medical manipulations), such as bleeding, thrombosis, pulsating hematomas, spasms, arteriovenous fistulas, dissections, etc. Due to the fact that such diseases are quite rarely diagnosed at the curable stage. In some cases, subclinical false aneurysms are detected incidentally during ultrasound studies [27].

Diagnosis of a false iatrogenic aneurysm is established on the basis of history, clinical, ultrasound and angiographic data. These signs are revealed during examination of any patient. The detection of a false aneurysm is an indication for treatment associated with the risk of rupture. Diagnosis of false iatrogenic aneurysms is established on the basis of clinical and angiographic studies. Currently, ultrasound + duplex scanning has become the main method for diagnosing iatrogenic aneurysms [28]. If a false aneurysm of the femoral artery is suspected in cases of stable hemodynamics, ultrasound + DS of the femoral artery of its projection is prescribed. For this appointment, a consultation with a vascular surgeon is required. The most informative method for studying iatrogenic false aneurysms is multislice computed tomography, which allows non-invasive and more accurate assessment of the state of the arterial and venous bed [4].

Timely diagnosis and determination of the causes of iatrogenic vascular injuries, after diagnostic and therapeutic procedures, is necessary for the prevention of relatively rare vascular complications and their rapid surgical correction, although this is difficult to do [22].

In recent years, the literature has described many of the consequences associated with the use of angiography. Some researchers[29] pay attention to the fact that iatrogenic damage to blood vessels, with radiopaque methods of examination and probing, manifests itself in the form of: thrombosis of the vessel under study; perforation of the wall at the site of catheter insertion. However, iatrogenic angiotrauma after angiography occurs in 0.2 to 0.8% (33 out of 3934) of cases.

In our practice, we have encountered localization of iatrogenic aneurysms. Therefore, we considered it necessary to dwell in detail on this group of angioiatrogenic aneurysms. On this problem, in the literature there are reports of iatrogenic pseudoaneurysms that have arisen after medical manipulations and performed operations on the vessels.

Currently, modern methods of treatment of various manifestations of iatrogenic aneurysms are used. One of the correct methods is compression treatment. Thus, in this case, it is necessary to propose TR Band as an effective non-invasive method for the treatment of pseudoaneurysms after catheterization [30].

Compression treatment is performed to spontaneously close the site of arterial function after angiography. This treatment is carried out within 15-30 minutes after the procedure. Produced compression provides hemostasis in this area and prevents the formation of pseudoaneurysms [31,32]. For the treatment of post-catheterization aneurysms, direct hand pressure on the indicated area is used, which stops the blood flow in the aneurysm [33]. This can also be achieved with bandaging under ultrasound control. Another 2 cm stent graft was delivered and successfully placed through the fistula. AVF completely disappeared, right well preserved. Control angiography 3 weeks and 5 months after treatment did not reveal fistulas and stenoses inside the stent grafts.

Babunashvili A. M. et al (2017) [34], described a new technique and technology for the treatment of a false aneurysm of the radial artery caused by a transradial approach (TRA) using coronary angiography. Traditional external compression with the cessation of radial blood flow leads to a local environment associated with an increase in the likelihood of radial artery occlusion. This technique involves obtaining an ipsilateral unilateral (same-side) approach to the radial artery, distal to the RAP neck, followed by a prolonged sheath residence time in the RAP neck that allows thrombosis of the RAP sac and maintains patency of the lumen of the radial artery [34]. Ultrasonography confirmed the diagnosis of pseudoaneurysm. Consequently, the TR Band was used to compress the mass. Therefore, the TR Band is proposed as an effective conservative non-invasive method for the treatment of pseudoaneurysms after catheterization [30].

Tsiafoutis I., Zografos T. et al (2018), [33] noted that after the procedure at the radial puncture site, the patient had a gradually expanding pulsating mass, which was confirmed by ultrasound. It was a large pseudoaneurysm originating from the right radial artery, measuring  $27 \times 17$  mm. After 2 unsuccessful attempts at manual compression and due to the limited amount of thrombin, percutaneous endovascular repair was chosen as an alternative to surgical repair [32]. Open reconstructive surgery is the method of choice in the treatment of false aneurysms of iatrogenic etiology, especially complicated forms [35].

It should be noted that before the proposed compression method, aneurysms were treated only surgically. D.A. Korotkov et al. [36] believe that endovascular vascular occlusion is a relatively fast, low-traumatic, independent method of treatment.

Rentgenendovascular interventions often use a coated stent graft for injuries and aneurysms. The success of endovascular operations, especially for arterial aneurysms, is associated with a strict selection of patients. It is based on a careful measurement of the diameter of the aneurysm. The length of the internal lumen of the aneurysm can have a complex course, which leads to a shortening of the endoprosthesis, sometimes up to 1-2 cm. There are isolated reports in the literature about the surgical treatment of false aneurysms of the axillary artery after X-ray endovascular interventions [37,38]. However, this treatment is also associated with complications. Staphylococcus aureus has been isolated in more than 90% of all reported cases. A ruptured false aneurysm can be serious and may occur days or

weeks after hospital discharge. Surgical treatment of an infected radial artery pseudoaneurysm is strongly recommended, including removal of the false aneurysm and repair or ligation of the artery [39]. Compression is painful and often requires anesthesia. Positive results with this treatment range from 47 to 100%. Relapse is about 30%. If the aneurysm is more than 3 cm in diameter, surgery is performed with a lateral suture in the area of the defect [40]. If a large amount of blood accumulates in the aneurysm, then the thigh becomes tense and painful. In this case, it is necessary to surgically evacuate the hematoma and reconstruct the damaged vessel. In some cases, it is impossible to perform a puncture of the cavity, due to filling with a thrombus and soft tissues. Most researchers note the correctness of the compression method of treatment under ultrasound control, which makes it necessary for surgical treatment, only for large aneurysms or aneurysms with a wide neck [41].

Until now, surgical reconstruction has been the traditional gold standard in the treatment of iatrogenic aneurysms. A number of authors consider an increase in the size of an aneurysm as absolute indications; aneurysm rupture and limb ischemia [40].

Particular attention is paid to the section devoted to a promising minimally invasive direction in angiology: puncture obliteration of false aneurysms using thrombin [42].

In case of infected iatrogenic aneurysms, bypass autovenous shunting outside the zone of infection with ligation of the proximal and distal sections of the aneurysm is performed as the method of choice. Synthetic prostheses are not used. Rare complications are an allergic reaction and arterial thrombosis or embolism. Due to the development of antibodies against clotting factors, the risk of thrombotic complications increases with repeated administration of thrombin [43]. Complex reconstruction of an arteriovenous fistula (AVF) after hemodialysis. Due to proximal stenosis v. cephalica, the patient developed aneurysms of "fistula" veins: segment v. cephalica and v. intermedia cubiti complicated by AVF thrombosis. The outflow of blood from the AVF was carried out in a retrograde direction. One week after thrombosis, aneurysm v. intermedia cubiti containing dense thrombi was excised. Aneurysmorrhaphy v. cephalica, excess wall excised. An anastomosis of the reconstructed vein with the brachial artery was formed distal to the previous anastomosis. Plastic surgery of the stenotic proximal segment v. cephalica using resected aneurysm walls. After 1 year, AVF has been successfully used for hemodialysis [44].

Percutaneous techniques are used to treat post-catheterization iatrogenic aneurysms. Currently, the introduction of thrombin, collagen plugs and coils are performed under ultrasound control. Although some authors note the possibility of an aneurysm recurrence. Most researchers note recovery, absence of complications and relapses [45].

In our opinion, such a division when performing operations based on absolute and relative indications of patients with false iatrogenic aneurysms of peripheral arteries and veins is incorrect. Since the presence of an aneurysm is an absolute indication for surgical reconstruction of the patient.

Modern principles of diagnostics and choice of tactics of surgical treatment include the following stages - preoperative correction of risk factors, active surgical tactics, lateral and circular sutures on vessels, prosthetics and vascular plasty.

Due to the steady increase in the frequency of iatrogenic vascular aneurysms, their treatment is becoming increasingly important. An effective method for diagnosing these diseases is ultrasound and angiography. For the treatment of false iatrogenic aneurysms, surgical reconstruction of the vessels is of great importance.

### Conclusion

Based on the foregoing, it can be concluded that iatrogenic vascular injuries and their consequences represent a rather heterogeneous group of injuries. In severity, to date, for operational and effective treatment, the following has not been developed: an algorithm for tactical and therapeutic actions; working classification of these vascular injuries and not proposed: modern approaches; scientific and methodological recommendations for the diagnosis and surgical treatment of various types of vascular injuries (COVID19).

In the medical and practical work of medical institutions, especially in surgical hospitals and specialized vascular surgery centers, it is necessary to pay more serious attention to the diagnosis and effective treatment of iatrogenic vascular injuries with optimal surgical methods and techniques.

**Conflict of interest.** The authors declare no conflict of interest.

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