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Etiology and management of iatrogenic femoral pseudoaneurysm

Karolina Mazurkiewicz[1], Łukasz Kruszyna[2], Zbigniew Krasiński[2]

[1]Gastrointestinal Surgical Oncology Department, Greater Poland Cancer Centre, Poznan, Poland

[2]Department of Vascular and Endovascular Surgery, Angiology and Phlebology, Poznan University of Medical Sciences, Poznan, Poland

Abstract

Iatrogenic femoral pseudoaneurysm is a well-known complication of various endovascular interventions. Early diagnosis and effective management are crucial to prevent potential complications such as hemorrhage, limb ischemia, or infection. This publication reviews current strategies and advancements in the treatment method of iatrogenic femoral pseudoaneurysm, including imaging modalities for diagnosis conservative measures, minimally invasive techniques such as ultrasound-guided thrombin or glue injection, endovascular interventions, or surgery when necessary. Additionally, the publication discusses outcomes, recurrence rates, and factors influencing treatment decisions. Understanding the spectrum of available management options and their respective risks and benefits is essential for optimizing patient care and minimizing morbidity associated with this vascular complication.

Keywords: pseudoaneurysm, iatrogenic, embolization, ultrasound, endovascular treatment, surgery

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Introduction

In the modern era, less invasive procedures are the gold standard in many medical cases. Percutaneous intervention (PCI) is the most common technique to treat cardiac artery diseases [1]. Percutaneous approach is also used in various cases of peripheral artery disease. Some patients need to have vascular access for invasive blood pressure monitoring, dialysis, often blood draws, or intense fluid transfers. For over thirty years, the femoral artery has served as a main entry point for percutaneous intervention such as coronary artery catheterization. Similarly, vascular specialists have predominantly utilized femoral access for non-cardiac procedures, with their frequency rising significantly over recent decades [2]. As with any invasive intervention, percutaneous approaches have some risk of complications, one of which is iatrogenic femoral pseudoaneurysm. This review focuses on the definition, etiology, risk factors, diagnosis, and treatment of this specific problem.

Definition

Pseudoaneurysm (PSA) is defined as a disruption of the arterial wall resulting in arterial blood leakage to the adjacent surrounding tissues. Unlike a true aneurysm that involves all three layers of the arterial wall, a pseudoaneurysm is formed when there is a breach in the arterial wall, also known as a "neck" of the pseudoaneurysm [3] (Fig. 1). Pseudoaneurysms are typically limited by surrounding tissues, and as such they carry a significant risk of rupture which can cause severe bleeding and be life-threatening. If left untrea-

Address for correspondence: Karolina Mazurkiewicz MD, Gastrointestinal Surgical Oncology Department, Greater Poland Cancer Centre, ul. Garbary 15, 61–866 Poznań, Poland, e-mail: mazurkiewiczkarolina9@gmail.com

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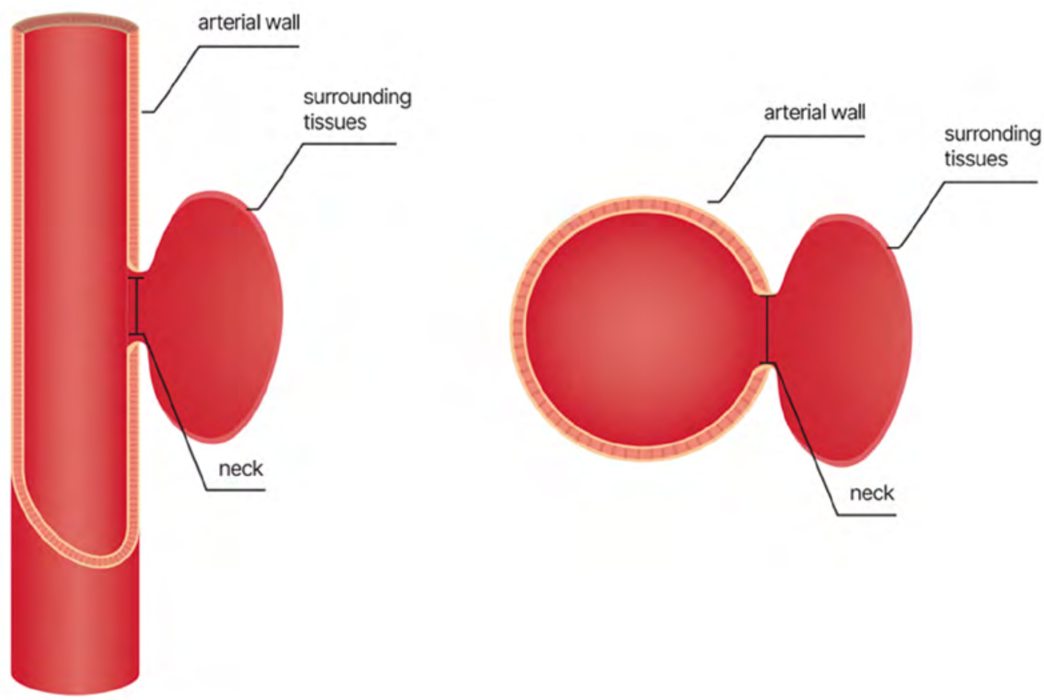

Figure 1. Pseudoaneurysm (PSA)

ted, a femoral pseudoaneurysm can potentially lead to complications such as continuous enlargement of the pseudoaneurysm and chronic pain [4].

Etiology and risk factors

A comprehensive analysis of injuries categorized by the type of medical procedure (diagnostic versus interventional) reveals a higher prevalence of adverse events following therapeutic procedures (8%) in comparison to diagnostic procedures (0,2–0,5%) [5]. The elevated incidence of injuries in therapeutic procedures can be attributed to the utilization of larger vascular devices and the frequent need for administering anticoagulant and antiplatelet therapy during the procedures [5]. Urgent intervention carries a greater risk than elective one [2]. Peri-procedural risk factors include catheterization of both artery and vein and distal femoral puncture [3]. The segment of the artery punctured in the groin is very important. A much greater risk of pseudoaneurysm formation is associated with the puncture of the external iliac arteries (EIA) or arteries below the bifurcation of the femoral artery (deep femoral artery (DFA) or superficial femoral artery (SFA). This may be related to the lower effectiveness of compression in these areas [6]. In some cases, Vascular Closure Devices (VCD) are used more often. VCD failure is rare but it depends on device selection, patient characteristics, and operator experience. In general, when VCD deployment is unsuccessful, it significantly increases the risk of vascular complications such as PSA [7]. Patient-related risk factors are female gender, age greater than 75, arterial calcification, obesity, and low platelet count [2]. Patients who are on anticoagulant or antiplatelet therapy are at increased risk of PSA formation [5].

Diagnosis

Diagnosis can be difficult to confirm only by clinical examination when a patient has hematoma or groin discomfort. Pseudoaneurysm should be considered if a patient suffers from pain that is out of proportion to expected after the procedure and coexisted swelling in the groin [5]. The typical presentation of a femoral pseudoaneurysm includes a pulsatile, tender, and palpable mass near the site of the injury or procedure [8]. An enlargement pseudoaneurysm can cause pressure on the femoral nerve leading to severe pain and neuropathy. Also, skin ischemia and infection may occur [9]. Compression of the femoral vein could rarely cause deep venous thrombosis. Differential diagnosis should consider also abscess, hematoma, arteriovenous fistula, and lymphadenopathy [10]. The main diagnostic test that is also good for differentiating the pathology is duplex ultrasonography incorporating B-mode imaging, color flow visualization, and analysis of Doppler pulse wave pattern [5]. Color Doppler Imaging reveals turbulent, bidirectional, swirling blood flow which is known as "ying--yang sign" and is pathognomonic for pseudoaneurysm [11]. By using ultrasound can be also described specific characteristics such as the size of the pseudoaneurysm, neck features, or vessel of origin [9]. "To-and-fro" pattern in the neck is also characteristic of false aneurysm imaging with spectral Doppler interrogation [12]. The "to" represents the arterial blood entering the sac during systole, while the "fro" represents blood flowing away from the sac during diastole [13]. Some asymptomatic lesions can be incidentally found in CT scans of the abdomen or pelvis. Another method for diagnostic of PA is computer angiography (CTA). It helps to identify the precise location, the originating artery, the adjacent hematoma, and any accompanying injuries that play a pivotal role in devising a treatment strategy, including determining the most suitable approach and method of intervention [12]. The last option is Magnetic Resonance Angiography which can be useful in patients with renal failure or iodine allergy. It could be problematic due to the cost, availability, and time of the test which can be inconvenient in postprocedural patients [12].

Treatment

Management of PSA includes observation, ultrasound-guided compression, ultrasound-guided thrombin or glue injection, and surgical treatment such as endovascular intervention or open surgery.

Observation

The most common indication for the observation and waiting for spontaneous thrombosis of a PSA is its small size. Most often, a diameter of less than 3 cm is given as an indication for observation [14]. Another parameter that can be important in spontaneous thrombosis is the length of the neck. PSA with a neck 0.9 cm or longer results in earlier spontaneous thrombosis than that with a shorter neck [15]. Also, smaller flow volume rated in color duplex ultrasound imaging is associated with spontaneous closure [16]. The main reason for resignation from observation is the need to use anticoagulants and cases that should have been repaired immediately [14, 17].

Ultrasound-guided compression

In the early 1990s, the introduction of ultrasound--guided compression (UGC) resulted in a significant reduction in the need for surgical repair of PSA. The method entails positioning an ultrasound probe on the groin area to directly observe the aneurysm's neck using imaging. Then, the probe is pressed against the neck of the aneurysm to eliminate flow through the pseudoaneurysm while maintaining flow in the native artery. The average compression time is 10–15 minutes then the pressure is released, and repeated at 5 to 10 minutes up to 3 times per treatment session or until the pseudoaneurysm is totally thrombosed [18]. This method is simple, non-invasive, and effective. The success rate ranged from 54% to 100% in the literature [9]. The most common reasons for failure are the use of anticoagulants and the large size of the sac. Eisenberg et al. [19] reported that the failure rate in patients using anticoagulants was 70% compared to 26% in patients without anticoagulants. Altuwaijri et al. [8] reported failure in all patients receiving anticoagulants [20]. The size of the pseudoaneurysm larger than 3 or 4 cm in diameter negatively affects the success rate of UGC. PSA size greater than 6cm failed in compression [20]. A higher success rate was also reported in PSA smaller than 2 cm [21]. Also, the length and diameter of the aneurysm neck are considered parameters influencing therapeutic success. Neck diameter greater than 4 mm and track length shorter than 8 mm are risk factors for compression failure. It is related to higher blood flow by the wider neck and difficulty in neck obliteration and thrombosis. A significant risk factor of failure is also a high BMI > 28 kg/m^2 [22]. Early diagnosis is also needed when one wants to use ultrasound-guided compression treatment. Eisenberg et al. [22] found that chronic pseudoaneurysms are more difficult to thrombose after the compression. The time to start compression therapy is also important because if compression begins 48 hours after the formation of the pseudoaneurysm, the risk of failure increases significantly [22]. The main limitation of the technique is pain occurring during the procedure. Also, it takes a lot of time, and it is difficult because the operator must hold the probe in the right position with the same pressure for a long time [21]. Complications are rare but may occur as rapid enlargement of the pseudoaneurysm, skin necrosis, rupture, distal embolization, or venous thrombosis [3]. Also, there are some reports of vasovagal attacks and new-onset cardiac events [9].

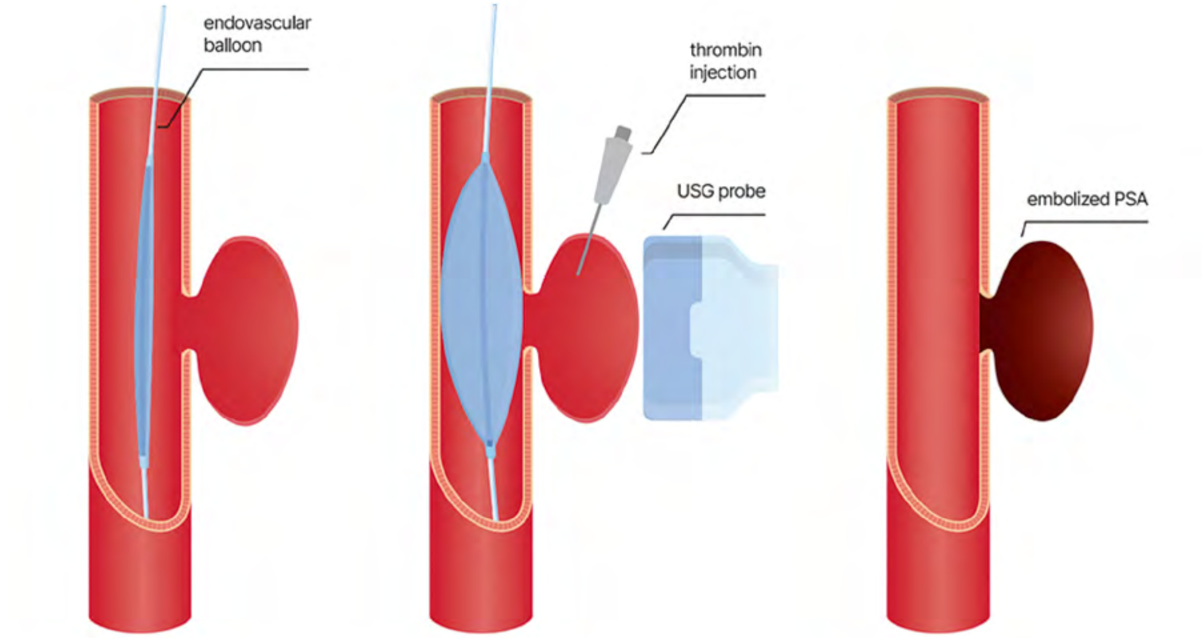

Figure 2. KERBI method

Ultrasound-guided thrombin or glue injection

Ultrasound-guided thrombin injection is the treatment of choice in iatrogenic femoral pseudoaneurysm in recent times. The technique requires careful ultrasound examination of the affected femoral artery: the origin of the pseudoaneurysm, the size of the sac, length, and diameter of the neck [2]. Thrombin is an active form of prothrombin and it takes part in converting soluble fibrinogen into insoluble fibrin which forms thrombus [21]. Bovine thrombin is most commonly used but it may result in allergic reactions and in some cases even anaphylactic shock [21]. The ultrasound probe should be placed directly over the pseudoaneurysm. Under sterile conditions needle tip should be placed in the center of the sac as far from the neck as possible to avoid injection into the femoral artery [23]. Placing the needle is done under ultrasound guidance with the color Doppler turn-off to better visualize the needle tip. Then color Doppler is back on while 0,5–1 ml thrombin is administered to assess thrombosis and patency of the femoral artery and vein. Distal pulse is a Doppler check after the injection. In some cases procedure was repeated if pseudoaneurysm was still present [24]. After the procedure, patients need at least a few hours of bed rest and then imaging checking of thrombosis or recurrence and patency of the vessels [23, 24]. The reported success rate is very high between 85% to 100% [8, 25–27]. This method is more practical than UGC because it consumes less time and is less painful for the patients [21]. UGTI does not require patient sedation, it could be performed in outpatients [3]. Is also reported that the success rate is not adversely affected in anticoagulants such as heparin or warfarin [3, 26, 28, 29]. Complications are very rare and are reported in below 4% of cases [12]. The most common complication is distal embolization but thrombin injection could also lead to urticaria, skin cellulitis, abscess formation, and rupture of PSA [21]. Thrombotic incidents are the most feared ones. They occur especially when a large volume of thrombin is injected in a small PSA with a wide neck but the presence of natural lytic factors prevents symptomatic ischemia in most cases [3, 24]. To avoid this kind of complication there is a new treatment method called KERBI (Keeping the Endovascular Ballon in place during thrombin Injection) [30] (Fig. 2). It requires an endovascular approach to insufflate the balloon across the PSA neck along with thrombin injection [12]. The best candidate for this kind of procedure is a patient with a hostile groin, obesity, and failure after the first attempt of thrombin injection in whom only surgical repair is left. The KERBI procedure is contraindicated in patients with sepsis, substantial F-PSA accompanied by neuropathy, distal ischemia, or skin/tissue necrosis. In such cases, open surgery represents the recommended approach [30]. Minici et al. [31] his study also reported the treatment of PSA with a wide neck by blocking blood flow by cross-over approach by placing a catheter with a balloon dilatator near the neck of the PSA. Then the balloon was dilatated for about 10–15 minutes. Once the blood flow within the PSA was stopped, a thrombin injection was performed under ultrasound guidance [31]. Another method using ultrasound guidance is percutaneous glue injection. Fibrin-based tissue glue is a medical adhesive commonly used in various medical procedures, especially vascular anastomosis, to achieve hemostasis and promote tissue sealing. The majority of commercially available products contain 2 acting agents such as fibrinogen and thrombin, and 1 antifibrinolytic m e.g. aprotinin to prevent premature degradation of created fibrin [32]. Blood clots formed in reaction to thrombin, whether originating from humans or bovines, more readily experience endogenous fibrinolysis. The technique followed is similar to ultrasound-guided thrombin injection. The needle is positioned under ultrasound guidance to the PSA sac as far as possible from the origin of the inflow. To prevent coagulation in the needle, the solution should be applied quite rapidly and in small doses [33]. Infiltration of the glue into the sac is monitored with ultrasound to ensure complete thrombosis. Success rates range from 87.3% to 100% [32, 33]. Limitations of these studies are small group of patients, retrospective analysis, and also lack of long--term follow-up. The most common contraindications to this method are similar to those in ultrasound-guided thrombin injection such as skin necrosis, active bleeding, nerve or vein compression, septic complications, very large PSA, or absence of PSA neck [32]. Also known contraindication of the use of percutaneous obliteration methods is the coexistence of arteriovenous fistula with PSA [34]. As well as thrombin injection, fibrin-based tissue glue injection is accompanied by the risk of distal embolization which is a potentially life-threatening condition. To evaluate complete thrombosis and lack of complications all patient requires ultrasound follow-up after 24 hours and 1 or 2 weeks. Percutaneous ultrasound-guided fibrin-based tissue glue injection is a safe and effective treatment method for PSA. Percutaneous ultrasound-guided fibrin-based glue injection, as well as percutaneous thrombin injection, is not advisable in patients presenting symptoms of mass effect (nerve, vein compression, or skin necrosis) because thrombosis converts PSA into non-pulsating mass, which does not yield immediate decrease of PSA volume [35]. This highlights the necessity for innovative percutaneous treatment techniques for iatrogenic PSA to induce a reduction of the chamber volume of PSA. Del Corso et al. [35] in a study aimed to check the effectiveness and practicability of percutaneous treatment of iatrogenic PSA based on microinjections of cyanoacrylate glue [*n*-butyl-2-cyanoacrylate + comonomer (NBCA-MS)] after US-guided PSA compression. In this study 76 from 94 total iatrogenic PSA were femoral. In locoregional anesthesia, using an ultrasound probe, the emptying of the PSA sac was obtained. Verification of the proper collapse of the PSA chamber was established by observing a complete absence of blood flow within the PSA chamber. After that, under strict US control, 0.2 ml NBCA-MS was injected followed by 5 minutes of compression. The goal was to glue superior and inferior walls together. Sometimes there was a need for additional glue injection if sights of PSA reperfusion were observed after a slight release of probe compression. In cases of PSA, larger than 5cm preliminary US-guided introduction of a 14G needle into the PSA cavity and slow compression was performed to gain complete collapse of the PSA chamber. The early success rate of the procedures was 100%. The late success rate was 99% — in one patient asymptomatic PSA was detectable in a 3-month US scan. This patient underwent retreatment and showed no PSA in 12 months of US follow-up. In 91% of the patients complaining of mass effect, there was immediate relief from symptoms. This study has some limitations but it is worth noting that this percutaneous procedure could extend a group of patients who can be cured using minimally invasive technique [35].

Surgical treatment

Endovascular intervention

In some cases, surgical intervention is needed. There are two options for surgical management endovascular or open approach. Endovascular treatment plays a crucial role in removing pseudoaneurysm from the bloodstream resulting in its thrombosis. Generally, two main methods are employed embolization or insertion of the covert stent [21]. These procedures can be conducted under local anesthesia. They are well-tolerated by most of the patients and associated with shorter time of hospitalization than after open surgery. This eliminates the need for general or locoregional anesthesia, which is particularly advantageous for individuals frequently dealing with advanced cardiovascular disease who may not be able to endure vascular reconstruction and bleeding [36]. To decide which is the best option for the treatment of PSA, some parameters should be assessed such as the size of the neck, the presence of collateral supplies, and the dispensability of the pattern artery [12]. In cases where the origin artery is expendable and has no collateral supplies, the application of coils for proximal embolization is performed and deemed to be sufficient. In these conditions, it can be also the use of N-butyl 2-cyanoacrylate glue [21]. Nevertheless, in the presence of extensive collateralization, it becomes essential to perform both distal and proximal embolization using coils. If the donor artery is not expendable and the PSA neck is narrow, exclusion of the PSA sac from the circulation should be performed, securing the origin artery [12]. Coil packing can be performed either by throwing the ipsilateral groin directly to the PSA, or less commonly, via the contralateral route using the cross-over technique. Embolization of the PSA itself is achieved by releasing coils one by one through the catheter with its tip placed directly in the PSA under fluoroscopic guidance. In an alternative approach, coils are not detached but instead stay connected to their delivery system, while observing the development of the thrombosis within the PSA. Following the complete thrombosis of the PSA, the withdrawal of both the coil and its delivery system as well as the catheter, took place [8]. While releasing coils is considered the most effective for PSA with a narrow neck, there is the risk of recanalization due to the inherent characteristics of the coils. However, soft helical coils manage this concern by securely packing the sac. If necessary, extra thrombin or glue can be introduced into the sac, building upon the existing framework of coils, either through percutaneous methods or via the same endovascular route [12, 21]. Direct coiling of the PSA may potentially increase pressure in the sac which does not have all three layers of the wall leading to the rupture. Coils may also prevent occluded PSA from shrinking and additionally, they may also serve as a potential site for infection [36]. For wide-neck PSA, stents are a valuable method of treatment for their effective exclusion of PSA from circulation. Bare stents can be placed across the PSA with coils placed through the stent struts resulting in thrombosis of the PSA itself. Stent grafts present a reliable and minimally invasive choice for managing PSA with a wide neck. However, covered stents should only be used in large and straight arteries because of the increased risk of thrombosis in small vessels. Careful evaluation of the vascular anatomy should be performed before using a stent graft [21]. These can serve as excellent treatment methods for PSA of the DFA, obviating the necessity for an open surgical repair and maintaining the patency of the artery. Furthermore, brief covered stents prove to be effective in treating PSA of SFA without extending towards the CFA, a location that might be considered for future catheterization [36]. However, it is crucial to note limitations in its application, as the deployment of the stent graft carries the risk of occluding DFA. Therefore, it is advisable to perform femoral angiography from an oblique perspective to assess the feasibility of device insertion. This approach enables the examination of an adequate landing zone in the CFA, in relation to the origin of DFA [31]. Stent-graft placement as any other treatment method has some limitations. One of them is a higher subacute occlusion rate compared to uncovered stents. This difference is attributed to the delayed onset of endothelization, which can trigger a thrombogenic reaction. Because of that younger patients with long life expectancy may benefit from the surgery rather than stent-graft placement, given that extended-term patency of these devices is less than optimal [36]. Another restriction is a potential risk of stent deformation, fracture, or migration in the mobile hip area due to repetitive movements and compression [37]. Additional limitations associated with stent grafts encompass significant elongation and tortuosity of the iliac arteries, which can inhibit contralateral femoral access. Also, the PSA location near the femoral bifurcation increases the risk of failure by using a covered stent. Constraints on reusing the groin for future access are also notable considerations [36].

Open surgery

In the new world, minimally invasive surgery is marginalizing open surgery, but one needs to remember that in some cases there is no other safe option for the patient. When choosing a treatment method, the patient's general condition, comorbidities, medications taken, and the effectiveness of the method must be considered. Open surgery is often the fastest treatment method, therefore in hemodynamically unstable patients, it is the best option [38]. Expeditious exploration of the groin is warranted in large hematomas with imminent skin necrosis or those exhibiting ongoing expansion. Furthermore, if there are suspicions of infected pseudoaneurysms, though uncommon, surgical repair is recommended to rectify the arterial defect. Urgent surgical decompression and resection of the pseudoaneurysm (PSA) become imperative when an expanding pulsatile mass causes compression on underlying structures, leading to claudication, neuropathy, or critical limb ischemia. Another common indication for open surgery treatment is failure of other treatment options [2, 3, 39]. The technique of the surgical treatment mostly depends on the surgeon's preference. The main goal of this procedure is to meticulously and precisely dissect the common, deep, and superficial femoral arteries. Then thorough exploration is performed to find defects of the arterial wall. Some surgeons prefer to do it through the transverse incision in the femoral region and others prefer the vertical incision [2, 40]. In certain cases where clamping of the artery is necessary administration of a standard dose of intravenous heparin is needed. Then defect is sutured using 5/0, 6/0 polypropylene suture [40]. Infrequently, substantial arterial defects may demand patch angioplasty, with the preference for autologous tissue application due to the notably elevated risk of complications related to wound healing associated with this procedure [2, 39]. Large hematomas neighboring PSA are common indications to open surgery due to the need to evacuate them. This often creates a cavity that should be drained to avoid fluid collection and infection [2]. The complication rate of this treatment method is very high even up to 20% [3, 39]. The most common complications of the operative intervention concern the surgical site. The most dangerous condition is bleeding, which sometimes requires a blood transfusion. Infection of the surgical site or incisional dehiscence are often indications of repeated surgical interventions and antibiotic therapy, which significantly prolongs hospitalization. Additionally, there is a risk of femoral nerve injury during surgery, as the native anatomy may be concealed by the overlying hematoma. The major disadvantage of surgical treatment is the necessity of general anesthesia, which causes a lot of burden in patients with many comorbidities. In such patients, perioperative myocardial infarction was reported. Very rarely described complications may lead to the loss of a limb or even death [2, 3, 39, 40].

Conclusion

Despite the low frequency of femoral pseudoaneurysms, the rising number of percutaneous procedures carried out by vascular surgeons and other specialists underscores the necessity for a comprehensive understanding of this complication. The approach to management of this problem has undergone significant evolution over the past few decades. The majority of small pseudoaneurysms tend to resolve spontaneously without the need for intervention, making observation a prudent course of action. In the comprehensive care of vascular patients, vascular surgeons must have proficiency in the technical aspects of noninvasive management. This involves interpreting images for diagnostic purposes, conducting noninvasive ultrasound-guided therapies, and resorting to traditional surgical intervention when deemed appropriate.

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