REVIEW ARTICLES

Richard P. Cambria, MD, Section Editor

Femoral pseudoaneurysms after percutaneous access

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The femoral artery has been the primary percutaneous-based arterial access site for coronary artery catheterizations for more than three decades. Noncardiac percutaneous-based procedures have also been performed primarily with femoral access and have increased in number exponentially by vascular specialists in past decades. Groin complications are infrequent in incidence after femoral arterial access for cardiac and peripheral diagnostic and interventional cases, with groin hematomas and pseudoaneurysms being the most common. Until ultrasound-based treatment modalities became the mainstay of treatment, vascular surgeons were the primary specialty managing pseudoaneurysms, but now other specialties also manage these cases. This review outlines the clinical implications and current issues relevant to understanding the ideal treatment strategy for this common complication. (J Vasc Surg 2014;60:1359-66.)

Historically, the common femoral artery has been, by far, the most commonly used percutaneous arterial access site. The traditional method of entry into the femoral arterial system has been the modified Seldinger technique. There is debate over which technical method to use as a landmark for entry ("best pulse," guidance with fluoroscopy, and most recently, ultrasound-guided puncture) to achieve successful arterial cannulation with sheath introduction.

Many patients rate their interventional experience on the degree of access site discomfort encountered during and after the procedure. This is comparable to a patient undergoing an open reconstruction and judging the skill of the surgeon on the external appearance of the incision. With percutaneous-based procedures, patients are not aware of whether the operator achieved optimal luminal gain with stent placement or whether asymptomatic distal embolization occurred, but they are aware of access complications.

Many access-related complications can occur, and although some are life- and limb-threatening, such as retroperitoneal hemorrhage or arterial occlusion, emergency surgery is rare, occurring in well below 1% of patients. Rapid and persistent hemostasis is essential for a return to the prepuncture state. Any loss of hemostasis at the entry site results in a spectrum of local hemorrhage, if located below the inguinal ligament.

At the most urgent end of the spectrum is an expanding hematoma, secondary to ongoing hemorrhage within the soft tissue space that may require urgent endovascular or surgical intervention if pressure application to the site cannot resolve the problem. At the other end of the spectrum is a temporary hemorrhage that subsides, resulting in hematoma or somewhere in between. The fibrin shell prevents an expanding hematoma but lacks arterial wall sealing, which allows for ongoing blood extravasation from the artery into a contained area, a "false aneurysm sac," which is described as a femoral artery pseudoaneurysm. This review focuses on this specific problem—iatrogenic femoral artery pseudoaneurysms—including incidence, risk factors, diagnostic approach, management, new techniques, and unresolved issues.

INCIDENCE

The reported incidence of femoral artery pseudoaneurysms varies widely in the literature, with some society guidelines expecting an acceptable rate of <0.2%.[1] In drastic comparison, a prospective study of >1000 patients demonstrated pseudoaneurysms in 3.8% of patients when routine duplex imaging was performed.[2] Although this study is >20 years old, a more recent study demonstrated similar results when routine ultrasound imaging was performed, with an incidence of 2.9% in >500 consecutive patients.[3]

RISK FACTORS

Multiple patient-related and procedure-related factors have been identified in the increasing incidence of femoral artery pseudoaneurysms. Patient-specific factors include body mass index, gender, degree of arterial calcifications,

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Table. Risk factors for femoral pseudoaneurysms

Patient-related factors
• Advanced age
• Gender: Female > male
• Body habitus: increased body mass index
• Platelet count: increased risk with decreasing platelet count
Procedural-related factors
• Puncture site: below the bifurcation
• Sheath size: increasing size
• Interventional procedures higher risk than diagnostic procedures
• Urgent vs elective procedures
• Femoral artery and vein cannulation
• Anticoagulation and antiplatelet administration and continued administration postprocedure

and preprocedural platelet counts. Procedure-specific risk factors include the urgency of the procedure, diagnostic vs interventional procedures, the site of arterial cannulation, the size of the sheath, combined arterial and venous access, procedural antiplatelet medication use, and anticoagulation.[4] Postprocedural factors that have been associated with an increased risk of development of a femoral pseudoaneurysm include the need for continued anticoagulation and urgent percutaneous coronary intervention. In a study of >2000 patients undergoing emergency percutaneous coronary intervention who had duplex imaging of the groin, the incidence of pseudoaneurysms was 2.3% higher than what has been reported in most nonemergency series. Other statistically significant risk factors for pseudoaneurysms in this study included gender and age, with women and those aged >75 years at increased risk for pseudoaneurysms during their hospitalization.[5] The Table lists the risk factors for the development of pseudoaneurysms.

DIAGNOSIS

The initial step in the diagnosis of femoral artery pseudoaneurysms should always be the physical examination. Unfortunately, secondary to the painful nature of the adjacent hematoma and recent catheterization, the groin is extremely sensitive to palpation and examination. The limb may also become swollen secondary to underlying hematoma or pseudoaneurysm compression of the femoral vein that rarely results in sufficient compression to cause deep venous thrombosis.

A prospective study by Mlekusch et al[4] evaluated clinical parameters in identifying femoral artery pseudoaneurysms. The presence of a pulsatile mass had a 100% positive and negative predictive value. Additional clinical parameters, including bruit, nonpulsatile mass, or superficial painful pulse palpation, were less accurate in a study of 23 patients with pseudoaneurysms.[4] In a larger prospective study, Kent et al[6] reported that the physical examination was extremely accurate, with a sensitivity of 83% and a specificity of 100% in 53 patients who were examined by vascular surgeons before their duplex examinations. Although these series demonstrate impressive accuracy of physical examination, this depends to a large extent on observer acuity, particularly for small pseudoaneurysms. Therefore, the duplex examination has become the gold standard for the definitive diagnosis and development of a management strategy.

Laboratory parameters may also aide in the diagnosis of pseudoaneurysms. A study by Mlekusch et al[4] demonstrated that the clinical examination was very accurate and correlated with a positive ultrasound imaging for pseudoaneurysm. All patients with duplex confirmation of false aneurysms had a preoperative platelet count of <200,000/L, whereas the 250 patients without a false aneurysm had platelet counts >200,000/L.[4] The use of a D-dimer test after percutaneous-based access has also been evaluated. A study by Hoke et al[7] compared 72 controls with 48 patients with pseudoaneurysms. They demonstrated higher D-dimer values in patients with pseudoaneurysms compared with controls (1.9 vs 0.8 μg/mL; $P < .001$) and an increasing pseudoaneurysm size with increasing quartile of D-dimer values. They concluded that, with a negative predictive value of 90%, a D-dimer value of <0.67 μg/mL could be used as a screening laboratory assessment before duplex imaging. A noteworthy finding was that all patients with a pseudoaneurysm had preprocedural platelet counts <200,000/L and no patients with platelet counts >200,000/L had a pseudoaneurysm.[7]

The potential benefit of these two laboratory values in selecting which patients need duplex examinations of groin hematomas for suspected or potential pseudoaneurysms is obvious. The scenario is similar to the emergency department D-dimer testing in patients with a swollen leg. With a high negative predictive value, patients with platelet counts >200,000/L and D-dimer levels within normal reference ranges could forego a duplex evaluation and reduce negative workups and, ultimately, health care dollars. The population of this study was small, and larger studies are needed to verify these results, and as stated earlier, the diagnosis is best made by duplex imaging for now.

IMAGING

Duplex ultrasound remains the cornerstone of imaging for patients with groin complications after catheterization. Duplex is not only the initial imaging modality of choice but also the primary method of monitoring with observation and the modality for direct nonsurgical therapy (ie, compression/thrombin injection).

Duplex imaging must differentiate a pseudoaneurysm from other pathology and accurately identify patients who need future imaging or an immediate intervention. Duplex imaging includes ultrasound for adequate assessment of groin pathology and B-mode imaging for measuring hypoechoic collections (ie, hematoma); however, B-mode alone cannot determine the presence of a persistent arterial defect. A 5- to 7-mHz linear transducer is used initially for evaluation, and a sector transducer is reserved for obese patients or those with a large groin hematoma. Color flow imaging is used to assess flow within the hypoechoic mass to differentiate a simple hematoma from a pseudoaneurysm. Confirmation that no connection is demonstrated with the adjacent venous system is imperative. Doppler waveform analysis with a low resistance pattern that implies an arteriovenous fistula would exclude management with thrombin injection.

Color flow can aid in the anatomic characterization of the aneurysm, including neck diameter, length of the tract from the neck to the aneurysm sac(s), number of sacs, and size in millimeters. The flow volume and maximum aneurysm diameter should be recorded. Color flow will demonstrate the classic "yin-yang" shape as arterial blood leaves the arterial defect and reflects back within the artery. Doppler waveform analysis should also be performed to rule out the presence of concomitant arteriovenous fistulae, which have a characteristic low resistance pattern with a considerable diastolic flow component.

MANAGEMENT

Observation and natural history. As in true aneurysms of the peripheral arteries, observation plays an important role until a size threshold is met. More than half dozen studies in the 1990s reported pseudoaneurysm observations. One of the first series, by Kresowik et al,[8] studied seven pseudoaneurysms, ranging in size from 1.3 to 3.5 cm, that were monitored weekly with serial duplex examinations. All pseudoaneurysms successfully spontaneously thrombosed ≤4 weeks of the initial diagnosis.[8]

A larger series was published in 1992 by Paulson et al,[9] which included 24 pseudoaneurysms that were studied serially with color Doppler ultrasound imaging. Detailed duplex characteristics were evaluated to determine which patients had successful thrombosis with observation compared with those who eventually underwent intervention. This included the volume of flow, ratio of forward to reverse flow, duration of diastolic flow, and neck length. Only the volume of flow in the lumen was statistically different, with smaller flow volumes associated with spontaneous closure (1.8 mL vs 4.4 mL; $P = .02$). Unlike the previous series by Kresowik et al,[8] only 58% had spontaneous thrombosis without intervention. Unfortunately, this series did not report the indications for intervention.[9]

Also, contrary to the success with observation by Kresowik et al,[8] Kent et al[10] reported that one-third of observed femoral pseudoaneurysms required repair. Only nine of 16 pseudoaneurysms spontaneously thrombosed, and the size did not necessarily correlate with who would require repair. Of note, three of the seven patients who required repair needed ongoing anticoagulation from the time of diagnosis until surgical intervention. The results from this study led the authors to recommend repair in patients who require anticoagulation and raised caution in using duplex parameters to predict which patients can be treated conservatively.[10]

In a small study by Samuels et al[11] in 1997, 11 patients were evaluated with duplex parameters to detect successful thrombosis. The length of the neck predicted earlier successful thrombosis, with those with a neck length >0.9 cm undergoing spontaneous thrombosis at a mean of 9 days vs 52 days for those with shorter neck lengths.[11]

The largest series in the literature on observation of pseudoaneurysms, and likely the most widely quoted, is the work by Toursarkissian et al[12] during the same year. Their study included 147 patients with pseudoaneurysms with a maximum diameter <3 cm, which was more patients than the sum of all the previous series combined. The main exclusions for enrollment were the need for immediate surgical intervention or the use of anticoagulants. Intervention was avoided in 89% of patients, with a mean time to thrombosis of 23 days. The average number of duplex examinations was higher, as expected, in those with serial examinations compared with those with immediate surgery (2.6 per patient with observation).[12]

Ultrasound-guided compression. In the early 1990s, surgical repair was the mainstay for postcatheterization false aneurysm. Fellmeth et al[13] reported a >90% success with ultrasound-assisted compression, encouraging a nonsurgical approach as the first line of management. Throughout the 1990s, procedures were done in radiology suites under direct physician supervision with ultrasound-directed compression, which dramatically reduced the number of surgical interventions. The technique involves placement of the ultrasound probe on the groin with direct visualization of the neck of the aneurysm. Pressure is applied to the probe to eliminate flow through the aneurysm neck to the aneurysm, with maintenance of arterial flow within the native femoral artery. Continued evaluation at 5- to 10-minute intervals to assess arrest of flow into the aneurysm sac is typical. This technique is continued until patient discomfort does not permit further compression, operator fatigue is too great, or successful aneurysm thrombosis is achieved. Most of large series report an average compression time of nearly 30 minutes.

Limitations of this technique include patient discomfort, frequent need for sedative administration for patient comfort, and failure rates higher than those achieved with duplex-guided thrombin injection (DGTI). The factors most commonly associated with failure of compression included the ongoing need for anticoagulation and increasing size of the aneurysm sac.[14] In a series by Schaub et al[14] of 219 pseudoaneurysms, the highly statistically significant predictors of failure of ultrasound-guided compression were ongoing anticoagulation and length of aneurysm neck (<10 mm), with a success rate of 71% vs >93%, respectively, for both subgroups. The aneurysm volume was statistically significant in the compression bandage cohort only in this large series but not with ultrasound-guided compression.[14]

DGTI. The initial technique was described 25 years ago by Cope and Zeit,[15] before the widespread use of ultrasound-guided compression instead of operative therapy. DGTI has supplanted ultrasound-guided compression as the initial therapy of choice, secondary to the speed of thrombosis,

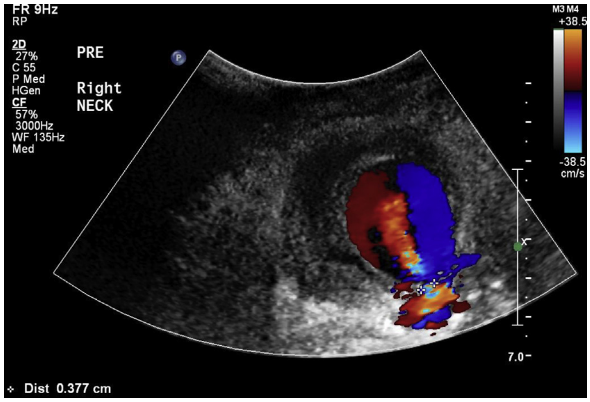

Fig 1. Color duplex imaging of a femoral pseudoaneurysm, with to-and-fro flow noted, with neck diameter with calibrated measurement of the aneurysm neck.

Fig 2. Echogenic needle tip is visualized in B-mode at the periphery of the pseudoaneurysm sac (away from the neck of the aneurysm).

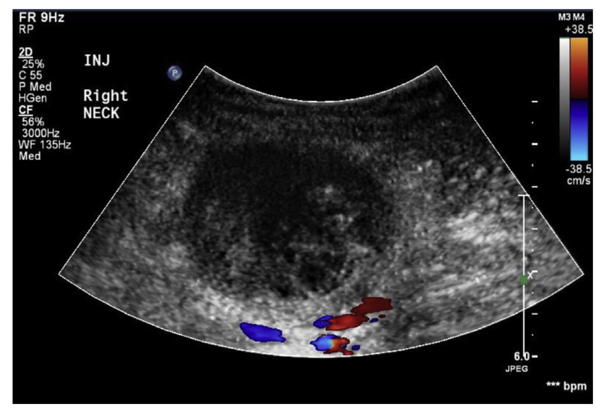

Fig 3. Successful thrombosis with lack of flow in the pseudoaneurysm and persistent flow in femoral arteries below the pseudoaneurysm sac is noted.

reduction in pain associated with the procedure, and the improved success in most series.

In most centers, the radiology department offers this therapy; however, at our institution, the vascular surgery section has been the primary service responsible for evaluation and management of our own groin-related complications or those from our cardiology colleagues for more than a decade. The procedure consists of the following steps:

- Complete examination of arterial anatomy of affected femoral artery
  - Site of origin of the aneurysm: common femoral or femoral/deep femoral
  - Waveform pattern of outflow arterial tree
  - Size of the aneurysm, including the number of lobes and the dimensions of flow lumen
  - Length and diameter of the aneurysm neck (Fig 1)
- Prepare the groin site with antiseptic and use a sterile probe cover
- Local anesthetic should be considered at skin entry site
- Needle size: 19- to 25-gauge spinal needle with tuberculin 1-mL syringe
- Under B-mode imaging, identify the sac most adjacent to the artery and direct the needle tip to the periphery of the aneurysm sac "away from the neck"
- Inject 0.1-mL aliquots of 1000 IU/mL topical thrombin after reconstitution
- Alternate between color Doppler and B-mode imaging during the injection to assess for thrombosis (Figs 2 and 3)
- After thrombosis is achieved, assess the femoral arteries for Doppler and color flow, confirming similar pattern as preprocedure
- Bed rest for 2 hours, then allow ambulation

Critical technical points:

- Maintain the needle tip in the periphery of the aneurysm sac.
- Accessing the aneurysm sac in obese patients requiring curvilinear probes is more difficult secondary to significantly obscured visualization.
- Do not inject an aneurysm with a sac size <1 cm. Highest arterial thrombosis risk.
- Thrombosis or embolization is rare: Use the minimal amount of thrombin to occlude the aneurysm and always perform postinjection imaging, including Doppler and color flow imaging of femoral artery and waveform analysis or peripheral vascular resistance.

In a prospective nonrandomized study of 274 patients with femoral artery pseudoaneurysms treated with DGTI, 52 (19%) were being treated with anticoagulation at the time of therapy. The overall success rate was 97% and was not adversely affected by anticoagulation use. Of the seven failures with the first injection, three underwent a successful second injection, three had successful adjunct ultrasound-guided compression therapy, and one patient required surgical correction.[16]

The largest nonrandomized study directly comparing ultrasound-guided compression and DGTI was reported by Khoury et al.[17] With 189 patients undergoing compression and 131 with DGTI, the success rate favored DGTI (96%) over ultrasound-guided compression (75%). The primary reason for compression failure was pain with compression or an aneurysm depth that did not allow for adequate compression, whereas the failures occurring during DGTI were primarily related to intra-arterial injection of aneurysms <2.5 cm and short necks.[17]

In our experience of >200 DGTI, we have had one patient with acute limb ischemia. This patient presented immediately after the injection procedure with common femoral artery occlusion and underwent successful open surgical thrombectomy. Most other series report symptoms immediately or within several hours, with varying degrees of management. Percutaneous-based thrombectomy and even catheter-directed lysis are options in patients with extensive arterial occlusion.

Gorge et al[18] prospectively evaluated the effectiveness of ultrasound-guided compression in 36 patients with current administration of acetylsalicylic acid and clopidogrel. If compression failed to achieve complete aneurysm thrombosis after 40 minutes, then DGTI was performed. In addition, two-thirds of patients had received heparin or enoxaparin ≤12 hours of treatment. Only 17% of patients had successful thrombosis with compression alone, with 30 patients subsequently receiving DGTI, with a success rate of 93%.[18]

Previously, our group conducted a literature review on the recurrence of pseudoaneurysm after successful DGTI and found an incidence of only 3.4% in 1375 reported successful injections. The use of routine repeat duplex examinations, therefore, could be questioned, especially in a cost-containment environment, after a successful thrombin injection procedure.[19] In a previously reported series by our group, >100 procedures were performed, with no intra-arterial injections, embolic complications, or allergic reactions reported.

Other described techniques. A host of other techniques have been used to successfully treat postcatheterization false aneurysms. Many agents have been injected into the aneurysm sac to promote thrombosis, of which, topical reconstituted thrombin is the most commonly used agent, and some series have reported the use of saline, glue, and coils. Saline by far is the least expensive agent, rivaled only by the cost of topical thrombin at <US $50, whereas coils and glues are >$250 at our institution and may serve as a nidus for infection.

Endovascular techniques, typically from a contralateral femoral access, can be used but may result in a contralateral femoral complication. The use of covered stents and bare stents with coil placement through the stent struts (ie, as used in intracranial therapy) should be avoided, secondary to the flexion point of the common femoral artery, unnecessary costs of products, etc.

Surgery. Surgical exploration for groin-related complications continues to have a role in select cases. Large hematomas with impending skin necrosis or that continue to expand should undergo prompt exploration. In addition, suspected infected pseudoaneurysms, which rarely occur, should also undergo surgical repair of the arterial defect. Severe pain and nerve compression with neurapraxia are also indications for surgical decompression of the overlying hematoma and pseudoaneurysm repair.

Technical considerations include the method of obtaining proximal arterial control (ie, standard groin incision vs suprainguinal incision) for control of the distal external iliac artery and orientation of the incision and are at the discretion of the surgeon. A groin incision is generally safe and effective for pseudoaneurysms in contrast to exploration for a "high stick" resulting in a retroperitoneal hematoma. Unless the patient has had a previous vertical incision, our group favors a transverse incision because our anecdotal experience suggests a lower frequency of incisional complications. Technical aspects include meticulous dissection of the femoral artery to identify the arterial defect, ensuring that the suture repair incorporates the full thickness of the arterial wall and not solely "bites" of the adventitia and fibrin layer covering the artery. During surgical exploration, a thorough circumferential exposure of the common femoral artery, superficial femoral artery, and profunda is required to look for possibility of multiple injury sites and "through-and-through" punctures that leave posterior wall injuries. Simple interrupted repair with the superior and inferior edges of the defect approximated by intima to adventitia directional passage of the needle is sufficient. Large hematomas adjacent to false aneurysms will often leave a cavity once evacuation of the hematoma has been achieved, and consideration for closed suction drainage should be entertained. Rarely, large arterial defects require patch angioplasty, and autologous tissue should be applied secondary to the unusual high rate of wound-related complications associated with this operation.

Complications associated with operative intervention are mostly surgical-site related. Garcia et al[20] recently reported outcomes of 79 patients managed with operative repair, and the most common complication was blood loss requiring transfusion. This series also reported incisional dehiscence in 12% and infection in 19% of procedures.[20] This includes a 17-year experience with nearly one-quarter developing postoperative complications. Bleeding was reported most frequently, with wound-related complications reported in 6.5% of the 92 patients. Of note, patients with complications experienced a longer intensive care time and hospital length of stay. Risk factors for complications included older age and the presence of chronic obstructive pulmonary disease.[21] Also, femoral nerve injury may occur because the native anatomy may be obscured by the overlying hematoma. A recommended management algorithm is presented in Fig 4.

RANDOMIZED TRIALS

Several small randomized trials have compared therapies or technical aspects of treatment of femoral pseudoaneurysms. Paschalidis et al[22] randomized 168 patients to manual compression with and without ultrasound guidance. Therapy was performed for up to 60 minutes, and repeat sessions were performed in unsuccessful cases.

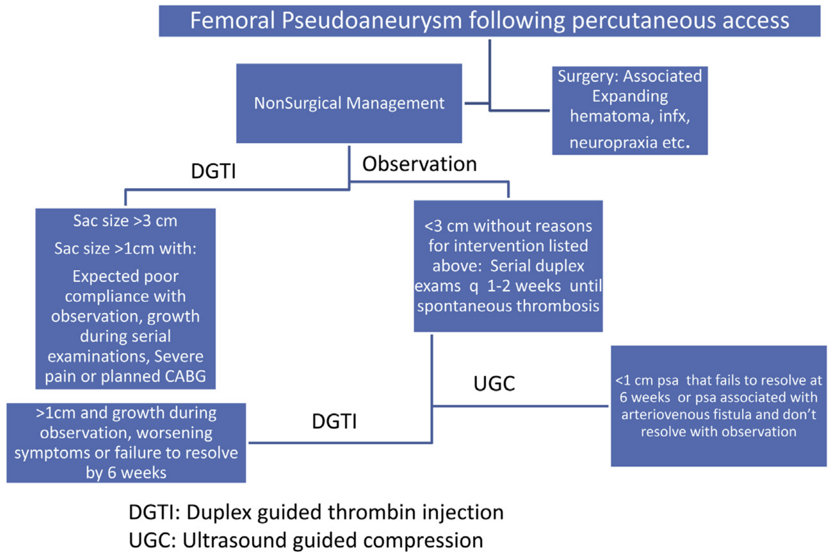

Fig 4. Femoral pseudoaneurysm management algorithm. *CABG,* Coronary artery bypass grafting.

Failure was twice as likely with ultrasound-guided compression compared with standard compression (4.7% vs 9.4%). However, ultimate success was similar between the two methods, with 2.3% of the standard compressions requiring surgery vs 1.1% of the ultrasound-guided therapy procedures. The length of treatment was not reported for either cohort.[22]

Another study randomized 38 patients to compression with a FemoStop (Radi Medical Systems, Uppsala, Sweden) or to ultrasound-guided compression. Both modalities required ~30 minutes for successful obliteration of the aneurysm. Success rates were similar between both cohorts, with a success rate of 79% with the FemoStop device and 74% in patients undergoing ultrasound-directed compression.[23]

Ultrasound-guided compression and DGTI were compared in a small randomized series by Lonn et al.[24] However, only 30 patients were randomized to the two treatment modalities. A dramatic difference was found in favor of thrombin injection, with all 15 patients receiving successful thrombosis in contrast to a 13% initial success rate and only a 40% success rate after two treatments in patients with compression only. Ultrasound-guided compression was used with a FemoStop. The balloon was raised above systolic pressure and left in place for 30 minutes, then repeated for 30 minutes if the aneurysm sac was not successfully closed, followed by bed rest until the following morning. All failures in the compression cohort were ultimately successfully treated by thrombin injection.[24]

The technique of bolus vs slow injection of topical thrombin into the false aneurysm has been compared in 73 patients. The two groups were similar in demographics and characteristics of the aneurysm (neck length/width and blood flow at the neck). The overall success was similar between the two groups. A pulse oximeter was placed on the great toe of the treated limb, and clinical and objective decreases in the oxygen saturation were considered to have embolization. The frequency of clinical or objective development of embolization was ~30% in both groups. Of note, >70% of the aneurysms occurred from the superficial femoral or deep femoral arteries, with <30% from the common femoral artery.[25]

COCHRANE REVIEWS

Two reviews have been conducted by Tisi et al[26,27] on the subject of femoral pseudoaneurysms. The first review was in 2006 and compared surgical vs nonsurgical intervention for femoral pseudoaneurysms; however, surgical repair was not an arm for either of the studies reviewed, only nonsurgical techniques. The limitation of this initial review was based on the evaluation of only two small randomized trials, which were mentioned above. The first compared the use of the FemoStop device vs ultrasound-guided compression, and the second compared ultrasound-guided compression vs DGTI. Only limited conclusions can be achieved from reviewing these two small studies.

The second review was conducted only 3 years later, with two additional small studies added. This additional review compared two compression methods with ultrasound-guided compression, and two studies compared ultrasound-guided compression vs DGTI. The results of such small cohorts fail to support a compression-first approach, as Tisi et al[26] have recommended. It appears clear from the aggregate of retrospective studies that pseudoaneurysms of the currently acceptable size threshold (>3 cm) to warrant treatment are more effectively treated with a DGTI.

UNSOLVED ISSUES WITH TREATMENT

What is the current natural history of pseudoaneurysms? All of the natural history studies were reported before the widespread use of clopidogrel, which has recently been manufactured as a generic medication with a decreased price, which has potentially resulted in increased use. Clopidogrel (Sanofi-Aventis, Bridgewater, NJ), was released in 1997, and may affect the development of spontaneous thrombosis of pseudoaneurysms. In addition, newer more potent oral antiplatelet agents have recently reached the market.

Additionally, there are currently no guidelines for an ideal management strategy such as size threshold and which size variables should be measured to determine treatment (ie, flow, lumen, or total aneurysm size including thrombus). Should the threshold be lowered for patients with new-generation antiplatelet or anticoagulants agents? There is enough evidence to suggest that ongoing anticoagulation reduces the likelihood of spontaneous thrombosis or thrombosis with standard compression.

What perioperative restrictions should be included for patients after DGTI? Currently, at our institution, we are performing outpatient thrombin injections in patients who are diagnosed with pseudoaneurysms after discharge. After a successful thrombin injection, we order 2 hours of bed rest and then discharge the patient. Patients diagnosed with pseudoaneurysms are discharged 2 hours after the procedure to limit unnecessary hospital days.

Additionally, with the low rate of recurrence, should any imaging be recommended after documented thrombosis? Furthermore, in an ever-increasing push for cost containment, should patients have a duplex examination 3 weeks after the initial diagnosis of a pseudoaneurysm to assess for successful thrombosis with observation, because this is the mean time in previous studies for successful spontaneous thrombosis, or should selective thrombin injections of smaller pseudoaneurysms be performed with clinical follow up to reduce health care costs?

CONCLUSIONS

Although the incidence of femoral pseudoaneurysms is low, the increasing percutaneous volume by vascular surgeons and other specialists requires a thorough understanding of this complication. Most small pseudoaneurysms will spontaneously resolve without intervention, and observation is prudent. Technical aspects of noninvasive management should be in the armamentarium of vascular surgeons who provide comprehensive management of the vascular patient in the interpretation of images for diagnosis, noninvasive ultrasound-guided therapies, and traditional surgical intervention when indicated.

AUTHOR CONTRIBUTIONS

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