

# Femoral artery aneurysms

## Abstract

True aneurysms are dilatations of blood vessels, bounded by the tunica intima, tunica media and tunica adventitia. False aneurysms are dilatations bounded by the tunica adventitia only, and are more common than true aneurysms. The femoral artery is the second most common location for true peripheral artery aneurysms, and the most common site of false aneurysms. If left untreated, devastating complications can occur, such as infection, rupture, ischaemia and limb loss. Femoral artery aneurysms should be identified early and managed by a vascular specialist. This article outlines the evidence for the epidemiology, investigation and management of femoral artery aneurysms.

**Key words:** Aneurysm; Femoral; Peripheral; Pseudoaneurysm; Surgery; Vascular

Submitted: 29 May 2022; accepted following double-blind peer review: 31 October 2022

Balamrit S Sokhal<sup>1</sup>

Yangmyung Ma<sup>2</sup>

Sriram Rajagopalan<sup>2</sup>

Author details can be found at the end of this article

**Correspondence to:**

Yangmyung Ma;  
yangmyung.ma2@nhs.net

## Definition

Femoral artery aneurysms can be classified by anatomy as true or false femoral artery aneurysms (Figure 1). True femoral artery aneurysms are defined as a localised dilatation of the tunica intima, tunica media and the tunica adventitia of a patient's femoral artery by up to 150%, surpassing its normal diameter of 1 cm in healthy adult humans (Sandgren et al, 1999; Corriere and Guzman, 2005). This increases linearly with age, owing to reduced elasticity and reduced vascular smooth muscle; however, a larger body surface area and male sex also contributes to a relatively larger vessel (Sandgren et al, 1999; Jani and Rajkumar, 2006). In accordance with the Cutler and Darling (1973) classifications, true femoral artery aneurysms can be further subclassified into three types, depending on the artery affected: common femoral, superficial femoral and profunda femoris (Levi and Schroeder, 1997). A false femoral artery aneurysm (also termed a pseudoaneurysm) is defined as a dilation caused by a haematoma contained only by the tunica adventitia or a pseudo-fibrous capsule (Levi and Schroeder, 1997).

This article reviews the literature regarding femoral artery aneurysms for vascular and non-vascular clinicians. Knowledge of this rare yet important pathology is vital to prevent devastating complications.

## Epidemiology

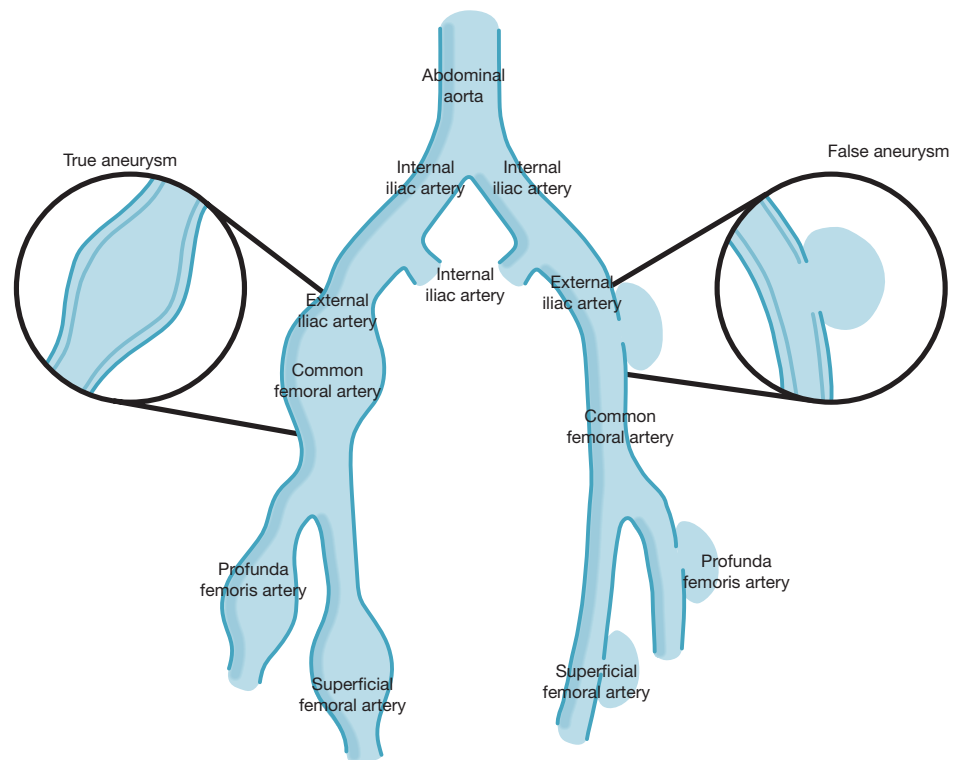
Approximately 3% of all peripheral aneurysms occur in the femoral artery (Dighe and Thomas, 2008), with femoral artery aneurysms being the second most common site of peripheral artery aneurysm after popliteal aneurysms (Lawrence et al, 1995; 2014; Ahmed et al, 2021). Approximately 25% of femoral artery aneurysm cases are discovered incidentally, compared to just 1% of abdominal aortic aneurysms (Levi and Schroeder, 1997; Jarrett et al, 2002; Hotonu et al, 2018; Ahmed et al, 2021).

## True aneurysms

Isolated true femoral artery aneurysms are uncommon, with an incidence rate of 5 per 100 000, and are found predominantly in men aged over 65 years, with a factor of 15–20:1 (Jarrett et al, 2002; Lawrence et al, 2014; Perini et al, 2014; Tulla et al, 2022). In half of the identified cases, true femoral artery aneurysms tend to be one of multiple aneurysms (Lawrence et al, 1995). Some 50–90% of patients with true femoral artery aneurysms have concomitant abdominal aortic aneurysms (Jarrett et al, 2002; Sharma and Nalachandran, 2009; Piffaretti et al, 2011; Perini et al, 2014). There is a lower incidence of femoral artery aneurysms concomitantly with iliac artery aneurysms and popliteal artery

## How to cite this article:

Sokhal BS, Ma Y, Rajagopalan S. Femoral artery aneurysms. *Br J Hosp Med.* 2022. <https://doi.org/10.12968/hmed.2022.0258>



**Figure 1.** Locations of aneurysms of the femoral artery.

aneurysms (Jarrett et al, 2002; Perini et al, 2014). Femoral artery aneurysms can occur bilaterally in up to one-third of cases (Hotonu et al, 2018; Tulla et al, 2021). Common femoral artery aneurysms are the most prevalent type (57% vs 16% for superficial femoral artery aneurysms and 17% for profunda femoris artery aneurysms) (Piffaretti et al, 2011). Despite being predominantly atherosclerotic in nature, cases have been reported in patients with Behçet's disease, Marfan syndrome or acromegaly (Corriere and Guzman, 2005).

### False aneurysms

False femoral artery aneurysms are the most common form of femoral aneurysm, with incidence rates ranging between 0.5% and 9% (Stone et al, 2014). False femoral artery aneurysms are most commonly iatrogenic, usually as a result of a puncture site from a percutaneous procedure failing to heal appropriately (Lenartova and Tak, 2003). Therefore, false femoral artery aneurysms can be prevented with careful catheterisation of the femoral artery. They occur in 0.1–0.2% of patients who have had diagnostic angiograms and 0.8–2.2% of patients who have had interventional procedures, complicating up to 6% of femoral arterial catheterisations overall (Corriere and Guzman, 2005). They can also be caused by penetrating trauma (20% of all traumatic aneurysms) and failure of vascular anastomosis (0.8–2.2%) (Gabriel et al, 2007; Tulla et al, 2022). A study of 2600 patients undergoing emergency primary percutaneous coronary intervention found the incidence of false femoral artery aneurysms to be 2.3% higher than in non-emergency settings (Abdel Wahab et al, 2019). The risk of false femoral artery aneurysm formation is greatest if the puncture site is in the superficial femoral artery (2.9% vs 1.2% for profunda femoris artery and 0.6% for common femoral artery) (Gabriel et al, 2007).

Risk factors for false femoral artery aneurysm formation post-catheterisation can either be patient- or procedure-related. Patient factors include increased body mass index, female sex, hypertension, antithrombotic treatment and platelet count (Corriere and Guzman, 2005). Procedural factors increasing risk include urgency, procedure site, needle sheath size and whether the procedure is performed for diagnostic or interventional reasons (Corriere and Guzman, 2005; Stone et al, 2014).

## Pathophysiology

### True aneurysms

True femoral aneurysms involve the tunica intima, tunica media and tunica adventitia layers of the artery (Piffaretti et al, 2011). The specific pathophysiology of aneurysm formation is not fully understood, although it is likely caused by atherosclerosis (Piffaretti et al, 2011). The loss of elastin, as well as chronic immune cell infiltration of the tunica media and adventitia of the vessel, decreases the integrity of the wall of the lumen over time (Aune et al, 2018; Ahmed et al, 2021). Infiltration by macrophages increases matrix metalloproteinase release, which leads to the decrease in vessel wall integrity and, eventually, to full-thickness dilation of the vessel (Aune et al, 2018). As a result, blood flow through the vessel is turbulent, causing aneurysms and thrombus formation (Atallah et al, 1995; Levi and Schroeder, 1997; Ahmed et al, 2021).

Smoking is the biggest risk factor linked to aneurysm formation, as it causes activation of tissue plasminogen activator, which induces matrix metalloproteinase release from macrophages, further contributing to aneurysm formation (Aune et al, 2018; Ahmed et al, 2021). Other risk factors include male sex, hypertension and hyperlipidaemia (Lawrence et al, 2014). Aneurysms that are not caused by atherosclerosis are rare and are usually a result of trauma or infection or, more rarely, are related to the presence of Marfan syndrome (Piffaretti et al, 2011).

### False aneurysms

False femoral artery aneurysms occur most commonly as a result of traumatic injury to the vessel wall following an interventional procedure (Corriere and Guzman, 2005). Histologically, only the tunica intima and media are affected, with the tunica adventitia remaining intact (Corriere and Guzman, 2005). This allows blood to enter surrounding tissues (Stone et al, 2014; Tulla et al, 2021), which can result in the formation of fibrous tissue that surrounds the aneurysm wall, eventually leading to a pulsatile haematoma (Corriere and Guzman, 2005).

## Presentation

Approximately 30–40% of individuals with femoral artery aneurysms are asymptomatic (Corriere and Guzman, 2005; Lawrence et al, 2014; Aune et al, 2018), with the majority of patients presenting with acute complications (Corriere and Guzman, 2005). Some 30–50% of patients present with a rupture: 26% with distal limb ischaemia from embolisation, 15% as a result of acute thrombosis and the remainder with either a groin mass or pain, or via incidental discovery (Levi and Schroeder, 1997; Perini et al, 2014). The risk of rupture is proportional to the diameter of the aneurysm, although this risk is not as extreme as that in abdominal aortic aneurysms (Levi and Schroeder, 1999; Piffaretti et al, 2011). Symptoms of rupture include severe pain and haemodynamic instability (Ahmed et al, 2021).

For both true and false femoral artery aneurysms, the risk of thrombosis is 17% and rupture is 2% in aneurysms less than 5 cm diameter; for aneurysms more than 5 cm, there is a 20% risk of rupture and 5% risk of thrombosis (Levi and Schroeder, 1999). The incidence of thrombosis or embolus varies depending on the location of the aneurysm (Lawrence et al, 2014). It is highest for profunda femoris artery aneurysms (45%), followed by superficial femoral artery aneurysms (26%) and common femoral artery aneurysms (15%). As the location of profunda femoris artery aneurysms is deeper, these increase in size before a patient presents clinically (Lawrence et al, 2014).

A full, thorough history should be taken from the patient (Tulla et al, 2021), which should elicit risk factors for aneurysm formation including smoking, hyperlipidaemia, antithrombotic use, history of intravenous drug use and recent percutaneous intervention (Tulla et al, 2021). Following this, a full cardiovascular and peripheral vascular examination should be performed, with particular attention given to any pulsatile and expansive mass in the abdomen and distal pulses, which could indicate multiple aneurysms (Tulla et al, 2021). However, around two-thirds of aneurysms will not be detected by physical examination alone, unless the aneurysm is very large or the patient has a smaller body mass index (Leon et al, 2008). For patients presenting with a groin mass and pain, important differentials

to consider are inguinal hernia, inguinal lymphadenopathy and saphena varix (Tulla et al, 2021). Clinicians should use a stethoscope to listen for any bruits over the inguinal region, which would indicate turbulent blood flow and, therefore, a femoral artery aneurysm (Tulla et al, 2021). A history consistent with a femoral aneurysm should also support findings (Tulla et al, 2021).

## Investigations

### True aneurysms

Computed tomography angiography is the best and most widely used investigation for diagnostic evaluation of true femoral artery aneurysms (Jarrett et al, 2002; Leon et al, 2008) (Figures 2 and 3). B mode ultrasound and magnetic resonance imaging can also be used, although these are unable to distinguish between a partially thrombosed aneurysm and a soft tissue tumour (Jarrett et al, 2002; Leon et al, 2008). All patients diagnosed with true femoral artery aneurysms should also be screened for other meta-synchronous and synchronous aneurysms, given that most femoral artery aneurysms are associated with either bilateral aneurysms, other peripheral aneurysms or general peripheral arterial disease (Leon et al, 2008).

### False aneurysms

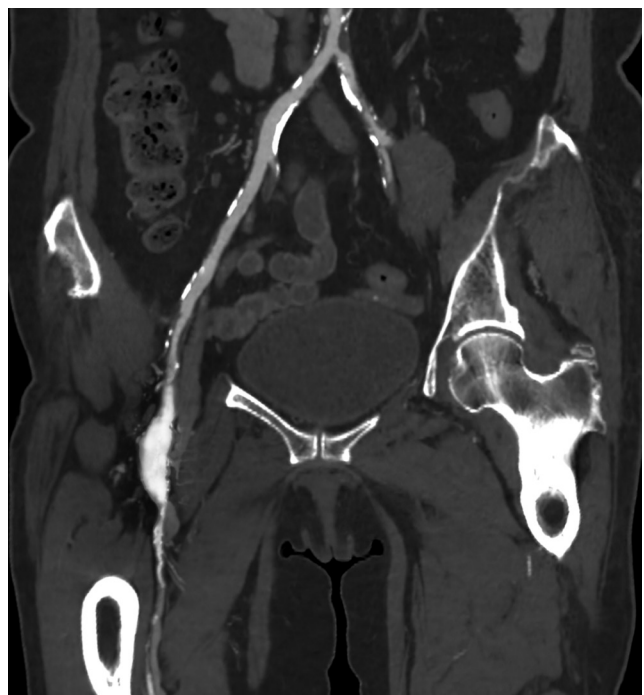
For suspected false femoral artery aneurysms, duplex ultrasound is the initial investigation of choice, as this has a sensitivity of 92–96% (Tulla et al, 2021). The size of the aneurysmal sac, alongside the dimension of the jet through the neck of the aneurysm, should be recorded and then categorised into type I (involving only the common femoral artery) or type II (involvement with the profunda femoris artery) (Piffaretti et al, 2011; Tulla et al, 2021).

## Management

Surgical intervention is indicated for all symptomatic femoral artery aneurysms or asymptomatic femoral artery aneurysms measuring >2.5 cm, although this threshold can be increased to 3.5 cm, as acute complications are less likely to occur in femoral



**Figure 2.** Computed tomography scan of a female patient with an aneurysm (white bulge, centre) of the femoral artery.



**Figure 3.** Computed tomography scan of a female patient with an aneurysm (white bulge, lower centre left) of the right femoral artery (left).

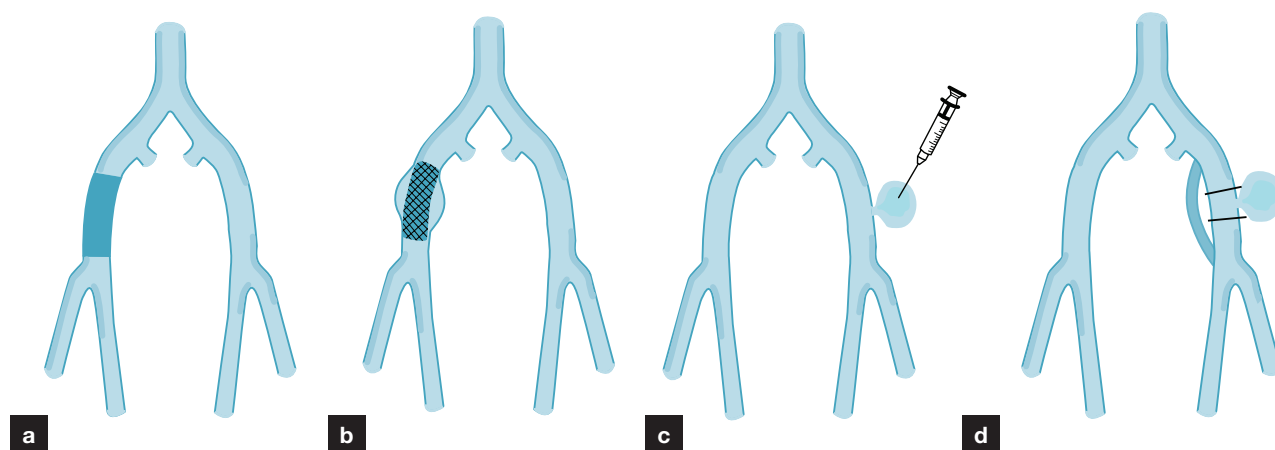
artery aneurysms <3.5 cm (Piffaretti et al, 2011; Lawrence et al, 2014). Symptomatic patients commonly have an intraluminal thrombus associated with the aneurysm, which significantly increases the risk of future complications, especially in aneurysms measuring >4 cm; therefore, surgical intervention should also be considered, independent of the size threshold for the aneurysm (Lawrence et al, 2014). Symptoms requiring intervention include claudication, pain, nerve compression, rupture and thrombosis (Lawrence et al, 2014). Patients with saccular aneurysms should be considered for surgery from the onset of diagnosis, and fusiform aneurysms of the superficial femoral artery should be treated like fusiform aneurysms of popliteal arteries (Atallah et al, 1995). This involves simple ligation of the proximal and distal ends of the aneurysm and interposition with an autologous reversed saphenous vein graft (Atallah et al, 1995).

Asymptomatic femoral artery aneurysms should be monitored by computed tomography angiography and surgically treated when symptoms develop or the size reaches the 2.5 cm threshold (Pinto et al, 2017). According to Cutler and Darling (1973), the type of repair depends on the following factors: patency of femoral-popliteal segment, aneurysm patency, and location of the origin of the profunda femoris artery. However, no studies or trials confirm whether this makes a difference (Piffaretti et al, 2011). Surgery for superficial femoral artery aneurysms take less operating time compared to that for common femoral artery aneurysms and profunda femoris artery aneurysms and requires a shorter stay in hospital (Piffaretti et al, 2011).

### True aneurysms

Both open and endovascular methods of management are possible, with open management being the most common (Saleem et al, 2021). All open repair options require general anaesthetic and carry the risk of lymphatic, wound and bleeding complications (Rancic et al, 2013). There is no correlation between perioperative complications and symptomology of patients (Lawrence et al, 2014), and there are no specific contraindications for surgery (Saleem et al, 2021). High-risk patients can have the procedure using local or regional anaesthesia (Saleem et al, 2021). Open treatment modalities include aneurysm excision and graft interposition, aneurysm excision and bypass, and aneurysm ligation (**Figure 4a**) (Dighe and Thomas, 2008; Pinto et al, 2017). Ligation is ineffective for ruptured aneurysms (Perini et al, 2014). The choice of procedure and the technique used depends on the extent of the disease.

An initial longitudinal groin incision is preferred to a transverse incision, as this allows better exposure of the proximal sections of the profunda femoris artery and superficial femoral artery (Saleem et al, 2021). Similarly to open abdominal aortic aneurysm surgery, the patient is heparinised, typically with a dose of 5000 units (dose varies based on surgeon's preference), before clamping the proximal and distal ends of the artery (Ahmed et al, 2021; Saleem et al, 2021). Exclusion of the aneurysm by ligation and use of a bypass graft is favoured over direct end-to-end anastomosis (Levi and Schroeder, 1997; Lawrence et al,



**Figure 4.** Management strategies for various types of femoral artery aneurysms. a. Interposition vein graft. b. Femoral stenting. c. Thrombin injections. d. Ligation with or without revascularisation.

2014). Autologous vein is the graft of choice; however, prostheses can be used for older patients to reduce operating times (Atallah et al, 1995). Bilateral aneurysms are treated with multiple surgeries, usually performed a year apart (Piffaretti et al, 2011).

Endovascular repair using a stent graft (ie Viabahn, Gore) is not widely used for femoral artery aneurysms, except for false femoral artery aneurysms in haemodynamically unstable patients or traumatic femoral artery aneurysms (Figure 4b) (Saleem et al, 2021). The integrity of stents may be compromised, owing to the proximity of the aneurysm to the hip joint, leading to limited blood flow to the distal limb (Rancic et al, 2013). Endovascular treatment of traumatic femoral artery aneurysms is advantageous, as there is minimal blood loss and a shorter operating time, as well as a quicker recovery and a shorter hospital stay (Abdel Wahab et al, 2019). Despite its benefits, this method is associated with an increased risk of thrombosis, and the surgery is more expensive to perform because of the use of stents (Abdel Wahab et al, 2019). In particular, endovascular repair of the common femoral artery and profunda femoris artery are associated with high rates of complications (Abdel Wahab et al, 2019).

Minimally invasive techniques can be performed under local anaesthetic (Rancic et al, 2013). An endograft is telescoped into the aneurysm via an 18 G needle and 0.035 inch guiding wire and opened with a balloon (Rancic et al, 2013). This is performed with limited dissection of the anterior wall of the femoral artery, using an angiogram for reference (Rancic et al, 2013). There is a risk of compromising blood flow to the profunda femoris artery. The distal end of the anastomosis can be constructed by:

1. Suturing into the bifurcation of the femoral artery
2. Suturing into another endograft in the deep femoral artery
3. Suturing into a normal vascular graft and anastomose to femoral bifurcation or patent bifurcated branches (superficial femoral artery or profunda femoris artery) (Rancic et al, 2013).

No amputations, complications or deaths have been reported using this technique, with a graft expected to be patent from 9–48 months (Rancic et al, 2013). The median length of hospital stay is reported to be 4 days (Saleem et al, 2021).

### False aneurysms

Treatment options for false femoral artery aneurysms include conservative observation, ultrasound-guided thrombin injections, ultrasound-guided compression or open surgical repair (Madia, 2019; Tulla et al, 2022). This is dependent on symptomology and whether the aneurysm is infected.

#### Non-infected

False femoral artery aneurysms less than 2 cm can be conservatively monitored with patient education and strict safety netting measures for complications (Madia, 2019). For larger aneurysms, ultrasound-guided thrombin injections are the management method of choice over conservative observation or ultrasound-guided compression, as the procedure is low risk and has a success rate of up to 97%, compared to 88% for ultrasound-guided. Indications for the use of ultrasound-guided thrombin injection include asymptomatic aneurysms, failure of conservative management, a longitudinal, thin aneurysm neck (width of <10 mm) clearly visualised on ultrasound, an aneurysmal sac >10 mm, or failure of conservative or ultrasound-guided compression (Horn et al, 2017; Sizemore et al, 2018; Yang et al, 2018). Surgical management is preferred if the patient is allergic to thrombin or if the aneurysm is infected, rapidly expanding, very large (50 mm wide or a 4 mm puncture site) or symptomatic as a result of skin maceration, neurological compromise or compression of surrounding structures. All of these factors increase the risk of complications from thrombin management (Huseyin et al, 2013; Horn et al, 2017). This procedure can be performed under local anaesthetic (Madia, 2019). An ultrasound-guided injection of up to 1000 units of topical thrombin can be used to manage simple false femoral artery aneurysms (Figure 4c) (Sheiman and Brophy, 2001; Gabrielli et al, 2016). Injections for complex, multilocular false femoral artery aneurysms should initially be introduced to the lobe, which is not directly connected to the femoral artery and thus may require an additional injection (up to a total of 1500 units). These patients should be monitored for 24 hours and retreated when necessary (Sheiman and Brophy, 2001; Gabrielli et al, 2016;

Madia, 2019). Patients will require short-term ultrasound and clinical follow up to ensure success (Sheiman and Brophy, 2001). Complications occur in 1.2% of patients, with distal embolisation being most common, at 0.5% (Madia, 2019). Alternatively, a compression-assisted removable guidewire or open surgery can be used to treat complex false femoral artery aneurysms (Gabielli et al, 2016; Madia, 2019).

### Infected

Surgical repair may be reserved for aneurysms that are infected, rapidly expanding or causing compressive symptoms (Madia, 2019). Simple arterial ligation without simultaneous vascular reconstruction is the preferred method, particularly in patients with a history of intravenous drug use for over 5 years, and is associated with low major adverse limb events (**Figure 4d**) (Salimi et al, 2008; Qiu et al, 2016; Quiroga et al, 2021). Alternatively, early vascular reconstruction using autologous (great saphenous vein, deep femoral vein or internal iliac artery) or prosthetic grafts can be performed (Salimi et al, 2008). These procedures often carry a 20% complication rate in the form of bleeding, haematoma, perioperative myocardial infarction and amputation (Madia, 2019). Emergency revascularisation is not recommended following simple ligation, because of the increased likelihood of infection and other complications, such as amputation (Arora et al, 2001; Salimi et al, 2008).

## Outcomes

Overall outcomes of femoral artery aneurysms are positive if identified early and managed appropriately, with improved outcomes more frequently observed in true rather than false femoral artery aneurysms (Saleem et al, 2021).

### Conservative

The reported outcomes of conservative management of femoral artery aneurysms are conflicting. Cutler and Darling (1973) found that 43% of patients managed conservatively developed acute complications. However, in their study of 182 patients with femoral artery aneurysms, Lawrence et al (2014) found very few acute complications (6%), with the majority of patients (64%) undergoing elective repair once aneurysms reached a 2.5 cm threshold. An acute complication in the form of rupture is most common (3% vs 2% for thrombosis and 1% for embolisation). Therefore, femoral artery aneurysms must be identified, investigated and risk-stratified early, so the aneurysm can be monitored and repaired when the threshold is reached, resulting in lower risk of complications and consequently improved outcomes.

### Surgical

Survival rates following surgery for femoral artery aneurysms are reported to be high, and postoperative outcomes are positive, with few cases of mortality and amputation along with high graft patency rates (Jarrett et al, 2002; Piffaretti et al, 2011; Lawrence et al, 2014). Short-term complications are most commonly wound-related, such as infection and haematoma. However, cases of lymphatic leak, bleeding, thrombosis and embolisation have been documented (Saleem et al, 2021). The incidence of major operative complications is reported to be up to 20% (Lawrence et al, 2014), with wound infection seroma or haematoma found in as many as 12% of cases; however, the occurrence of lower extremity ischaemia, deep vein thrombosis and compartment syndrome is relatively rare, occurring in 1.5%, 1% and 1% of cases respectively (Saleem et al, 2021). Complications unrelated to aneurysm repair include respiratory and renal complications (Saleem et al, 2021). Thirty-day mortality is reported to be up to 1.1% of patients (Lawrence et al, 2014).

Long-term prognosis is generally positive, with most complications being non-limb-related. Similar 5-year survival rates have been seen between observed and conservatively managed patients (Lawrence et al, 2014). Overall survival at 6 months is 88–94.5%, 88.6% at 1 year and 61.1–77.6% at 5 years (Jarrett et al, 2002; Piffaretti et al, 2011; Lawrence et al, 2014; Perini et al, 2014). Around 27% of patients died of non-aneurysmal causes (Lawrence et al, 2014). Cases of critical limb ischaemia or amputation can be secondary to lack of distal targets for revascularisation or postoperative graft thrombosis, reported by Perini

et al (2014) in 7% of cases. Lawrence et al (2014) found the mean ankle brachial pressure index at 1 year to be 0.91. Graft patency was reported at 90% in the first 6 months and 85% at 5 years (Perini et al, 2014). Symptomology was not a significant factor in survival (Lawrence et al, 2014). **Figure 5** outlines the pathway of presentation to management for patients with femoral artery aneurysms.

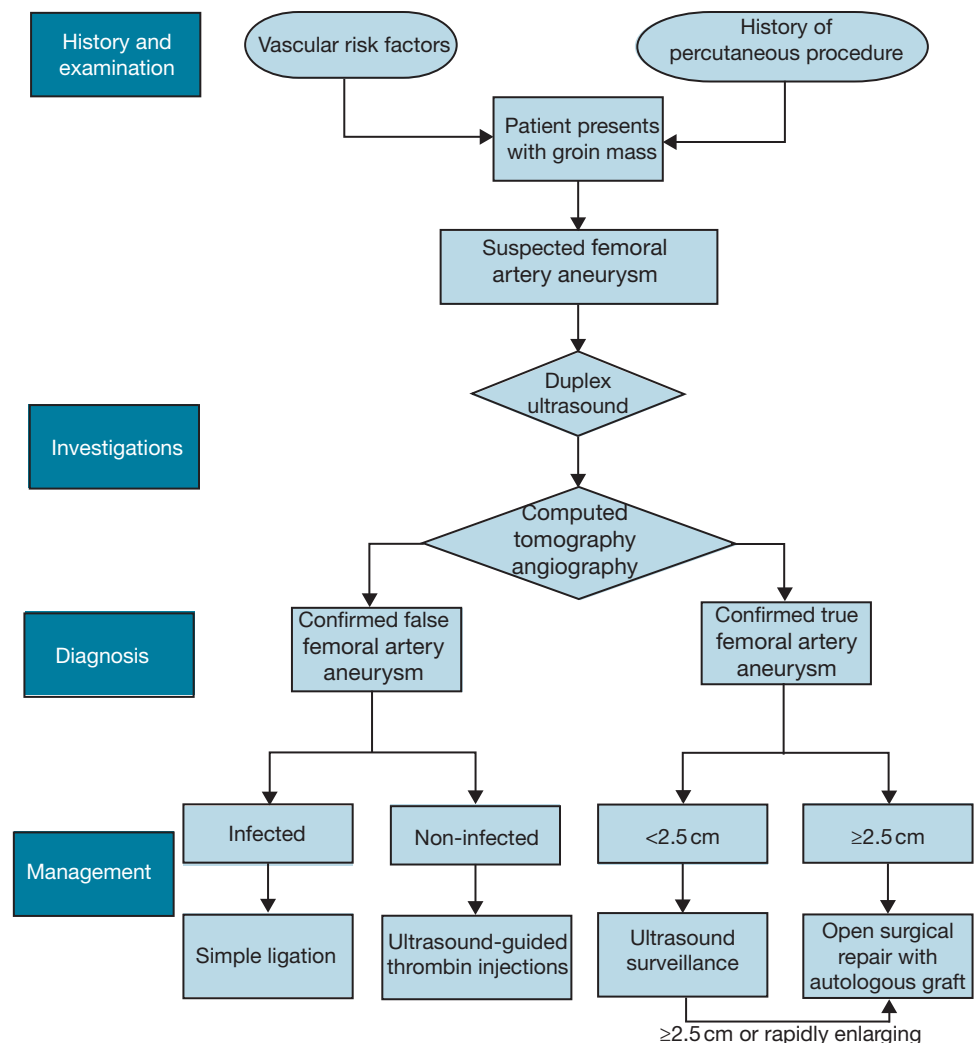
### Conclusions

Femoral artery aneurysms are dilations of either the common femoral artery, superficial femoral artery or profunda femoris artery, predominantly occurring in males over 65 years of age. False femoral artery aneurysms are more common than true aneurysms, and are frequently caused by percutaneous procedures. Thorough history-taking and examination is required to elicit diagnosis, and early vascular input is required to monitor patients and prevent complications. Although open surgical repair is currently the gold standard of management, endovascular and minimally invasive approaches have successfully been used to treat patients. This article will help clinicians appropriately identify and manage patients with femoral artery aneurysms and aid in early referral to a vascular specialist. This will improve overall patient outcomes through the prevention of devastating complications.

#### Author details

<sup>1</sup>School of Medicine, Keele University, Keele, UK

<sup>2</sup>Department of Vascular Surgery, Royal Stoke University Hospital, Stoke-on-Trent, UK



**Figure 5.** Pathway from presentation to management, based on available literature.

© 2022 MA Healthcare Ltd

## Key points

- False femoral artery aneurysms are more common than true femoral artery aneurysms, and are most commonly associated with catheterisation of the femoral artery for cardiac procedures.
- True aneurysms <2.5 cm and false aneurysms >2 cm can be managed conservatively if asymptomatic.
- Open surgical repair is the preferred management for true aneurysms reaching the 2.5 cm threshold.
- Ultrasound-guided thrombin injections are the treatment of choice for false aneurysms reaching the 2 cm threshold.
- Infected false aneurysms can be managed by simple arterial ligation without immediate revascularisation, as this reduces the likelihood of further infection and complications, such as amputation.

## Conflicts of interest

The authors declare that there are no conflicts of interest.

## References

- Abdel Wahab MA, Farouk N, Saleh OI. Early outcomes of traumatic femoral artery aneurysm (open repair versus endovascular treatment). *Ann Vasc Surg.* 2019;54:146–151. <https://doi.org/10.1016/j.avsg.2018.05.056>
- Ahmed A, Heyes A, Pandher J, Rajagopalan S. Abdominal aortic aneurysms. *Br J Hosp Med (Lond).* 2021;82(5):1–7. <https://doi.org/10.12968/hmed.2019.0351>
- Arora S, Weber MA, Fox CJ et al. Common femoral artery ligation and local debridement: a safe treatment for infected femoral artery pseudoaneurysms. *J Vasc Surg.* 2001;33(5):990–993. <https://doi.org/10.1067/mva.2001.114212>
- Atallah C, Al Hassan HK, Neglen P. Superficial femoral artery aneurysm—an uncommon site of aneurysm formation. *Eur J Vasc Endovasc Surg.* 1995;10(4):502–504. [https://doi.org/10.1016/S1078-5884\(05\)80178-9](https://doi.org/10.1016/S1078-5884(05)80178-9)
- Aune D, Schlesinger S, Norat T, Riboli E. Tobacco smoking and the risk of abdominal aortic aneurysm: a systematic review and meta-analysis of prospective studies. *Sci Rep.* 2018;8(1):14786. <https://doi.org/10.1038/s41598-018-32100-2>
- Corriere MA, Guzman RJ. True and false aneurysms of the femoral artery. *Semin Vasc Surg.* 2005;18(4):216–223. <https://doi.org/10.1053/j.semvascsurg.2005.09.008>
- Cutler BS, Darling RC. Surgical management of arteriosclerotic femoral aneurysms. *Surgery.* 1973;74(5):764–773. <https://doi.org/10.5555/uri:pii:0039606073900858>
- Dighe S, Thomas P. Ruptured superficial femoral artery aneurysm treated by simple ligation. *Singapore Med J.* 2008;49(6):e151–e152
- Gabriel M, Pawlaczyk K, Waliszewski K, Krasniński Z, Majewski W. Location of femoral artery puncture site and the risk of postcatheterization pseudoaneurysm formation. *Int J Cardiol.* 2007;120(2):167–171. <https://doi.org/10.1016/j.ijcard.2006.09.018>
- Gabrielli R, Rosati MS, Vitale S, Siani A, Caselli G. Thrombin injection and compression with removable guidewire in the treatment of postcatheterization femoral pseudoaneurysm. *J Cardiovasc Surg (Torino).* 2016;57(4):510–513
- Horn M, Stahlberg E, Goltz J et al. Management of groin pseudoaneurysms: indications and outcomes for thrombin injection vs. surgical treatment. *J Vasc Med Surg.* 2017;5(1):300. <https://doi.org/10.4172/2329-6925.1000300>
- Hotonu SA, Johnson CHN, Kansal N, Bhattacharya V. Common femoral artery aneurysm repair using bifurcated graft. *BMJ Case Rep.* 2018:bcr2017223331. <https://doi.org/10.1136/bcr-2017-223331>
- Huseyin S, Yuksel V, Sivri N et al. Surgical management of iatrogenic femoral artery pseudoaneurysms: a 10-year experience. *Hippokratia.* 2013;17(4):332–336
- Jani B, Rajkumar C. Ageing and vascular ageing. *Postgrad Med J.* 2006;82(968):357–362. <https://doi.org/10.1136/pgmj.2005.036053>
- Jarrett F, Makaroun MS, Rhee RY, Bertges DJ. Superficial femoral artery aneurysms: an unusual entity? *J Vasc Surg.* 2002;36(3):571–574. <https://doi.org/10.1067/mva.2002.125841>

- Lawrence PF, Lorenzo-Rivero S, Lyon JL. The incidence of iliac, femoral, and popliteal artery aneurysms in hospitalized patients. *J Vasc Surg.* 1995;22(4):409–415. [https://doi.org/10.1016/S0741-5214\(95\)70008-0](https://doi.org/10.1016/S0741-5214(95)70008-0)
- Lawrence PF, Harlander-Locke MP, Oderich GS et al. The current management of isolated degenerative femoral artery aneurysms is too aggressive for their natural history. *J Vasc Surg.* 2014;59(2):343–349. <https://doi.org/10.1016/j.jvs.2013.08.090>
- Lenartova M, Tak T. Iatrogenic pseudoaneurysm of femoral artery: case report and literature review. *Clin Med Res.* 2003;1(3):243–247. <https://doi.org/10.3121/cmr.1.3.243>
- Leon LR, Taylor Z, Psalms SB, Mills JL. Degenerative aneurysms of the superficial femoral artery. *Eur J Vasc Endovasc Surg.* 2008;35(3):332–340. <https://doi.org/10.1016/j.ejvs.2007.09.018>
- Levi N, Schroeder TV. Arteriosclerotic femoral artery aneurysms. A short review. *J Cardiovasc Surg (Torino).* 1997;38(4):335–338
- Levi N, Schroeder TV. True and anastomotic femoral artery aneurysms: is the risk of rupture and thrombosis related to the size of the aneurysms? *Eur J Vasc Endovasc Surg.* 1999;18(2):111–113. <https://doi.org/10.1053/ejvs.1999.0842>
- Madia C. Management trends for postcatheterization femoral artery pseudoaneurysms. *JAAPA.* 2019;32(6):15–18. <https://doi.org/10.1097/01.JAA.0000558236.60240.02>
- Perini P, Jean-Baptiste E, Vezzosi M et al. Surgical management of isolated superficial femoral artery degenerative aneurysms. *J Vasc Surg.* 2014;59(1):152–158. <https://doi.org/10.1016/j.jvs.2013.07.011>
- Piffaretti G, Mariscalco G, Tozzi M et al. Twenty-year experience of femoral artery aneurysms. *J Vasc Surg.* 2011;53(5):1230–1236. <https://doi.org/10.1016/j.jvs.2010.10.130>
- Pinto S, Jantre M, Prendergast M. Ruptured superficial femoral artery aneurysm: a case report. *Radiol Case Rep.* 2017;12(2):244–246. <https://doi.org/10.1016/j.radcr.2017.01.020>
- Qiu J, Zhou W, Zhou W et al. The treatment of infected femoral artery pseudoaneurysms secondary to drug abuse: 11 years of experience at a single institution. *Ann Vasc Surg.* 2016;36:35–43. <https://doi.org/10.1016/j.avsg.2016.03.030>
- Quiroga E, Shalhub S, Tran NT, Starnes BW, Singh N. Outcomes of femoral artery ligation for treatment of infected femoral pseudoaneurysms due to drug injection. *J Vasc Surg.* 2021;73(2):635–640. <https://doi.org/10.1016/j.jvs.2020.05.074>
- Rancic Z, Pecoraro F, Pfammatter T et al. Less invasive (common) femoral artery aneurysm repair using endografts and limited dissection. *Eur J Vasc Endovasc Surg.* 2013;45(5):481–487. <https://doi.org/10.1016/j.ejvs.2013.01.038>
- Saleem T, D'Cruz JR, Baril DT. *Femoral Aneurysm Repair.* Treasure Island (FL): StatPearls; 2021
- Salimi J, Shojaeefar A, Khashayar P. Management of infected femoral pseudoaneurysms in intravenous drug abusers: a review of 57 cases. *Arch Med Res.* 2008;39(1):120–124. <https://doi.org/10.1016/j.arcmed.2007.07.004>
- Sandgren T, Sonesson B, Ahlgren R, Lanne T. The diameter of the common femoral artery in healthy human: influence of sex, age, and body size. *J Vasc Surg.* 1999;29(3):503–510. [https://doi.org/10.1016/S0741-5214\(99\)70279-X](https://doi.org/10.1016/S0741-5214(99)70279-X)
- Sharma S, Nalachandran S. Isolated common femoral artery aneurysm: a case report. *Cases J.* 2009;2:7522. <https://doi.org/10.1186/1757-1626-2-7522>
- Sheiman RG, Brophy DP. Treatment of iatrogenic femoral pseudoaneurysms with percutaneous thrombin injection: experience in 54 patients. *Radiology.* 2001;219(1):123–127. <https://doi.org/10.1148/radiology.219.1.r01ap43123>
- Sizemore G, Ayubi F, Clark B, Kellicut D. Ultrasound-guided percutaneous thrombin injection following iatrogenic femoral artery pseudoaneurysm: patient selection and perspectives. *J Vasc Diagn Interv.* 2018;2018(6):1–5. <https://doi.org/10.2147/JVD.S127255>
- Stone PA, Campbell JE, AbuRahma AF. Femoral pseudoaneurysms after percutaneous access. *J Vasc Surg.* 2014;60(5):1359–1366. <https://doi.org/10.1016/j.jvs.2014.07.035>
- Tulla K, Kowalski A, Qaja E. *Femoral aneurysm.* Treasure Island (FL): StatPearls; 2021
- Tulla K, Kowalski A, Qaja E. *Femoral artery pseudoaneurysm.* Treasure Island (FL): StatPearls; 2022
- Yang EY, Tabbara MM, Sanchez PG et al. Comparison of ultrasound-guided thrombin injection of iatrogenic pseudoaneurysms based on neck dimension. *Ann Vasc Surg.* 2018;47:121–127. <https://doi.org/10.1016/j.avsg.2017.07.029>