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Popliteal arterial aneurysms

Carlton Rowlands[1]

Sofian Youssef[2]

Sriram Rajagopalan[1,3]

Author details can be found at the end of this article

Correspondence to:
Sofian Youssef;
sofian_y@hotmail.co.uk

Abstract

Aneurysms are associated with significant complications if not diagnosed and managed appropriately. Popliteal arterial aneurysms are the most common peripheral aneurysm, and can cause pain, nerve compression, ischaemia and limb loss. Vascular surgery is an emerging specialty under the remit of general surgery, with the primary objectives of preventing death and limb loss. This article summarises the epidemiology, investigation and management of popliteal arterial aneurysms for vascular and non-vascular trainees.

Key words: Aneurysm; Endovascular aneurysm repair; Popliteal; Vascular

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Definition

A popliteal arterial aneurysm is a localised dilatation of more than 1.5 times the diameter of the adjacent arterial segment (Callum et al, 1974). Typically, the diameter of the popliteal artery ranges from 0.72 to 1.1 cm depending on age, sex, ethnicity and body weight (Trickett et al, 2002).

Epidemiology

The overall prevalence of popliteal arterial aneurysms in men aged 65–85 years is estimated at 1%. These account for 70–85% of all peripheral aneurysms, approximately half of which are bilateral (Shiwani et al, 2018; Beuschel et al, 2021). A meta-analysis of 16 353 cases reported that 1 in 4 patients with a unilateral popliteal arterial aneurysm had concurrent aneurysms (of which 1 in 6 had an abdominal aortic aneurysm) (van Laarhoven et al, 2021). This is consistent with earlier associations linking 37% of bilateral popliteal arterial aneurysms with aortic, iliac and femoral aneurysms (Ravn et al, 2007). The incidence of popliteal arterial aneurysms differs between the sexes; the incidence in women is reported as 1.6%, but most cases in both sexes are operated on only as a result of symptoms (Peeran et al, 2016). The incidence is greater in men (3%), but the age at the time of repair is similar (73.5 years in women vs 71.7 years in men) (Aldoori and Rahman, 1999; Peeran et al, 2016).

Pathophysiology

While the precise pathogenesis is yet to be delineated, the process of aneurysm formation is likely to involve proteolytic degradation of the vessel wall, whereby abnormalities in the production and regulation of metalloproteinases result in an inflammatory response. This may be compounded by haemodynamic stress and flow turbulence. Genetic predisposition to mechanical stresses and decreased wall strength has also been reported in the pathological dilation of the artery (Dawson et al, 1997). Anatomically, the popliteal fossa provides a source of haemodynamic stress. Within this space, the artery becomes more tortuous as the knee is flexed and it elongates on extension. Moreover, the femoral artery transitions from a tightly packed position anterior to the adductor magnus to a freely movable position as the popliteal artery in the popliteal fossa. The adductor hiatus marks this transition point and acts as a site for mechanical traction and compression forces that may precipitate haemodynamic stress (Kale et al, 2012). A mechanical scissoring effect with the adjacent vastus medialis has also been reported to lead to an adductor canal outlet syndrome, with subsequent thrombosis of the femoral artery at the level of the hiatus (Cohn and Taylor, 1990). A computed tomography angiogram axial image through the knee joint showing a fusiform aneurysm of the popliteal artery is shown in Figure 1 (Oh, 2013).

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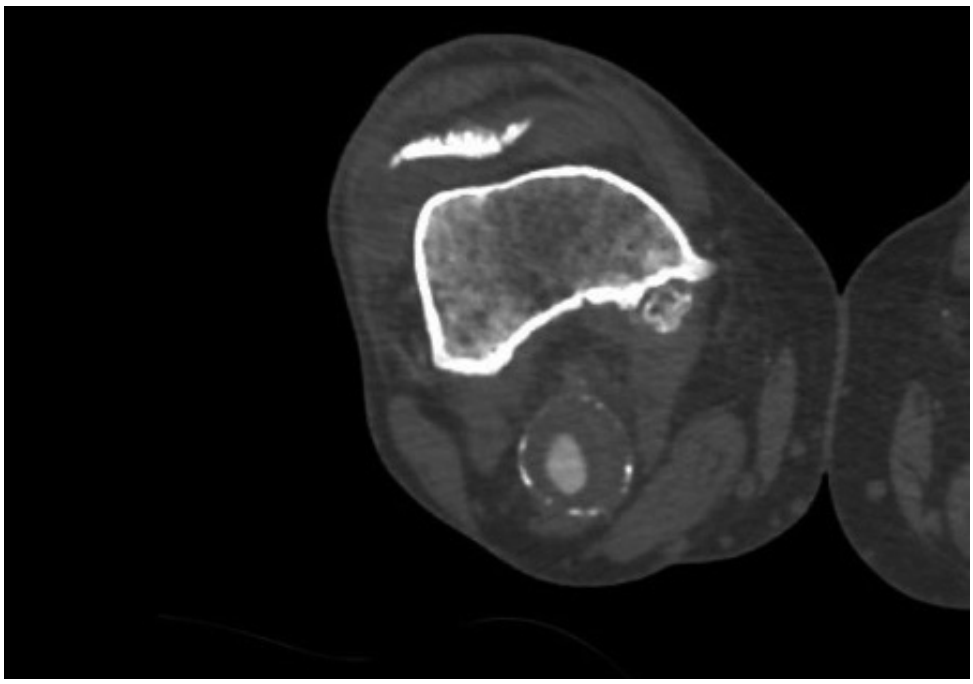

Figure 1. Axial computed tomography angiogram of the right leg through the knee, demonstrating a fusiform popliteal artery aneurysm posterior to the knee joint (Oh, 2013).

Examination

The popliteal artery is situated deeply within the popliteal fossa as a continuation of the femoral artery. It is located medial to the biceps femoris and lateral condyle of the femur, and lateral to the semimembranosus and medial condyle of the femur (Moore and Dalley, 2006). For optimal examination, the knees should be semi-flexed; palpating using two hands, thumbs placed together anterior to the knee and palpating in the popliteal fossa with index, middle and ring finger. It is important to note that only 60% of popliteal arterial aneurysms result in examinable pulsatile masses in the fossa (Kassem and Gonzalez, 2021).

Investigation

Duplex ultrasonography is the screening and diagnostic imaging modality of choice to detect a popliteal arterial aneurysm and provide an estimate of its diameter (Golchehr et al, 2018). It also offers important details of vessel patency, mural thrombus formation and vessel outflow status, all fundamental components of surgical decision making. Alternative imaging includes computed tomography or magnetic resonance angiography, which provide accurate measurements of true lumen diameters and inform operative repair.

Complications

Complications of ischaemia are common in patients with popliteal arterial aneurysms, occurring in approximately 42–77% of patients and with amputation rates of up to 20% (Dawson et al, 1991). Chronic limb ischaemia is a symptomatic reduction in blood supply over >14 days (graded Rutherford I–IV), which may occur as a result of embolising fragments of thrombus contained within the aneurysmal sac. Acute limb ischaemia may result from sudden thrombotic occlusion of the aneurysm. Rupture of a popliteal aneurysm is very rare. Compression of the popliteal vein or the tibial nerve may cause indirect symptoms of leg oedema and pain respectively, and above-ankle amputation is required in 4% of patients with these complications (Roggo et al, 1993). Therefore, there is a convincing argument for pre-emptive treatment of popliteal arterial aneurysms – it is suggested that aneurysmal sacs measuring more than 2–3 cm should be considered for early intervention (Galland and Magee, 2005).

Management

The primary indication for surgical management of popliteal arterial aneurysms is active symptomatology because of the increased associated risk of thrombosis, peripheral arterial disease and limb loss. Historically, there has been a high rate of amputation in patients presenting with acute limb ischaemia from a popliteal arterial aneurysm. As such, a pre-emptive approach to the surgical management of popliteal arterial aneurysms is also needed. Key high-risk features warranting consideration for early treatment are (Galland and Magee, 2005):

1. Symptomatic aneurysms
2. Aneurysms measuring greater than 2 cm
3. Aneurysmal 'kinking' > 45° angulation
4. Reduced distal patency (often referred to as 'runoff')
5. Thrombosis.

Theoretically, as vessels enlarge the risk of 'kinking' increases, as may the risk of thrombosis or micro-emboli (Galland and Magee, 2005). The evidence regarding surgical 'cut off points' remains sparse, based mainly on single-centre data with few randomised controlled trials (Kassem and Gonzalez, 2021). More high-quality, objective, multicentre research is needed to stratify evidence-based cut-off points for surgical intervention.

Conservative management vs open vs endovascular repair

Options for management of popliteal arterial aneurysms can be broadly categorised into three approaches: non-operative conservative management, open surgical repair and endovascular popliteal aneurysm repair (Tsilimparis et al, 2013). Conservative management in the form of duplex surveillance is mainly reserved for asymptomatic patients with aneurysms <2 cm. Open surgical repair comprises two options: bypass or in-lay repair with vein or synthetic graft (Figure 2). Bypass surgery involves ligation of the proximal and distal popliteal artery, and bypass of the excluded segment with a reversed saphenous vein (autologous graft) or prosthetic graft (Figure 2a). Occasionally, as a result of vessel quality, the proximal anastomosis may need to be made to the common femoral artery and distally to the tibio-peroneal branch (Joshi et al, 2019). In-lay repair involves the posterior approach, whereby the sac is opened and the interposition graft is anastomosed to the neck of the aneurysm and the outflow vessel distally. The sac is closed over the aneurysm with or without partial sac wall excision (Figure 2b). The third modality is endovascular; a small groin incision is made to access the ipsilateral common femoral artery. A heparin-bonded stent is then placed under radiological guidance to exclude the aneurysmal sac (Figure 2c). Endovascular

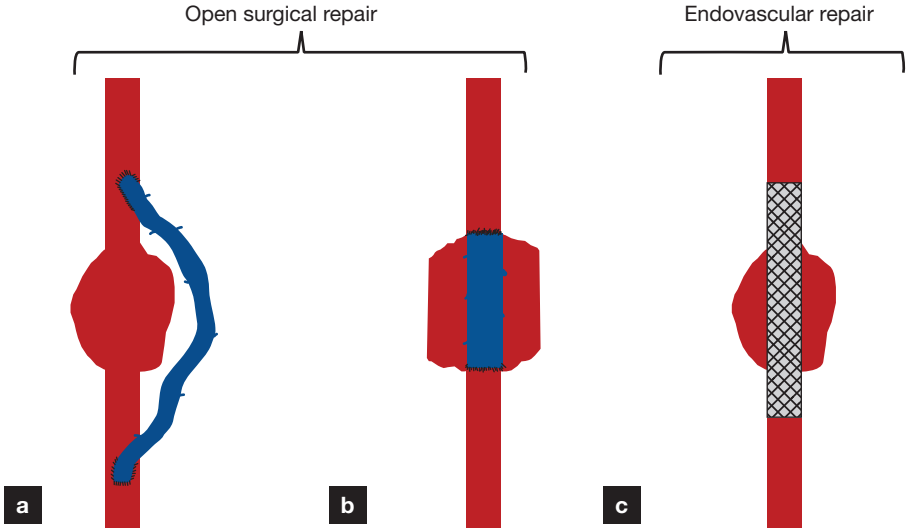

Figure 2. Three definitive approaches to the treatment of popliteal arterial aneurysms: open surgical repair in the form of (a) bypass surgery and (b) in-lay repair, or (c) endovascular repair. Adapted from Tsilimparis et al (2013).

management may be deemed appropriate in anatomically suitable patients, who are otherwise unfit for general anaesthetic or open surgical repair as a result of multiple comorbidities.

The advent of endovascular aneurysm repair has transformed vascular practice. Although minimally invasive endovascular surgical approaches present undoubted benefit of reduced cosmetic scarring and faster postoperative recovery times, primary patency rates remain central to decision making. Primary patency, as described by Sidawy et al (2002), is 'the interval from the time of access placement until any intervention designed to maintain or re-establish patency, access thrombosis, or the time of measurement of patency'. Secondary patency is the time interval from access placement to complete site abandonment (Sidawy et al, 2002). Patency rates are a popular measure for the efficacy of both open and endovascular repairs. Open surgical repair has been regarded as the gold standard since Leake et al (2017) reported a 76% primary patency at 5 years, showing this to be both a durable and effective approach. High-quality evidence comparing open vs endovascular approaches to popliteal aneurysm repair is sparse and currently limited to one small randomised controlled trial, published almost two decades ago (Antonello et al, 2005). While the study reported inferior endovascular patency rates at 1 year (93.3% vs 100%; relative risk 0.94; 95% confidence interval 0.88–1.13, moderate certainty evidence), patency rates at 4 years were insignificantly different (Joshi et al, 2019). More recent evidence from a meta-analysis (14 studies, level 1b to 2b evidence, 4880 international popliteal arterial aneurysm repairs) suggests favourable primary patency rates with open surgical repair (88% vs 81% at 1 year, 79% vs 69% at 3 years) (Leake et al, 2017). However, there was no significant difference in secondary patency at 3 years. Endovascular popliteal aneurysm repair has a lower rate of postoperative complications (0.56%, 4/713), whereas open surgical repair is associated with a 7.3–22% complication rate and a five-fold increase in wound infection rate (Leake et al, 2017). However, composite complication rates (adverse events secondary to the procedure itself yet not a direct consequence of it) were equal between procedures.

Careful interpretation is required when assessing the likelihood of thrombosis. Open surgical repair is associated with a reduced risk of thrombosis, whereas thrombosis following endovascular popliteal aneurysm repair exclusively occurs within the first 30 days postoperatively. 'Endoleaks' are a well-documented complication of endovascular repairs of all kinds. There is currently a lack of systematic classification regarding endovascular popliteal aneurysm repair endoleaks, categorisation currently follows that for abdominal aortic repairs (Seiler et al, 2020). Without comprehensive, tailored classification systems, it remains difficult to precisely stratify adverse treatment effects to offer a balanced comparison of endovascular popliteal aneurysm repair and open popliteal aneurysm repair (Seiler et al, 2020). Endovascular popliteal aneurysm repair is a potentially safe alternative to open surgical repair with some higher rates of short-term reintervention and graft thrombosis (Tian et al, 2020).

Formal clinical recommendations regarding the recommended surgical approach are yet to be developed by independent bodies such as the National Institute for Health and Care Excellence. As such, Leake et al (2017) have proposed a treatment algorithm. The current indication for endovascular popliteal aneurysm repair is asymptomatic (or non-limb threatening but symptomatic), clinically stable patients, who also fulfil any one of the following criteria:

1. There is two or more vessel run off
2. Presence of a 15 mm landing zone with which to adhere the graft
3. Poor cardiovascular reserve (risks of high surgical morbidity).

Recommendations are also yet to be established for the medical management of these patients postoperatively. However, there is strong evidence that there is no benefit of using antiplatelet therapy post-endovascular repair. Cervin et al (2021) demonstrated that vessel patency was not affected by stent length, angulation or medical therapy in the form of single or dual antiplatelet therapy or anticoagulation.

Management of acute presentations of popliteal arterial aneurysm in the form of acute limb ischaemia may be classified as per the validated Rutherford classification. Acute limb ischaemia may be identified by the hexad of Ps, six symptoms starting with the letter P that indicate the presence of ischaemia: pain, pallor, poikilothermic, pulselessness, paraesthesia and paralysis (Rutherford et al, 1997). In all instances of acute limb ischaemia, patients are

Table 1. Clinical categories of acute limb ischaemia

					Doppler signals	
Grade	**Category**	**Sensory loss**	**Motor deficit**	**Prognosis**	**Arterial**	**Venous**
I	Viable	None	None	No immediate threat	Audible	Audible
IIA	Marginally threatened	None or minimal	None	Salvageable with prompt treatment	Inaudible	Audible
IIB	Immediately threatened	More than toes	Mild/moderate	Salvageable with prompt revascularisation	Inaudible	Audible
III	Irreversible	Complete anaesthesia	Complete paralysis	Amputation and permanent nerve damage	Inaudible	Inaudible

From Rutherford et al (1997)

anticoagulated with intravenous heparin and considered for urgent surgical intervention to prevent limb loss. The classification categorises based on viability, which informs further management options (Table 1).

Conclusions

Popliteal arterial aneurysm is the most common peripheral aneurysm, and these patients frequently have concurrent aneurysms. Thorough clinical history, examination and early vascular input are essential to effectively manage patients with popliteal arterial aneurysms. Vascular intervention is still evolving and long-term, objective, high-quality research is needed to develop effective risk stratification tools to determine the approach of choice. At present, open surgical repair remains the gold standard, providing the best primary patency rates.

Author details

[1]Department of Vascular Surgery, Keele University School of Medicine, Newcastle-under-Lyme, UK

[2]Department of Integrated Academic Training, University of Nottingham, Nottingham, UK

[3]Department of Vascular Surgery, University Hospitals of North Midlands NHS Trust, UK

Conflicts of interest

The authors declare that there are no conflicts of interest.

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Key points

- Elective repair of popliteal arterial aneurysms is associated with superior outcomes.
- Open surgical repair is currently the gold standard approach for popliteal aneurysm repair, offering superior primary patency rates, and lower reintervention rates and 30-day thrombotic or occlusion risk.
- Endovascular repair is an emerging approach for popliteal aneurysms providing shorter length of stay and low rates of wound complication.
- Thorough basic vascular examination of patients can improve detection rates of asymptomatic popliteal aneurysms.

Curriculum checklist

This article addresses the following requirements from the general internal medicine curriculum:

- Is focussed on patient safety and delivers effective quality improvement in patient care
- Providing continuity of care to medical inpatients, including management of comorbidities and cognitive impairment
- Managing medical problems in patients in other specialties and special cases

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