History of the Management of Popliteal Artery Aneurysms

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Management of popliteal aneurysms remains controversial. Debate continues as to when an asymptomatic popliteal aneurysm should be treated and, with concerns regarding the fate of a bypassed popliteal aneurysm and the advent of intravascular stents, what procedure is best.

This paper reviews the history of popliteal artery aneurysm management with particular emphasis on treatment and results before the modern era of arterial reconstruction. The aim of treatment then was to induce thrombosis. Now it is to prevent thrombosis.

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Aneurysms were first described more than 4,000 years ago. The Ebers Papyrus (ca. 2000 BC) describes features and treatment of peripheral artery aneurysms.1 Although these aneurysms were likely to be mostly traumatic in origin atherosclerosis and arterial calcification have been identified in Egyptian mummies.2 Galen (AD 131–200) is credited with the first definition of an aneurysm as “a localised pulsatile swelling which disappeared on pressure”.3 Antyllus (3rd century AD) is the first to have described an elective operation for an aneurysm. He also differentiated true from false aneurysms.

In 1953 a popliteal aneurysm was graphically described as a “sinister harbinger of sudden catastrophe”.4 The “sudden catastrophe” was that of thrombosis of the popliteal aneurysm leading to an acutely ischaemic limb. Up until the 20th century the aim of treating popliteal aneurysms was to induce thrombosis! Indications for operation at that time were pain, swelling of the leg and rupture of the aneurysm. From early in the 20th century attempts were made to prevent thrombosis from happening such that currently up to 80% of popliteal aneurysms are asymptomatic at the time of their treatment.5

Antyllus’ Technique

Proximal and distal ligatures were applied to isolate the aneurysm which was then opened and it’s contents evacuated.6 Sometimes the aneurysm was packed.

For popliteal aneurysm this technique was first successfully used by Keyslère in 1744.6 However, generally it was disastrous. Without the benefit of modern anaesthesia it would have been difficult for both patient and surgeon. The operation was usually undertaken when the femur and tibia had both been eroded by the aneurysm. Identification of vessels and control of bleeding would have been problematic. Late infection within the sac was often responsible for a fatal secondary haemorrhage. Bradford Wilmer, in 1779, stated that “…there is not, that I know, a single case upon record where that operation has succeeded”. Percivall Pott (1714–1788) advocated amputation as being the best treatment for popliteal aneurysms once they had become symptomatic.7 He stated that he had never “…seen any other operation than that of amputation which has preserved the life of the patient”.

Compression

The aim of compression, carried out either indirectly on the superficial femoral artery, directly on the aneurysm or a combination of the two, was to thrombose the popliteal aneurysm. This was first described as a potential treatment for popliteal aneurysm by Heister. The first three successful cases were described...
by Guattani in 1772. Several different techniques were used.

**Flexion**

This technique is attributed to the Swiss surgeon Theodore Maunoir (1806–1869). The principle was to flex the hip and knee joint or the knee joint alone so inducing thrombosis. This treatment could be used alone or in combination with other forms of compression therapy, for example, if compression therapy became “unbearable” this could be stopped temporarily but the knee kept in a flexed position. Alternatively, it could be used following failure of ligation. Recommendation for patient selection included age less than 50 years, those of a “non-irritable, placid temperament” and no arthritis. Aneurysm selection included those of “moderate dimensions”, those containing clot (though it is difficult to know how this was determined) and those at the lower rather than the upper end of the popliteal artery as results were likely to be better for the former.

Two methods are described. Firstly, flexion of the knee alone which could be achieved, for example, by attaching the heel of a patient’s slipper to a belt around his thigh or pelvis. The second was to flex both the hip and knee. Following gentle bandaging of the leg, with or without a pad in the popliteal fossa, the leg was held in position by a bandage around the thigh and ankle or by attaching the ankle to a belt around the pelvis, waist or shoulder. The limb was bandaged securely in this position. It was often recommended that the degree of flexion was increased over a period of time. Ideally, it was recommended that the patient should lie on the side of the aneurysm with the limb supported by pillows. In effect, the good leg overlying the leg being treated would act as a weight on the limb. It was commented that this technique was “... by no means painless.” Varying degrees of patient compliance were achieved and periods of “rest” were often required during treatment.

The results were variable. Success was sometimes achieved within hours, on the other hand, failure after many weeks of painful treatment was also recorded. Barwell reviewed 91 cases published in the literature and combined these with a further 16 which he personally acquired from patient records from St Bartholomew’s, Charing Cross, St George’s, Guy’s, St Thomas’ and University College Hospitals. Of the 91 published cases 26 were treated by flexion alone. In nineteen of these 26 cases the treatment was described as being successful. Overall, success was achieved in 42 of the 91 cases. Of the 49 failures 25 went on to ligation, 13 were treated by pressure, apparently with cure, four underwent amputation and three died. In four cases details were unclear. Barwell makes the point that it is likely that only successful cases were reported! Of the 16 cases obtained from hospital recorded seven were treated by flexion alone. Overall, success was achieved in seven cases, failure in six, there were two amputations and one patient died.

**Esmarch bandage (Reid’s method)**

First described by Sir Walter Reid RN in 1875. The Esmarch bandage was easily applied without any great experience. However, concerns were expressed that as the whole leg was compressed this could induce both arterial and venous thrombosis.

Results were presented to the Surgical Section of the International Congress, London 1881 by Mr Pearce Gould. Some 47 popliteal aneurysms had been treated. Success was achieved in 27. Of the failures 18 went onto have ligature, three of whom died, one other patient died, one underwent an amputation and one developed gangrene (outcome unknown). The point is made that in 22 of 47 cases treatment was repeated at least once. Of these 13 remained “uncured” and one patient died. (In other words success was achieved in 19 of 25 patients at the first treatment compared with only eight of 22 at subsequent treatments, $P < 0.0085$, Fisher’s exact test).

**Indirect pressure**

**Digital**

This involved trained assistants. One pressed on the femoral artery on the groin while another assessed whether pulsation was occurring in the popliteal aneurysm. A third person took over from the assistant in the groin when the latter became tired. After four hours a new team would take over. A 4–6 lb weight was placed over the assistant’s fingers pressing on the groin “...to spare muscular fatigue...” Willard Parker of New York used teams of medical students to carry out the procedure!.

**Use of weights**

This technique substituted digital pressure at the groin for various weights up to 12 lbs. Multiple weights in different parts of the thigh were sometimes used. Assistants were required to feel for pulsation in the aneurysm and adjust the position of the weights.
**Instrumental pressure**

Numerous devices were described, some of which are shown in Fig. 1. The principle was to wrap a device around the thigh. Each device had one or more screws which were tightened so as to apply pressure on the femoral artery in the thigh and/or groin. Pressure could be applied gradually so as to reduce slowly pulsation in the aneurysm. This seemed to result in a lower chance of either gangrene of the leg or skin necrosis at the point of pressure. The alternative was...
to tighten the screw such that immediate abolition of the popliteal pulsation was achieved.

Results have been described by Barwell. He took 148 cases from American, British and continental journals published 1870–1879. This he combined with 90 cases collected from the six London hospitals described earlier. Combining the data, this form of compression was successful in 112 of 238 (47%) cases. Some 91 of 118 failures (77%) went on to have ligation. The overall death and amputation rate was 7.5%. Duration of treatment varied. Instrument compression took an average of 12 days (range 24 hours–7 weeks), digital compression 5.5 days (4.5 hours to 24 days) and a combination of the two 44 days (44 hours to six months).

**Ligation**

Ambrose Pare (1510–1590) emphasised the danger of opening the aneurysm sac and recommended proximal ligation alone for treatment of an aneurysm. Ligation for an unopened aneurysm in the antecubital fossa was first carried out by the French surgeon Dominique Anel (1679–1725) in 1710. Doubts raised by contemporary detractors were that the aneurysm was not cured or if it was it was by luck only. The case, along with responses to these criticisms was eventually published in 1714. Some of the difficulties were due to the fact that the technique would obviously not work when dealing with an arteriovenous fistula. This condition was described by William Hunter in 1757.

**Proximal ligation at the neck**

On 22 June 1785 at the Hotel Dieu in Paris, Pierre-Joseph Desault (1744–1795), the French Surgeon, ligated a popliteal artery as it entered a popliteal aneurysm. He had dissected a spontaneously thrombosed popliteal aneurysm some nine years earlier in 1776. This suggested proximal ligation could imitate spontaneous cure. In some cases there is clearly a demarcation between a normal artery and the aneurysm. Under those circumstances the operation would certainly be feasible. However, not infrequently the demarcation between the feeding artery and the aneurysm is much less clear cut. The popliteal artery can be ectatic and thin walled, “...distempered some way above the dilatation...”. This would make identification of the junction difficult and furthermore, ligatures would be likely to cut through the abnormal artery. Desault only operated on one further case. The ligature was placed more proximally on the femoral artery using Hunter’s technique, of which he was aware.

In December 1785 John Hunter (1728–1793) carried out a proximal ligation at the neck for a popliteal aneurysm. This was a young man with a false popliteal aneurysm. Under tourniquet Hunter tied off the artery entering the aneurysm. The point was made that this was difficult. On the 5th postoperative day the artery “burst” at the point of ligature. At this point Hunter comments that “I then took up the artery a little higher, where was I sure it was sound”. Although the patient died three days later it is apparent that Hunter was impressed that operating on normal artery distant from the actual aneurysm was a sensible option. The first successful case carried out by Hunter was on a 45 year coachman. This patient could hardly walk because of an increasing pulsatile orange-sized swelling behind his knee. Hunter placed four ligatures on the artery well distant from the aneurysm. The patient left St George’s Hospital six weeks later. On his death, 15 months later Hunter examined the limb and found that the aneurysm was completely thrombosed. The procedure was variously described by Hunter’s contemporaries as an “eternal monument”, the “greatest wonder” and a “simple and beautiful operation”.

Barwell collected together 230 cases from the literature carried out between 1785 and 1869. To these he added 67 cases, details of which he obtained from the six London Hospitals. Overall, 67 of the 297 patients died (17.8%). However, he makes the point that results were improving throughout the time that cases were described. Of the 67 cases which he collected, carried out in the ten years between 1870 and 1879, only two patients died (3%) though 10 (15%) underwent a major amputation. Thus the “failure rate” during this period was 18%.

It is difficult to know what was the preferred choice of treatment for popliteal aneurysms during this time. It is clear that methods of treatment were often combined. Over the ten years that Barwell collected his data from the six London teaching hospitals he found that 90 cases of popliteal aneurysms had been treated with compression compared with 67 which underwent ligation. It is certainly possible that compression was the first line of treatment and ligation reserved for those where this failed.

**Endoaneurysmorrhaphy**

In 1888 Rudolph Matas (1860–1957), from New Orleans, carried out proximal and distal ligation of...
a brachial artery aneurysm. He then tried to remove the aneurysm sac. This proved impossible but as the sac continued to bleed he closed off all vessels entering and leaving it and obliterated the sac by successive layers of sutures within it. This he termed obliterative endoaneurysmorrhaphy (Fig. 2).

He described two further variations. Restorative endoaneurysmorrhaphy was carried out for saccular aneurysms. The aneurysm was opened, clot evacuated and the connection between the aneurysm and the native artery closed off and the sac obliterated. Flow continued through the patent artery. In reconstructive endoaneurysmorrhaphy continuity of the artery was maintained by making a new channel, by closing the arterial walls over a stent placed in the proximal and distal communicating vessels. Immediately before completing the anastomosis the stent was withdrawn and the obliteration completed.

In 1906 Matas reported the results of 34 aneurysms treated by endoaneurysmorrhaphy which had been operated on by 21 (mainly American) surgeons. Nineteen of these aneurysms were popliteal. Of these there was one postoperative death from sepsis. There were no cases of secondary haemorrhage or early gangrene. There were four late “relapses” two of these resulted in amputation. In discussion of that paper three further popliteal aneurysms were described as being treated by an endoaneurysmorrhaphy. All had a good outcome ultimately, although secondary haemorrhage occurred in one patient.

**Sympathectomy**

Despite the apparently encouraging results of obliteration of the PA it is clear that some legs become ischaemic. Estimates suggested amputation rates of 8–15%, allowing for unsuccessful cases not being published. Several tests were described to define whether the collateral circulation was likely to be adequate. None were reliable. The effect of sympathectomy on the circulation had been known for a few years. On June 9 1934 Clarence Bird from Louisville, Kentucky carried out a lumbar sympathectomy followed a month later by an oblitative endoaneurysmorrhaphy. The limb remained viable.

**Excision or Exclusion of Aneurysm and**

**Popliteal vein interposition**

First described by Jose Goyanes, from Madrid (1876–1964). A 41 year old baker had a symptomatic syphilitic and/or atherosclerotic PA ligated and bypassed

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in June 1906. Despite needing a priest postoperatively the short term results were good!!.

End to end anastomosis

Attributed to the German surgeon Enderlen (1863–1963) in 1907. Excision and re-anastomosis is still occasionally used for small, localised PA.18

Reversed saphenous vein interposition

Described as being the “ideal operation” it was first carried out for a popliteal aneurysm by Eric Lexer (1867–1937) from the University of Jena in about 1912. The first in Britain was carried out in the same year by Pringle, 1863–194119 and the first in USA by Bernheim in 1915.20 The procedure involves a posterior approach21 and has largely been superseded by ligation and bypass using a medial approach. It remains useful for large PA producing pressure symptoms in the popliteal fossa.

Synthetic graft interposition

First described by Crawford et al.22 Of 317 synthetic grafts used for the aorta or popliteal vessels, four were carried out for popliteal artery aneurysms. Results were encouraging.

Another way in which Dacron was used in the context of popliteal aneurysms was to use it to replace a native external iliac artery which in turn was used to replace the patient’s popliteal aneurysm.23 As before, it remains impossible to know the preferred choice of treatment for popliteal aneurysms during the early part of the 20th century. A review of all aneurysms operated on at the Johns Hopkins Hospital in Baltimore 1891–192224 provides some information. Of 142 aneurysms, 16 involved the popliteal artery.

Various ligation procedures were undertaken in eight cases, Matas procedures were attempted in three but in one case it was impossible due to rigidity of the wall of the aneurysm and an Antyllus technique was performed and two Lexer procedures were carried out in the latter part of the study.

In a review of 100 PA dealt with at the Mayo Clinic 1913–1951 Gifford et al.5 described 13 cases undergoing sympathectomy combined with removal (nine) or oblitative endoaneurysmorrhaphy (four). There was one postoperative amputation and they concluded that the treatment of choice for PA was sympathectomy followed by immediate “extirpation”.

Ligation and Bypass

Proximal and distal ligation of the PA combined with reversed saphenous vein bypass via the medial approach was first described by Edwards in 1969.25 He described six PA so treated with good results. He made the point that it was unnecessary to remove the popliteal aneurysm so avoiding damage to the popliteal vein.

This technique, using either vein or synthetic graft, is the most commonly used operation today. For elective repair of an asymptomatic PA 30 day mortality and limb loss are each less than 1%, residual symptoms are present in 1% of cases and 5 year graft patency is 70–94%.26 The results are generally worse following thrombosis of the PA.

Recent reports have suggested that following successful ligation and bypass the PA can go on to produce problems. Arterial flow within the aneurysm has been described in up to one third of cases27–29 and significant symptoms in up to one fifth of cases.28–30 Although not confirmed by others31 this is nevertheless a concern. Perhaps the posterior surgical approach described earlier needs to be re-evaluated in this context.

Analysis of data from the Swedish Vascular Registry showed a significantly higher risk of expansion of PAs in those treated by the medial bypass and ligation approach compared with the posterior approach.32

Thrombolysis

Low dose intra-arterial thrombolysis was first used in an attempt to clear a thrombosed popliteal aneurysm in the early 1980s.33 There is no doubt that lysis using streptokinase, urokinase or recombinant tissue plasminogen activator (rt-PA) can be effective in treating thrombosed PA.34 However, in addition to the recognised complications of bleeding in 5% and in particular intracranial bleeding in 1% of cases thrombolysis of thrombosed PA results in a unacceptably high risk of acute deterioration of the limb during lysis.35 As a result, there has been a trend away from pre-operative lysis to its use per-operatively to clear run off while the patient is undergoing ligation and bypass.

Endovascular Stenting

Palmaz stents combined with a polytetrafluoroethylene graft was first used to treat an asymptomatic PA in 1994.36 In selected cases results equivalent to ligation and bypass are being described.37 A meta-analysis of three studies comparing bypass with endovascular repair showed no difference in long-term patency.
However 30-day graft thrombosis and re-intervention were more likely following endovascular repairs.36

Conclusion

The management of popliteal artery aneurysms has evolved in a manner similar to that of managing other major arterial aneurysms. The role of endovascular compared with conventional open techniques is undergoing constant evaluation.

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