

Evolution Of Peripheral Arterial Aneurysm Surgery: From Fatal Bleeding To Endovascular Interventions

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Abstract

Arterial aneurysms have been recognized since ancient times and the term aneurysm is derived from the Greek word, meaning "a widening". Surgery of aneurysm is peculiar because compressive force of an expanding aneurysm may cause adhesions and indurations to the surroundings, so that extensive dissection can pose a danger to adjacent structures. So complete dissection can be abandoned and in many cases, partial resection is sufficient and reconstruction may be performed by "inlay" techniques or bypass procedures. We are presenting an overview of the history of peripheral aneurysm surgery.

INTRODUCTION

Our understanding of any disease advances as we gain new insights through continued experimental and clinical observations, which comes from past history and its developments. These new insights may enhance original conclusions and permit the emergence of new and noble principles of treatment. By current reporting standard, an aneurysm is defined as a permanent localized dilatation of an artery having at least a 50% increase in diameter compared with the expected normal diameter. Currently, surgical or endovascular intervention is the only accepted definitive therapy^[1].

THE PAST

An aneurysm is the dilatation of an artery full of spiritous blood. – FERNEL (1591)

Considerable attention has been given throughout ancient and modern history to the cause and treatment of aneurysms. One of the earliest texts known, by the EBERS PAPYRUS (2000 B.C.), contains a description of traumatic peripheral arterial aneurysms. GALEN (131-200) defined an aneurysm as a localized pulsatile swelling that disappeared on pressure and wrote, "if an aneurysm be wounded, the blood is spouted out with so much violence that it can scarcely be arrested".

The first elective operation for treatment of an aneurysm was reported by the most famous surgeon in Greek antiquity, ANTYLLUS, in the second century. His recommendation for aneurysm repair was named Antyllus method^[32]. "An operation for aneurysm whereby is applied two ligatures to

the artery, cut between them and evacuating its contents" remained the basis of direct arterial operations for next centuries. He was also first to recognize two forms of aneurysm – the developmental caused by dilatation and the traumatic following wounding of an artery.

In the seventh century, details of operative repair of an arterial aneurysm were rewritten by AETIUS of Amida in his book *De Vosorum Dilatatione* ("On the Dilatation of the Vessels"). Aetius also recognized the difference between true degenerative aneurysms and traumatic false aneurysms. Aetius also believed Galens teachings that no wound heals properly without the formation of pus, brought about by the application of dried herbs (incense)^[2].

AMBROSE PARE (1510-1590), who mainly contributed to the principles of proper wound care, also applied his observations to aneurysm operations. He described the death of a patient, whose brachial artery aneurysm had been treated by application of a caustic, resulting in a torrential fatal hemorrhage. In 1590, PETER LOWE (1550-1612), personal physician to King James VI in Scotland, reported that one of the highest ranking officers in the Spanish Regiment presented with a peripheral arterial aneurysm. Lowe prescribed conservative remedies for its growth but against his advice a second physician and a barber opened the swelling with a lance, which resulted in fatal outcome after some hours.

Nearly after a century, RICHARD WISEMAN (1625-1686), also known as "the father of English surgery," described an

aneurysm in the arm of a cooper from Maidenhead. During operative exposure of the aneurysm, it ruptured. Wiseman instructed an assistant to place his thumb over the hole and he inserted an instrument beneath the artery and ligated it, where upon the assistant removed his finger and the bleeding subsided [2,3,5].

In medieval times, brachial artery aneurysms were frequent iatrogenic complications of blood letting during attempted puncture of the median cubital vein, a practice that was popular for more than 2000 years. In fact, the first successful direct arterial repair, by LAMBERT in 1759 was performed for a brachial artery pseudoaneurysm after phlebotomy [2,4].

JOHN HUNTER (Figure-1) performed perhaps the most famous operation for an arterial aneurysm

Figure 1

Figure 1: Photograph of John Hunter, born on February 13, 1728, died October 16, 1793, Scottish surgeon.



Hunter had observed that the blood supply to the horns of deer changed under different conditions. A rich blood supply was present when the crest was full, but the blood vessels decreased in number and size when the horns shed. Hunter inferred that reserve vessels, now termed “collaterals”, might develop in humans if obstruction occurred in their arteries.

In December 1785, a beer delivery man was admitted to St. George's Hospital with a pulsatile mass in the popliteal fossa, possibly secondary to repetitive trauma against the coachman's seat while driving on rough streets. The patient had been symptomatic for 3 years, he complained of leg pain on walking and rested frequently presumably owing to arterial occlusion distal to the aneurysm. Standard treatment at that time entailed above-knee amputation. Hunter's previous experiments, however, suggested that collateral vessels have formed around the obstruction or the leg would have developed gangrene. Thus, he incised above the knee at a location now known as “Hunter's canal” and tied four ligatures around the artery. Four sutures were used to avoid sawing through the vessel. After a bout of local infection, the patient survived and was discharged fully ambulatory. Later, Hunter performed four similar operations and three were successful; the fourth patient died 26 days postoperatively [5,6,7,8].

In 1804, ANTONIO SCARPA (1752-1832) wrote a definitive treatise on the forms and diagnosis of arterial aneurysms. The first surgical ligation of a femoral artery aneurysm was performed in 1808 by ASTLEY PASTON COOPER (1768-1841). Although he is remembered for his contributions to inguinal hernia and female breast anatomy, his most famous operation was performed for a leaking iliac artery aneurysm in 1817. Cooper also cautioned that patients who present with one aneurysmal disease should be evaluated for the coexistence of others, an advice that is equally applicable today.

In 1810, DOMINIQUE ANEL described Anel's operation [33] “Ligation of an artery immediately above and on proximal side of an aneurysm”. The 18th century can be characterized as the era of arterial ligation for treatment of aneurysms, with surgeons such as BRASDOR and JAMES WARDROP defending the merits of different sites of ligation in relation to the aneurysms. The first attempted surgical correction of a subclavian artery aneurysm was performed in 1818 by VALENTINE MOTT, who ligated the artery. About this time, several ingenious treatments were also introduced. GIOVANNI MONTEGGIA (1762-1815) unwisely attempted to cure an aneurysm by injecting a sclerosant into it, which predictably failed because of rapid blood flow. Unsuccessful attempts to thrombose aneurysms by passing an electric current between needles stuck into the vessel were done in 1832. CHARLES HEWITT MOORE (1821-1870), at Middlesex Hospital in London, introduced obliteration of aneurysms by inserting steel wires in 1864,

once using 26 yards of the material [5,6,7,8].

A better method of treatment of peripheral aneurysm had been developed in 1888 by the RUDOLPH MATAS (1860-1957). His technique of endoaneurysmorrhaphy, involved clamping above and below the aneurysm, opening it, ligating branches from within and buttressing the wall with imbricated sutures. By 1906, he had performed 22 obliterative operations and 7 restorative operations (preserving the arterial lumen) with no recurrences. Matas endoaneurysmorrhaphy prestaged the current prevailing of "Internal" or intrasaccular reconstruction conceived by OSCAR, CREECH and MICHAEL DEBAKEY. In 1913, Matas reported 225 cases of endoaneurysmorrhaphy repair, and seven of these were subclavian aneurysms [9,10,11].

Modern techniques of aneurysm repair were made possible by ALEXIS CARREL (Figure-2) who demonstrated arterial replacement and successfully anastomosed blood vessels.

Figure 2

Figure 2: Photograph of Alexis Carrel, born on June 28, 1873, died November 5, 1944, French- American surgeon.



In 1890, Alexis Carrel was admitted to the Medical School

of Lyon, where he developed interest in blood vessel repair and did intensive research on vascular surgery. This interest was precipitated by an unsuccessful portal vein injury repair of the French president M. F. S. Carnot in 1894. With CHARLES CLAUDE GUTHRIE, he wrote in 1906: "The vessels must be handled very gently and the endothelium must be protected from drying by isotonic saline. No dangerous metallic forceps are used. Great care is exercised to obtain accurate and smooth approximation of the endothelium of the vessels without invagination. Sutures should be made with very fine needles while the wall is somewhat stretched. Stenosis or occlusion only occurs as a result of faulty technique" - which is still valid 100 years later. In 1910, he demonstrated that blood vessels could be kept in cold storage for long periods before transplanting them [12]. Carrel won the noble prize for his work in 1912 "in recognition of his work on vascular suture and the transplantation of blood vessels".

On June 12, 1906, JOSE GOYANES of Madrid excluded a luetic popliteal aneurysm by proximal ligation. In addition, he mobilized the adjacent vein and used it as an in situ interposition graft between the proximal femoral artery and the distal popliteal artery by means of end-to-end anastomoses [13,14]. Six months later in December 1906, ERICH LEXER resected an axillary artery pseudoaneurysm and restored continuity by using the great saphenous vein [15]. In 1913, PRINGLE also reported removal of popliteal and brachial aneurysms and bridging of the defect by saphenous vein graft[16]. Unfortunately, these important contributions, which had a good outcome, remained largely ignored until many years later.

The first clinical transplantation of a homologus artery from one human to another was performed by PIROVANO in 1910. HALSTEAD was the first to successfully combine ligation with resection of subclavian artery aneurysm in 1892. In 1916 Halstead reported 27 cases of a cervical rib in association with subclavian aneurysm and hypothesized the rheologic mechanism leading to post stenotic dilatation and aneurysm formation. Subsequent successful reports of aneurysm repair by MATAS, LEXER and PRINGLE at the turn of the twentieth century confirmed the feasibility of arterial suture and led to the development of modern vascular surgery [2,6,7].

The introduction of anticoagulants, especially heparin (discovered in 1916 by MACLEAN, animal experiments in 1918 by HOWELL, chemical purification in 1933 by

CHARLES and SCOTT and first clinical application by CRAWFORD in 1935), made it possible to control thrombosis. This was the magic key to reconstructive vascular surgery [3,7].

A technique of wrapping abdominal and peripheral aneurysms in cellophane was introduced by REA in 1948. He also attempted this to the abdominal aortic aneurysm of Albert Einstein, but failed [17].

In 1952, VOORHEES introduced Vinonyn -N, the first fabric prosthesis. Other prosthetic grafts such as PTFE by EDWARDS in 1957, Polyester by DEBAKEY in 1960 and e-PTFE by SOYER in 1972 also helped and expanded the available options for interposition grafting. The first case of arterial reconstruction by homograft for a subclavian aneurysm was described by SCHEIN and colleagues in 1956[18,19].

In 1934, LEWIS AND PICKNERG described the much more frequent occurrence of upper extremity thromboembolic complications associated with aneurysms. Crutch induced blunt trauma producing pseudoaneurysm of axillary artery was first described by ROB and STEANDVEN in 1956. The ulnar artery can be aneurysmal in the dominant hand due to repeated blunt trauma. This entity was first reported by GUATTANI in 1772 and the term 'Hypothenar hammer syndrome or aneurysm' was coined by CONN in 1970 [2,20].

THE PRESENT & FUTURE

One of the major developments in vascular surgery over the past years has been the introduction of endovascular repair of aneurysms. In 1967, DOTTER did canine experiments and was credited for first arterial stent designed for remote arterial insertion [21,22]. In humans, this was initially described for aortic aneurysms by J.C. PARODI in 1991. This technique uses an endoprosthesis, which is delivered through the femoral arteries, to exclude an aneurysm from the circulation[23]. In 1993, MAY and colleagues from Australia reported the first transluminal placement of a prosthetic graft stent device for treatment of subclavian artery aneurysms[24]. Endovascular repair has several theoretical advantages over conventional surgery, and early evidence suggests that endovascular surgery is better for patients with coexistent disease, who would be at high risk for conventional surgery. Endovascular stenting should be considered in the treatment of carefully selected patients with difficult and dangerous aneurysm. Currently, Cragg

endopro system developed by ROUSSEAU in 1996[25], Wallgraft (Schneider Minneapolis, Minn.), a self-expanding wallstent by KRAJECER in 1997[26,27], Palmaz stent and Corvita stent-graft are established grafts for treatment of peripheral arterial aneurysms[28]. Now the guidelines for the development and use of endovascular prosthesis and their reporting standards have been published in 1995, but they have unique complications and unresolved issues, especially long-term durability[29,30]. This modality is under rigorous prospective evaluation with randomized trials and comparative studies to know about late and long term results.

Direct compression therapy as reported by KRONZON I. in J Am Soc. Echocardiogr 1997 and ultrasound guided percutaneous injection of thrombin as described by LIAU and colleagues in 1997, are only for iatrogenic femoral and other pseudoaneurysms. These two modalities have some success in management of the fresh, uncomplicated, catheter-induced pseudoaneurysms, but are unlikely to succeed with infected and complicated aneurysms[31].

The history of vascular surgery is very extensive. Many other advances in asepsis, anaesthesiology, blood transfusion, coagulation, angiography, radiology, improved instrumentation and simplification of flow and pressure measurements helped to achieve the current status. Regardless of aetiology and site, the principle for aneurysm repair is still the same. The life threatening lesions should be addressed first, followed by the limb threatening lesions. The aneurysm must be excluded from the circulation and arterial circulation restored.

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