677

Part I

The Use of the Long Saphenous Vein for Lower Limb Salvage: The Evolution of the In situ Bypass

John D. Corson, M.D.,
Robert P. Leather, M.D., Dhiraj M. Shah, M.D.,
Vijay Naraynsingh, M.D., Allastair M. Karmody, M.D.

This paper is Part 1 of a two-part article. Part 2, "Technique and Results of In situ Saphenous Vein Bypass" will be published in the next edition. References for both parts will be published at the end of Part 2.

— THE EDITOR

Dr. John D. Corson is assistant professor of surgery, Albany Medical College, and chief, Vascular Surgery, Albany VA Medical Center. Dr. Robert P. Leather is professor of surgery; Dr. Dhiraj M. Shah is associate professor of surgery; Dr. Vijay Naraynsingh is a vascular fellow, and Dr. Allastair M. Karmody is professor of surgery and chief of Vascular Surgery, all at Albany Medical College, New York.

INTRODUCTION

Over the past two decades, tibial vessel bypass grafting has become recognized as a satisfactory technique for limb salvage. Reversed autogenous vein grafts have shown clear superiority over other conduits in the tibial position.[1-4] We feel that the superiority of the autogenous saphenous vein can be further augmented by using it in the nonexcised in situ position.[5]

This report traces the history of the use of autogenous vein grafts and in situ saphenous vein arterial bypass in the lower extremity (Fig. 1).

EARLY VENOUS AUTOGRAFTS

The earliest experiments with venous autografts were by Gluck in 1894,[6] and then by Exner[7] and Hopfner[8] in 1903. In experimenting with dogs in 1906, Carrel and Guthrie[9] successfully replaced the carotid artery with an external jugular vein graft and also replaced the femoral artery with a femoral vein graft.

continued

In situ Bypass

continued

At about this time, Jose Goyanes of Madrid attempted to replace the aorta of 15 dogs with vena cava grafts but was successful only on one occasion.[10] Undaunted by this laboratory experience, Goyanes[11] on June 12, 1906 interposed a segment of popliteal vein following excision of a syphilitic popliteal aneurysm in a 41-year-old candy maker. The patient maintained a viable extremity and his incision healed following a postoperative wound infection. Goyanes reported this first clinically successful autogenous vein graft in an obscure weekly Spanish medical bulletin and consequently the event was largely unnoticed by the rest of the medical world.

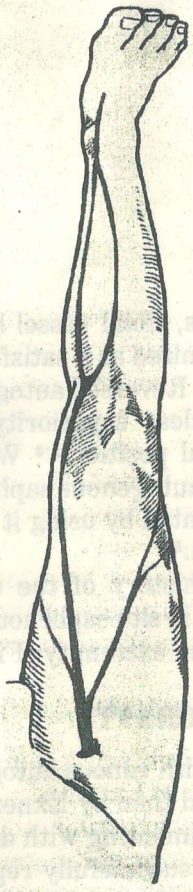

Fig. 1 The saphenous vein is left in its normal anatomical position. Mobilization is required only for a short segment at both the upper and lower ends to facilitate the arterial anastomoses.

One year later, unaware of Goyanes' case, F[illegible]ch Lexer,[12] professor of surgery at Konigsberg, [illegible]ccessfully used a 10cm segment of saphenous vein to bridge an arterial defect following excision of a large traumatic false aneurysm of the axillary artery. Five days postoperatively, the patient died of complications related to delirium tremens. At the post mortem, conducted by Lexer himself, the vein graft was found to be patent.

Stimulated by the report of this case, William Halsted at Johns Hopkins Hospital encouraged Bertrum Bernheim in 1909[13] to attempt a venous autograft to bridge a defect in the popliteal artery created by removal of a sarcoma. This initial clinical effort failed because of thrombosis. However, on Sept. 3, 1915, Bernheim successfully used a saphenous vein graft to replace an excised syphilitic popliteal aneurysm.[14,15] Bernheim emphasized the necessity for reversal of the vein graft so that the venous valves present would not obstruct the flow of blood.

Across the Atlantic at the Royal Infirmary of Glasgow, Hogarth Pringle[16] operated on a 49-year-old man with a large left popliteal aneurysm on May 16, 1912. He excised the aneury[illegible] and restored arterial continuity with a segm[illegible] of saphenous vein taken from the patient's other leg. The graft functioned well and the patient was back at work by Aug. 1, 1912.

NONSUTURED ANASTOMOSES

Almost every conceivable method has been tried to facilitate vascular suture or to substitute a nonsuture method in order to successfully bridge arterial defects.

Payr[17] experimented initially with absorbable magnesium rings. In 1915, Tuffier[18] proposed the use of silver tubes for bridging arterial defects, while Hopfner[8] had recommended and experimented with the use of two tubes bridged by a vein graft. During World War II, largely due to the work of Blakemore, et al.,[19] Vitallium tubes lined with vein grafts were used as arterial replacements with the cut ends of the arteries tied over the ends of the connecting cannulae (Fig. 2). DeBakey[20] analyzed 40 cases of the double tube vein graft technique and found a nonst[illegible]tically significant higher amputation rate with [illegible] technique than with other methods of repair at that time. The object of tube anastomosis in arterial

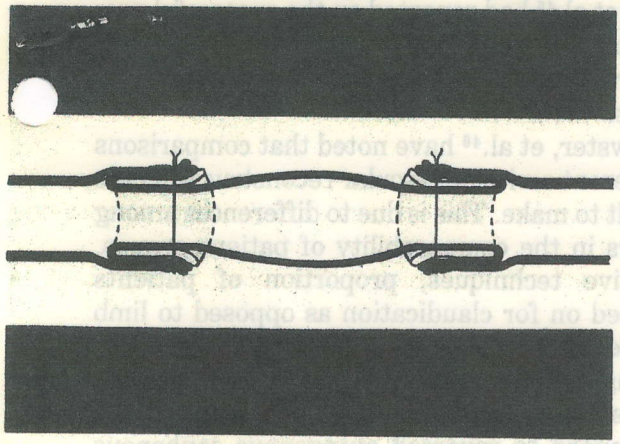

Fig. 2 In this nonsutured anastomosis, an arterial defect is bridged by a vein graft. Note the use of a Vitallium tube at each end.

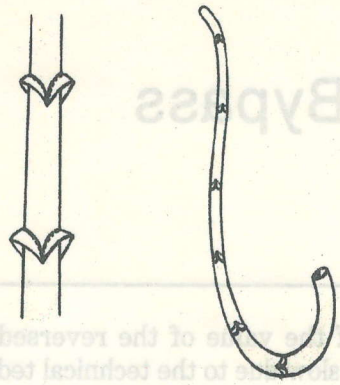

Fig. 3 The vein is everted and the exposed valve leaflets can be easily seen and excised.

injuries was to maintain the circulation while collaterals developed so that with gradual occlusion of the tube, the extremity would remain viable due to the improved collateral blood flow.

MILITARY EXPERIENCE

In 1913,[21] Ernest Yeger of Germany advocated the bypass principle for managing traumatic peripheral aneurysms. However, both thrombosis and infection vitiated efforts to save those extremities with vascular injuries that required vessel replacement. Occasional series of patients treated with vein grafts following traumatic aneurysms, such as those of Warthmuller[22] and Weglowski,[23] were reported during and after World War I.

During World War II, a limited number of autogenous venous grafts were used as reported by DeBakey.[22] The majority of these bypasses were done on patients with late traumatic aneurysms rather than acute arterial injuries. Sutured venous autografts were rarely used in the military theater.

During the Korean conflict, a team of vascular surgeons working in the mobile army surgical hospitals reintroduced the technique of vascular repair in the management of military wounds, especially in lower extremity wounds in which gangrene might develop without the use of a graft to restore arterial continuity. Hughes[24] analyzed 304 major vascular injuries that occurrd during military encounter. Thirty-four of these injuries were treated by autogenous vein grafts, with an 11.8% amputation rate. Nineteen of these 34 cases involved grafts below the inguinal ligament. The lowered amputation rate was in marked contrast to the 49% amputation rate reported in World War II for vascular injuries.[20]

During the Vietnam war, improved results due to refinements in the use of autogenous vein for infrainguinal arterial reconstruction have been documented by Rich.[25]

VEIN GRAFTS FOR OBLITERATIVE ATHEROSCLEROSIS

In 1949, Jean Kunlin[26] reported his early experience with vein bypass grafts on cases with obliterative atherosclerosis. This series included 11 cases with two graft failures and one death. His first vein bypass was performed on June 3, 1948 on a 54-year-old man on LeRiche's service. This patient had previously undergone a superficial femoral arterectomy. Due to intense fibrosis, an end-to-end anastomosis could not be done and, hence, the end-to-side anastomosis was conceived. By 1951, Kunlin had performed 17 similar bypass procedures with continued patency in seven cases.[27]

In 1951, Fontaine, et al.[28] reported 28 cases with venous autografts. Ten of them were patent at one to ten months after the procedures.

In the United States, Julian,[29] Lord and Stone,[30] Dale,[31] and Linton[32] pioneered the use of the autogenous vein in the femoropopliteal region. Vein bypass procedures for occlusions of the superficial femoral artery gradually became more popular during the late 50s and early 60s, while many workers were recording their disappointing experience with the failure of both arterial homografts and various synthetic grafts in the femoropopliteal region.[33-36]

continued

In situ Bypass

continued

Appreciation of the value of the reversed saphenous vein was slow due to the technical tedium associated with its use versus the relative ease and speed with which the other bypasses could be placed. There were also fears that the saphenous vein would become aneurysmal, which happened with vein replacements of larger arteries. Many thought that since the newer prosthetics worked well above the inguinal ligament, they would also do well in the infrainguinal position. Experience gained by Mannick, et al.[37,38] and by Darling and Linton[39] showed that autogenous vein grafts did stay open, even in patients with fair or poor runoff or in isolated popliteal artery segments. Several large follow-up series now attest to the fact that the autogenous reversed saphenous vein is the conduit of choice for bypass to the below knee popliteal artery for limb salvage.[40-42]

During the late 1950s and 1960s, there was considerable pessimism concerning the results of bypasses to vessels distal to the popliteal artery. In retrospect, the poor experience gained at that time with tibial bypasses was due to the overextension of the use of the prosthetic bypass. In addition, technical problems associated with small vessel anastomoses and poor distal runoff contributed to these unsatisfactory results. The experience of early pioneers with nylon prosthetics to the tibials was quite dismal, as reported in a series begun by McCaughan in 1957.[43] All of his bypass operations failed by 14 months. Despite improved prosthetic grafts in the past decade, autogenous vein remains the graft of choice for bypass to the tibial arteries.[1-5]

Advances in angiographic techniques, refinements in suture materials, the use of magnification and microsurgical instruments have all contributed to the improved results of infrainguinal bypass opertions. It has become recognized that the quality and diameter[40,42] of the saphenous vein are important determinants of the long-term performance of the graft. In particular, veins less than 4mm internal diameter have been noted to perform poorly.[39] By 1970, Noon, et al.[44] and Baird, et al.[45] had reported on the successful progression of the distal anastomosis on autogenous vein grafts down to the level of the ankle and foot vessels.

Brewster, et al.[46] have noted that comparisons of different series of vascular reconstructions are difficult to make. This is due to differences among authors in the comparability of patient groups, operative techniques, proportion of patients operated on for claudication as opposed to limb salvage, the frequency of prosthetic grafts used, the length of follow-up and the method of reporting results.

In regard to reversed autogenous saphenous vein grafts, Mehta[47] has culled from the literature the following conclusions: When operating for claudication using a reversed saphenous vein bypass graft to the popliteal artery, the five-year cumulative patency rate was 72% in a series of 894 cases taken from ten reported series between 1965 and 1979. In contrast, he found a 63% five-year cumulative patency rate for 1420 femoropopliteal bypass operations taken from 12 series between 1965 and 1979 in which the primary indication for surgery was limb salvage. He also analyzed 688 bypass operations to tibial vessels performed for limb salvage in seven series during the same time interval. There was a 48% five-year cumulative patency rate.

By 1971, there were over 50 reported clinical cases of the use of saphenous vein allografts.[48-52] Ochsner[53] recently updated his series of venous allografts in the lower extremity and showed a 50% occlusion rate at one year. Fifty percent of the remaining grafts stayed functional for up to four years. He stressed that the vein must have an initial diameter of 5mm to be used. The experience with saphenous vein allografts has been limited and have generally shown inferior results when compared to the results of autogenous reversed saphenous vein grafts.

IN SITU VEIN BYPASS

There has been some skepticism towards the rebirth of the in situ procedure. Many vascular surgeons were influenced by the report of Barner, et al.,[54] which confirmed their own poor results. Barner and his associates failed to show any advantage of the in situ bypass over conventional reversed autogenous vein bypass procedures.

The concept of the in situ bypass is attributed to K.V. Hall who, while working with Charles Rob at St. Mary's Hospital in London in 1959, suggested that the saphenous vein bypass might be

expedited if the vein was left in place and the valves rendered incompetent (personal communication with Rob, 1981). Rob made three separate attempts to do this with no long-term success. He used the blunt end of an internal varicose vein stripper to defunctionalize the valves by passing this instument from above. On his return to Oslo, Hall made one further unsuccessful attempt with the blind, blunt valve fracture technique of Rob. Hall[55] then resorted to a direct excision of the valve leaflets. Far from expediting the procedure, this became a more difficult, time consuming and technically demanding operation than the reversed vein technique. Hall used valve excision through multiple transverse venotomies until 1968 and subsequently reported on 252 in situ femoropopliteal bypass operations using this technique. Fifty-two of these bypasses were for limb salvage and the remainder for claudication. The five-year cumulative patency rate was 60%. Twenty-six percent of the veins were less than 4mm internal diameter.

Using blind, blunt valve fracture, Connolly[56] has reported on his experience and has shown a ten-year patency rate of 41% for femoropopliteal in situ bypass versus 43% for reversed vein bypasses. No dramatic differences were noted until the reports of Leather, et al., who have rekindled interest in the in situ saphenous vein bypass for limb salvage.[5,57] The Albany group reports a high operability rate of 95%, a vein utilization rate of 93%, and a high early patency rate using this technique for limb salvage. One particular advantage they have noted has been the successful use of veins less than 4mm internal diameter.

Another advantage of the in situ bypass is the matching of the large end of the nonreversed vein with the femoral vessels and the lower end of the vein with the smaller outflow vessels. It is of interest to note that in the past, various attempts have been made to exploit this hemodynamic advantage by removing the vein and rendering the valves incompetent and then using the vein as a bypass conduit in the nonreversed position (Fig. 3). However, this eversion valvectomy technique as originally suggested by Johnson[58] and used by Vanttinen, et al.[59] and McCaughan and Doan[60] showed no clinical advantage. These veins were exposed to all the disadvantages of handling and removal to which reversed veins were exposed. In order to maintain the integrity of the vasovasorum and the taper of the vein, it is essential to leave the vein totally in situ and then render the valves incompetent. This maintains a nonthrombogenic viable endothelial lining of the conduit.

The valve excision technique of Hall[61] is quite tedious and a variety of alternative techniques have been tried, such as the blind, blunt valve fracture technique with a vein stripped as originally tried by Rob. In order to defunctionalize the valves, Broom[62] used a ureteral catheter, Linton and Darling a ring stripper, Bellman and Kavarnees, a blunt 60cm needle.[63] In 1968, Samuels, et al.[64] reported on the use of a new venous valvulotome that when introduced into the vein from the distal end and withdrawn, rendered the valves incompetent. In 1973, Skagseth and Hall[65] used a similar instrument called the Hall venous valve stripper, and reported promising results with this instrument. Langeron[66] of France has used a valve stripper, developed by Cartier (personal communication, 1979) in Montreal, to strip the valves in a retrograde direction.

Despite considerable work with in situ bypasses by 1974, there were no published data that showed improved results with the in situ bypass over those of the reversed autogenous vein. It may be that although the taper was maintained, the techniques were too traumatic to the venous endothelium and resulted in limited early and late patency rates. It became apparent that the problem was to defunctionalize the valves with minimal endothelial trauma.

Leather[57] discovered that valve incision was a simpler and equally effective technique for rendering the valves incompetent. In the first 100 cases in his series, valve incision was done with intraluminal scissors introduced either through the upper end of the vein or through side branches. A prospective, randomized clinical trial of reversed saphenous veins and in situ veins using valve incision was then carried out that showed a cumulative patency rate at 12 months to be 93% for the in situ group, in contrast to 68% for the reversed vein group ($P < .001$).[69] The impressive results with in situ bypasses reported by the Albany group have now been duplicated and published by other vascular groups.[68-70] More recently, the Albany group[5] has developed instrumentation for simplifying valve incision and these instruments and the technique of the in situ bypass will be discussed in Part 2 of this paper.

SUMMARY

For the first time, there is data that show improved results with the in situ saphenous vein bypass using the valve incision technique. These data strongly suggest that this is the procedure

continued

In situ Bypass

continued

of choice for bypasses to the tibial vessels for limb salvage. Technical details of the proceure will be discussed, along with the updated results of the Albany series, in the next edition.

CS CS CS