How I do it: Endoscope-assisted in situ arterial reconstruction of the lower limb

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ABSTRACT

Arterial reconstruction with the great saphenous vein is a frequently performed vascular surgery technique for revascularization of chronic limb threatening ischemia. Surgeon variations of the procedure are common and aim to balance patency, limb salvage, complications, hospital resources, and technical feasibility. We describe a minimally invasive revascularization option using endoscope assistance for in situ great saphenous vein−arterial bypass to treat infrainguinal occlusive disease. We highlight patient selection, operating room setup, instrument details, and procedure strategies that facilitate the use of this technique. The development and refinement of minimally invasive techniques for lower extremity arterial bypass are critical to reduce wound complications and improve limb salvage outcomes in patients. (J Vasc Surg Cases Innov Tech 2024;10:101520.)

Keywords: Peripheral vascular disease; Vascular bypass; In situ bypass; Endoscopic technique; Endoscopic clipping; TTFM

Jordan et al[1] first described endoscopic great saphenous vein (GSV) isolation in 65 patients more than two decades ago. This technique was adopted from our cardiac surgery colleagues, who designed a minimally invasive vein harvest technique for coronary artery bypass.[2] Despite studies demonstrating a significant decrease in wound complications and hospital length of stay, the technique has not become popular in the vascular surgery community.[3] This might be due to concerns of reduced primary patency, which was shown in a meta-analysis of six (primarily retrospective) studies between 1996 and 2013.[4] However, a more recent 2016 study by Khan et al[5] did not show any difference in early or late patency or limb salvage outcomes between endoscopic and open in situ vein harvest.

The slow adoption of this minimally invasive technique might also be due to the lack of familiarity with the tools and protocol used for endoscopic vein isolation. In this report, we provide an in depth description of endoscope-assisted in situ arterial reconstruction of the lower limb using the GSV technique and strategies for technical success. This protocol emphasizes reduced disruption of the perivenous tissues; thus, keeping the GSV in its native position and orientation, similar to that described by Suggs et al[3] in 2001.

HOW I DO IT

Preoperative assessment and decision making. Patient selection is critical for endoscope-assisted in situ arterial reconstruction. Eligible patients have significant infrainguinal arterial occlusive disease resulting in chronic limb threatening ischemia, defined by Rutherford categories 4 to 6.[6] All patients undergo a preoperative computed tomography angiography for determination of the inflow and outflow target vessels and vein characteristics. In cases in which the tibial outflow is equivocal, a diagnostic angiogram is performed to select the appropriate outflow vessels for bypassing. Routine vein mapping is not necessary. For this in situ technique, vessel size match and location are key. Therefore, the proximal GSV must measure a minimum of 3 mm, and the saphenofemoral junction must be located within 10 mm of the patent arterial inflow vessel. This technique can be used for any medial approach outflow target, including above- and below-knee popliteal, tibial−peroneal trunk, and posterior tibial arteries. The inflow target can be the common femoral artery or a patent superficial femoral artery (SFA). Finally, patient body habitus should be evaluated because patients with thin soft tissue coverage around the knee have an increased risk of tissue tearing with the blunt dissection of the retractor device. It is ideal to have a layer of adipose tissue (∼5 mm) between the GSV and the skin.

Operating room setup, instruments, and personnel. Several additions to the standard vascular procedure setup are necessary for this endoscopic-assisted bypass technique. The key instruments that have aided in the success of this technique are summarized in the Table.

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Table. Specialized equipment details

Instrument	Company	Purpose
Endoscopic retractor, Bisleri model	Karl Storz	Dissecting fascial roof of GSV and retract superficial soft tissues
Endoscope Xenon 300, endoscope image1 S	Karl Storz	Relay communication tower between endoscope feed and virtual display
LigaSure Maryland jaw open and laparoscopic sealer/ divider	Medtronic	Blunt dissection to isolate GSV tributaries and thermal division of soft tissues
Endoscopic multiple clip applier (Ligamax 5), 5 mm	Ethicon Endo-Surgery	GSV tributary occlusion
Valvulotome	LeMaitre Vascular, Inc	In situ GSV valve lysis
VeriQ system	Medistim	Transit time flow measurements to assess for residual side branches or GSV defects

GSV, Great saphenous vein.

The use of an endoscopic system requires modification to the operating room setup such that the surgical assistant has an unobstructed view of the endoscope monitor. Fig 1 demonstrates an operating room setup conducive to the surgeon and surgical assistant working simultaneously for a left-sided procedure. This two-team approach is ideal for operating room efficiency, where the individual performing the endoscopic technique is typically a registered nurse first assistant, physician assistant, or surgical trainee.

Intraoperative procedure. The patient is placed supine on a standard procedure table and anesthetized. Antibiotic surgical prophylaxis (typically, cefazolin 2g) is given intravenously within 1 hour of the skin incision. Ultrasound guidance is used with a permanent marker to identify the course of the GSV, its major tributaries, and the anomalous posterior perforator veins because these can be difficult to assess via endoscopy. A longitudinal line is marked at the ultrasound location of the common femoral artery, and another intersection line is marked at the ultrasound location of the saphenofemoral junction. An example of vein mapping is shown in Fig 2. No tourniquet is necessary.

Simultaneous incisions are made at the proximal and distal anastomosis sites for arterial and venous exposure, respectively. In the proximal incision, the common femoral artery (CFA), SFA, and profunda femoris artery are dissected out in standard fashion and controlled with vessel loops. Distally, the GSV is identified, mobilized in its first 4 cm, visible tributaries are tie ligated with silk ties, and the GSV is transected to provide mobility. The surgical assistant can now extend caudad toward the distal GSV isolation by inserting the endoscopic retractor, equipped with the endoscope and LigaSure (Medtronic) device (Fig 3, *A*). The shape of the retractor is designed for blunt dissection and soft tissue retraction (Fig 3, *B*). Fascial plane identification and subsequent entry with the retractor tip facilitates creation of the GSV tunnel. The LigaSure device is used for blunt dissection to identify the GSV tributaries and cautery of non—GSV-associated bleeding from the adipose tissue or distal tributaries (Supplementary Video 1, online only). Suction attached to the endoscope provides smoke evacuation. The GSV is assessed visually for evidence of thermal injury during dissection. If an injury is identified, a small incision is made to expose the vein and imbricate the walls with interrupted 7-0 Prolene suture, taking care to avoid luminal narrowing. The GSV branches are double clipped but not divided (Fig 3, *C*). If a clip is inadvertently deployed on the main conduit, removal can be attempted with the endoscopic clip applier prongs. Should this not be successful, a small incision can be made to expose and remove the clip with DeBakey forceps and imbricate the wall as necessary. For distal lower leg bypass, a third incision is sometimes needed to bridge the length of the retractor.

The surgical assistant then isolates the GSV through the proximal femoral incision, switching positions with the primary operator (Fig 4). The primary operator continues the distal arterial dissection simultaneously. The time required for the vein exposure and clipping component of the case is between 20 and 30 minutes, depending on the operator. This time is not considered additional time to the case because it is performed in tandem with the arterial exposure.

Once the entirety of the GSV is visualized and the tributaries clipped, the patient is systemically heparinized with 100 U/kg of unfractionated heparin, and a minimum of 3 minutes is given for circulation (5 minutes if the ejection fraction is <60%). The target activated clotting time (ACT) is >250 seconds and is rechecked every 45 minutes; unfractionated heparin is readministered accordingly. The ACT is checked after every readministration of heparin to ensure the targets are met.

The GSV is divided at the SFJ and spatulated. Any visible valves are incised. The CFA, SFA, and profunda femoris artery are clamped for control. The CFA arteriotomy and proximal anastomosis are completed in standard end to side fashion. We prefer the parachute technique to initiate the suture line at the heel of the anastomosis. After completion of the anastomosis, the vascular clamps are released. The distal GSV is then divided and a pull valvulotome (retrograde Le Mills valvulotome) is used for the distal 4 cm of vein, followed by the LeMaitre pull

Fig 1. Operating room setup for left-sided procedure. This setup facilitates simultaneous common femoral artery and great saphenous vein (GSV) dissection. *RNFA,* Registered nurse first assistant.

Fig 2. Vein mapping indicating the course of the great saphenous vein (GSV), its major tributaries, and the common femoral artery and saphenofemoral junction.

valvulotome for a minimum of two passes. The GSV tunnel is observed for bleeding. If a conduit tear is suspected, the endoscope is reinserted and the site of injury visualized. If an avulsed branch is responsible for the bleeding, the clip applier can be used to apply an additional clip for hemostasis. In cases in which the GSV has a side wall tear, an additional incision is made to expose the vein and repair the tear under direct vision using 7-0 Prolene suture. The distal anastomosis is then completed in a standard end to side configuration.

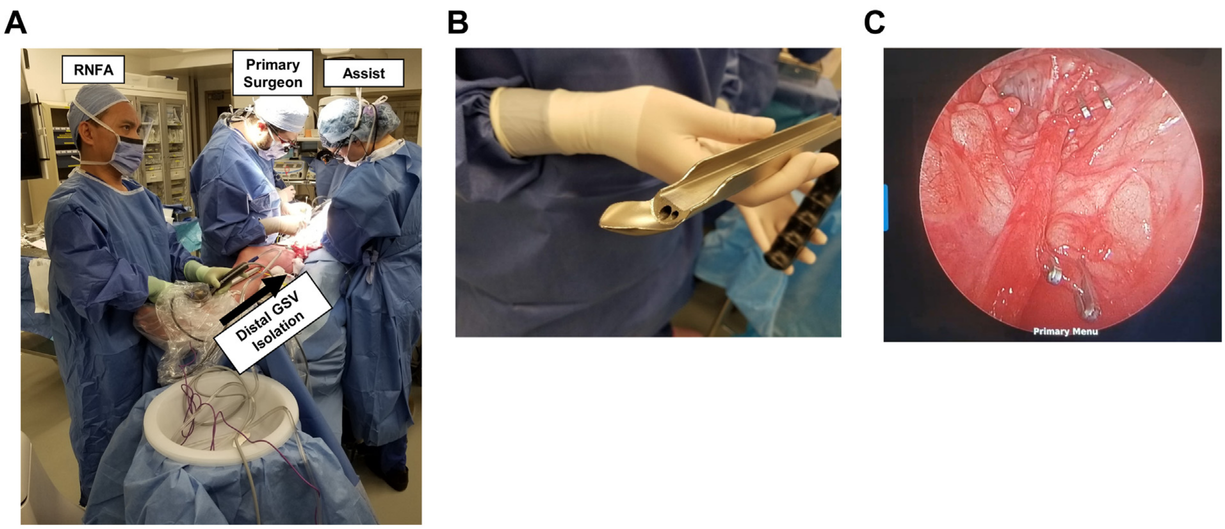

Fig 3. Endoscopic great saphenous vein (GSV) dissection and tributary occlusion. **A,** Endoscopic retractor insertion and distal GSV isolation. **B,** Endoscopic retractor, Bisleri model. **C,** GSV tributary occlusion with double clips. *RNFA,* Registered nurse first assistant.

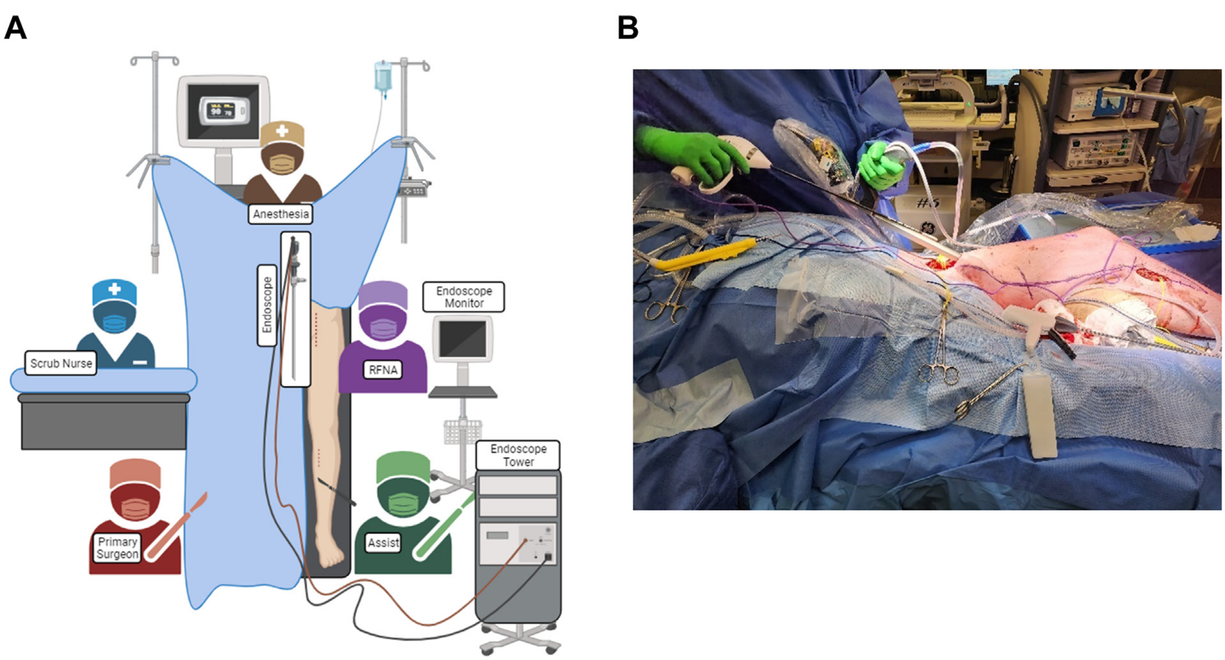

Fig 4. Operating room adjustment for proximal great saphenous vein (GSV) dissection. **A,** Schematic. **B,** Photograph showing endoscope, retractor, and dissection device from the proximal incision. *RNFA,* Registered nurse first assistant.

To forgo contrast, radiation, and an additional technologist, the VeriQ system (Medistim) can be used in place of a conventional completion angiogram. This is an ultrasound device that computes the transit time flow measurements to target flow >100 mL/min for popliteal bypasses and >80 mL/min for cruciate bypasses.[7] The presence of dampened flows represents missed GSV tributaries or retained valves. In the event of a missed branch, segmental external digital compression along the course of the GSV with simultaneous VeriQ interrogation can demonstrate the estimated location of the fistula. We then reinsert the endoscope, identify the branch visually, and apply two clips to obliterate the fistula.

The unfractionated heparin is then reversed with protamine to an ACT equal to the preoperative value. The femoral incision is closed with a minimum of two Vicryl layers, and all other incisions with a single Vicryl layer. Monocryl suture or staples are used for skin closure, depending on tissue tension.

Postoperative care. Postoperatively, an ankle brachial index is calculated before discharge. Subsequently, the patient is evaluated after 2 weeks by physical examination and a bedside spectral Doppler ultrasound. Duplex ultrasound scans are obtained in accordance with the Society for Vascular Surgery guidelines at 3, 6, and 12 months postoperatively and every 6 to 12 months thereafter.

DISCUSSION

We describe an approach to endoscope-assisted in situ arterial reconstruction of the leg and aim to bolster the vascular arsenal for the management of chronic limb threatening ischemia. With the rates of diabetes and obesity steadily increasing in our patient population, it might be time to further use this technique, given the significant challenges with wound healing these patients face. The other potential advantages afforded by a minimally invasive technique include greater patient mobility, a shorter length of stay, reduced pain, and improved cosmesis.[8] These benefits are the reasons cardiac surgeons have widely adopted the endoscopic technique for GSV harvesting and is a class IIa, level A recommendation from the 2018 European Society of Cardiology/European Association for Cardio-Thoracic Surgery guidelines on myocardial revascularization.[9] Furthermore, in our relatively small, acute care, academic hospital (440 beds), resource allocation is prudent, and we reduce costs by sharing equipment and highly trained personnel within our cardiovascular surgery division.

There are several modifications to this technique used by both vascular and cardiac surgeons in the literature. Technologies added to the endoscope can facilitate dissection tunnel development and GSV exposure, including adjunctive carbon dioxide insufflation.[10] Furthermore, carbon dioxide insufflation can be used in an open or closed system, with the latter requiring the use of an occluding balloon to plug the access site and increase the tunnel pressure ≤12 mm Hg.[11] One study suggests that closed systems might be associated with vein graft thrombosis.[12] Modifications can also be made to methods of tributary occlusion, including endoscopic clip application, cautery ligation, and angiographic embolization.[4,13] We prefer clip application to reduce the risk of inadvertent injury from thermal spread or endoluminal trauma. Finally, there are several strategies available for hemodynamic assessment of the vein bypass before surgery completion that can identify anastomosis issues, retained valves, and fistulas, including segmental flow measurements with ultrasound or angiography.

Although techniques differ between reported methods of endoscopic GSV isolation and arterial reconstruction, one common theme highlighted by a 2014 systematic review, which we endorse, is the need for an experienced surgical assistant with endoscopic skills. Reducing the rate of inadvertent vein injury, improving tributary identification and occlusion, and maintaining the integrity of the perivenous milieu are integral to the success of this procedure.

CONCLUSIONS

In this report, we describe our experience and technical strategy for lower limb revascularization via endoscope-assisted GSV isolation for in situ bypass. It is imperative that as technology advances, we continue to revisit minimally invasive techniques to evaluate their effectiveness in limb salvage and reducing hospitalization and wound complications. As this technique continues to improve, we foresee this subtype of in situ bypass becoming the standard of care for limb salvage programs, given its well-documented wound healing benefits and shorter lengths of stay compared with traditional vascular bypass.

DISCLOSURES

None.

Cartoon images were created using BioRender.com.

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