

Update on the Role of Lower Extremity Bypass in the Management of CLI

A review of indications, technical considerations, and current data for surgical bypass.

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The coexistence of endovascular intervention and lower extremity bypass as treatments for critical limb ischemia (CLI) can create areas of overlap and uncertainty when deciding between interventions.

At times, there can even be clinical equipoise. This article reviews the current indications for the consideration of bypass as a first-line therapy, important principles of surgical technique that may be germane to all forms of revascularization, and recent data regarding the management of CLI.

CURRENT INDICATIONS FOR BYPASS

Intervention is often indicated for patients with CLI as defined by rest pain, nonhealing wounds, or gangrene. As shown in the CLEVER trial, supervised exercise provides durable symptomatic improvement for claudicants with no adverse events,¹ and claudication infrequently progresses to CLI with proper risk factor management. Therefore, consideration should be given to the risk of intervention before revascularization for patients with claudication, although follow-up and patient compliance remain critical. For patients with CLI, the BASIL trial advised that relatively fit patients expected to live > 2 years should be considered for operative bypass given the apparent improved durability and reduced reintervention rate of surgery.² Inversely, those with significant comorbidities or a life expectancy < 2 years should be offered endovascular therapy when possible.

In our experience, the indication for revascularization has an impact on the decision, as larger areas of tissue loss (> 2 cm transverse diameter) have healed more often and more rapidly with bypass.³ Bypass may allow for revascularization of appropriate angiosomes that would be difficult to achieve with endovascular techniques.⁴ Lesion anatomy also plays a role in the decision because bypass may offer a good choice for patients with chronic total occlusions (TASC D lesions), especially with involvement of the common femoral bifurcation and the profunda femoris artery.

Bypass may be best for patients with long, complex tibial artery occlusive disease, particularly if an autogenous conduit is available.⁵ Finally, failed endovascular therapy can alter future bypass options of the target artery and length of bypass; therefore, a discussion of surgical versus endovascular therapy is warranted after failed endovascular therapy.⁶

SURGICAL BYPASS PRINCIPLES

The planning and performance of a surgical bypass are based on three principles: arterial inflow, arterial outflow, and bypass conduit. Arterial inflow provides an adequate source of blood flow, while outflow identifies a target artery (or vein in the rare case of deep venous arterialization [DVA]) that can accommodate the increased flow generated by the bypass to increase perfusion to the target tissue. Due to the success of endovascular interventions above the inguinal ligament, most inflow sources can originate just above or below the inguinal ligament, thereby avoiding the morbidity of open surgical options in the abdomen. Common infrainguinal procedures include femoral endarterectomy with profundoplasty and infrainguinal bypass originating from the common femoral artery.

Appropriate bypass conduit may be the most important and often challenging consideration in planning a bypass. The great saphenous vein remains the optimal choice, either ipsilateral or contralateral, with an established track record of good patency and limb preservation out to 5 to 10 years (Figure 1).⁷ Five-year limb preservation in excess of 80% can be achieved with the great saphenous vein. Patients with previously harvested or poor quality veins have historically turned to a prosthetic conduit with 2- and 5-year limb preservation rates of 52% and 35%, respectively, for femoropopliteal revascularization.⁸ Results for prosthetic bypass to the tibial arteries are much less satisfactory.⁹ An adjunct to improve the performance of prosthetic tibial bypass in those patients without autogenous conduit

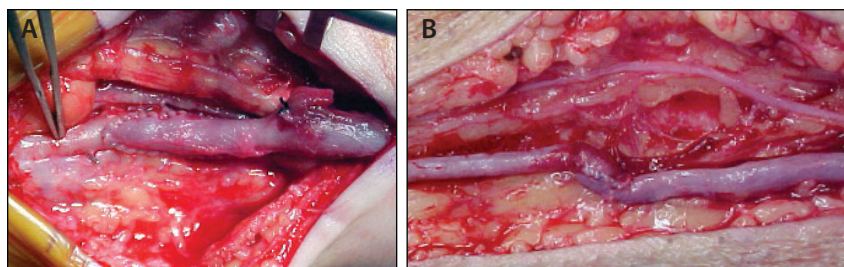


Figure 1. Vein bypass with tibial anastomosis (A). Composite vein bypass conduit (B).

involves the use of an anastomotic distal vein patch (DVP), which results in a 4-year limb preservation rate as high as 79%.¹⁰ The 1-year results are comparable to vein bypass, and the DVP bypass can be offered to patients with medical comorbidities or previous surgery to decrease operative time and magnitude of the procedure while achieving limb preservation.

A number of patients in a CLI practice will present without a suitable distal target artery for bypass or endovascular pedal access. This scenario, often referred to as a “desert foot,” can lead directly to major amputation. Using a method involving the principles of the DVP technique, a common ostium can be surgically created between a tibial arterial segment and corresponding tibial vein to take advantage of decreased outflow resistance, maintain a flow velocity in the bypass graft, and achieve patency. This technique has achieved patency of 64% and a limb preservation rate of 57% at 24 months in this challenging patient population.¹¹ Recently, this procedure

has been modified by disrupting two to four valves distally in the tibial vein to establish a component of DVA (Figure 2). DVA may augment retrograde perfusion per the capillary bed to enhance healing and limb preservation. To date, eight cases have been performed with the longest follow-up out to 6 months, with two major amputations in that time period (Richard F. Neville, MD, unpublished data, May 2020).

RECENT DATA

Prospective randomized data are lacking to guide clinicians in the optimal mode of revascularization for patients with CLI. We anxiously await the results of clinical trials such as BEST-CLI and BASIL-2. Two recent retrospec-

tive cohort studies demonstrated equivocal results between surgical bypass and endovascular revascularization. A single-center retrospective study of 108 patients with infrageniculate disease comparing open and endovascular approaches showed no significant difference in major adverse limb events (MALE), overall survival, or amputation-free survival (AFS) at 3 years. However,

an endovascular approach was associated with increased reinterventions during the follow-up period.¹² In a retrospective analysis of 264 patients with CLI, femoropopliteal bypass and femoropopliteal percutaneous transluminal angioplasty (PTA) were compared, with similar technical success and limb preservation rates for angioplasty and bypass for femoropopliteal revascularization. Additionally, patients deemed suboptimal for surgical bypass had inferior initial technical success and limb preservation, although the DVP technique was not used. Angioplasty was associated with a shorter hospital stay and fewer reinterventions for procedural complications.¹³

Several database analyses have been performed to address the question of surgical versus endovascular revascularization. An analysis based on the National Surgical Quality Improvement Program (NSQIP) database reviewed patients with CLI and isolated infrageniculate disease who underwent bypass-first or endovascular-first revascularization. The analysis demonstrated lower amputation rates in patients who underwent bypass first as compared with endovascular-first patients (4.3% vs 7.4%; 95% CI, 0.36–0.98) but higher wound complication rates (9.7% vs 3.7%; 95% CI, 1.71–4.42), increased major adverse cardiovascular events (MACE) (6.9% vs 2.6%; 95% CI, 2.18–6.88), and higher 30-day mortality rates (3.23% vs 1.8%; 95% CI, 1.26–6.11).¹⁴ No differences were noted in MALE, 30-day loss of patency, reintervention, readmissions, or reoperations. However, as with all NSQIP studies, the analysis is limited to the short term without follow-up beyond the perioperative period. With the addition of a propensity score adjustment, an observational study of Medicare claims data (N = 36,860) relating to CLI demonstrated significant differences in all-cause mortality between revascularization strategies (angioplasty, 54.7%; stent deployment, 53.7%; surgical bypass, 51.4%; $P < .05$ for all pairwise comparisons).¹⁵ In this analysis, surgical bypass patients had a higher amputation rate (10.8%) versus angioplasty (8.1%) and stent deployment (7.8; $P < .05$ for all pairwise comparisons except PTA vs stent).

Financial considerations and procedural cost may become increasingly important factors in decision-making for the mode of revascularization. A retrospective analysis of Medicare claims data of CLI-associated coding and cost

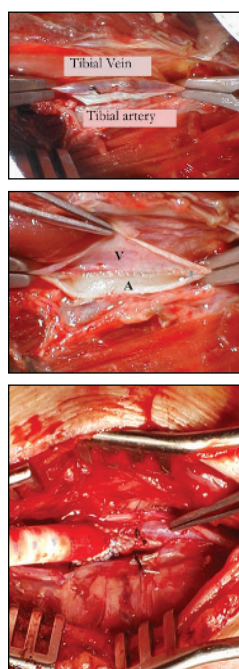


Figure 2. DVA with DVP bypass.

SUMMARY OF KEY CLI STUDIES

COMPARISON OF BYPASS AND ENDOVASCULAR INTERVENTION FOR POPLITEAL OCCLUSION WITH THE INVOLVEMENT OF TRIFURCATION FOR CRITICAL LIMB ISCHEMIA

Biagioni RB, Nasser F, Matielo MF, et al. *Ann Vasc Surg.* 2020;63:218-226.

- Inclusion criteria: CLI (Rutherford class 4 and 5); at least one infrapopliteal artery patent with continuous flow to the foot
- Primary endpoint: Time free from MALE, AFS, and early mortality (30 days) compared between the open and the endovascular groups
 - AFS for the endovascular group at 30 days and 1, 2, and 3 years was 93.7%, 79.3%, 69.9%, and 66%, respectively. For the open group, AFS was 88.4%, 77.4%, 68.3%, and 64.3%, respectively ($P = .73$)
 - Early mortality was 9.3% for the open group versus 1.5% for the endovascular group ($P = .060$)
 - The reintervention was statistically higher in the endovascular group compared with the open group (χ^2 test, $P = .0456$). The mean time for reintervention was sooner in the endovascular group than in the open group (χ^2 test, $P = .002$)
- Conclusion: At 3-year follow-up, overall survival and AFS were not statistically different between open and endovascular revascularization, with more reinterventions in patients who underwent an endovascular approach

CLINICAL OUTCOMES OF BYPASS-FIRST VERSUS ENDOVASCULAR-FIRST STRATEGY IN PATIENTS WITH CHRONIC LIMB-THREATENING ISCHEMIA DUE TO INFRAGENICULATE ARTERIAL DISEASE

Dayama A, Tsilimparis N, Kolakowski S, et al. *J Vasc Surg.* 2019; 69:156-163.e1.

- NSQIP database review from 2012 to 2015 to identify patients with CLI and isolated infrageniculate arterial disease who underwent primary infrageniculate bypass or endovascular intervention
- Endpoints were MALE, MACE, amputation at 30 days, reintervention, patency, and mortality
- Incidence of transtibial or proximal amputation was lower in the bypass-first cohort (4.3% vs 7.4%; odds ratio [OR], 0.60; 95% CI, 0.36–0.98)
- Wound complications were higher in the bypass-first cohort (9.7% vs 3.7%; OR, 2.75; 95% CI, 1.71–4.42)
- 30-day MACE was higher in bypass-first patients (6.9% vs 2.6%; adjusted OR, 3.88; 95% CI, 2.18–6.88), as were 30-day mortality rates (3.23% vs 1.8%; adjusted OR, 2.77; 95% CI, 1.26–6.11)

- Conclusion: CLI patients with isolated infrageniculate arterial disease treated by a bypass-first approach have a significantly lower 30-day amputation but higher MACE; this benefit was not observed when dialysis patients were excluded

LONG-TERM LIMB SALVAGE AND AMPUTATION-FREE SURVIVAL AFTER FEMOROPOPLITEAL BYPASS AND FEMOROPOPLITEAL PTA FOR CRITICAL ISCHEMIA IN A CLINICAL COHORT

Altmeppen M, Mattsson E. *Vasc Endovascular Surg.* 2019;53:112-117.

- Retrospective analysis of femoropopliteal disease between 1999 and 2013
- All patients underwent femoropopliteal bypass ($n = 140$) or PTA ($n = 152$) for CLI without other simultaneous intervention
- Primary technical success was 96% for bypass and 93% for PTA
- Technical success in patients not considered eligible for bypass surgery was 31% (10/32), which was significantly lower than in the other groups ($P = .00$). Patients who were considered not eligible for bypass surgery were older, predominantly female, and had a higher prevalence of pulmonary disease
- 30-day amputation rates were higher after endovascular intervention (15/152 vs 7/140)

PROPENSITY SCORE-ADJUSTED COMPARISON OF LONG-TERM OUTCOMES AMONG REVASCLARIZATION STRATEGIES FOR CRITICAL LIMB ISCHEMIA

Mustapha JA, Katzen BT, Neville RF, et al. *Circ Cardiovasc Interv.* 2019;12:e008097.

- Analysis of Medicare claims data involving patients with an initial CLI diagnosis who received endovascular intervention or surgical bypass between 2011 and 2015
- Propensity score weighting to determine the association of treatment type with all-cause mortality and major (above ankle) amputation
- Mortality > 4 years was 51.4% with surgical bypass, 54.7% with angioplasty, and 53.7% with stent placement with a pairwise comparison statistically different at $P < .05$
- Major amputation rate was 10.8% after surgical bypass and 8.1% after angioplasty (7.8% poststent deployment; $P < .05$ for a pairwise comparison)
- The risk of mortality or major amputation (analogous major AFS) was similar during follow-up with 56.1% after surgical bypass, 57.5% after angioplasty, and 56.3% with stent deployment, although selection bias could not be taken into account

DETERMINANTS OF LONG-TERM OUTCOMES AND COSTS IN THE MANAGEMENT OF CRITICAL LIMB ISCHEMIA: A POPULATION-BASED COHORT STUDY

Mustapha JA, Katzen BT, Neville RF, et al. *J Am Heart Assoc.* 2018;7:e009724.

- Analysis of Medicare beneficiaries (N = 72,199), which reviewed long-term outcomes and cost following an initial CLI diagnosis with comparisons among endovascular revascularization, surgical revascularization, or major amputation as the first-line treatment
- Of the initial cohort, 9,942 propensity score-matched patients were compared (8% rest pain, 26% ulceration, and 66% gangrene). Overall survival was 38% with endovascular revascularization (median survival, 2.7 years), 40% with surgical revascularization (median survival, 2.9 years), and 23% with major amputation (median survival, 1.3 years), which demonstrated a significant difference in survival between each mode of revascularization and major amputation ($P < .001$)
- Major amputation rates were similar for all pairwise comparisons ($P < .001$)
- The cost per patient-year during follow-up was highest for amputation (\$55,700; $P < .001$ for each revascularization procedure vs major amputation)

A SYSTEMATIC REVIEW AND META-ANALYSIS OF REVASCLARIZATION OUTCOMES OF INFRAINGUINAL CHRONIC LIMB-THREATENING ISCHEMIA

Almasri J, Adusumalli J, Asi N, et al. *Eur J Vasc Endovasc Surg.* 2019;58:S110-S119.

- 44 prospective studies with at least 1-year follow-up that enrolled 8,602 patients
- Patients with infrapopliteal disease had higher patency rates of great saphenous vein graft at 1 and 2 years (primary patency, 87% and 78%; secondary patency, 94% and 87%, respectively) compared with all other interventions
- Prosthetic bypass outcomes were notably inferior to vein bypass in terms of amputation and patency outcomes, especially for below-knee targets at 2 years
- Drug-eluting stents demonstrated improved patency over bare-metal stents in infrapopliteal arteries (primary patency, 73% vs 50% at 1 year) and were at least comparable to balloon angioplasty (primary patency, 66%)
- Survival, major amputation, and AFS at 2 years were broadly similar between endovascular interventions and vein bypass

RESULTS FOR PRIMARY BYPASS VERSUS PRIMARY ANGIOPLASTY/STENT FOR LOWER EXTREMITY CHRONIC LIMB-THREATENING ISCHEMIA

Darling JD, McCallum JC, Soden PA, et al. *J Vasc Surg.* 2017;66:466-475.

- Single-institution retrospective review of all patients with CLI undergoing first-time intervention between 2005 and 2014
- Freedom from reintervention was significantly higher in patients undergoing a first-time bypass procedure (62% vs 52% at 3 years; $P = .04$), as was freedom from restenosis (61% vs 45% at 3 years; $P < .001$)
- Complete wound healing at 6-month follow-up was significantly better after an initial bypass (43% vs 36%; $P < .01$)
- Primary patency was shown to be significantly higher among bypass-first patients (72% vs 63% at 3 years; $P = .02$)
- Survival after 3 years was higher in bypass-first patients (61% vs 52%; $P < .01$)

OPEN, PERCUTANEOUS, AND HYBRID DEEP VENOUS ARTERIALIZATION TECHNIQUE FOR NO-OPTION FOOT SALVAGE

Ho VT, Gologorsky R, Chandra V, et al. *J Vasc Surg.* Published online December 31, 2019.

- Literature review of indications, technique, and outcomes of DVA in patients with CLI/Rutherford class 4 or 5 with no distal target for traditional open or endovascular bypass
- One-year primary patency for open DVA was 44.4% to 87.5%; secondary patency was less reported but ranged from 55.6% at 1 year to 72% at 25-month follow-up. Limb salvage rates were 25% to 100%, wound healing occurred in 28.6% to 100% of cases, and rest pain resolved in 11.9% to 100% across cohorts. Major amputation rates ranged from 0% to 70%
- Endovascular DVA: primary patency was 28.6% to 40% at 6- and 10-month follow-up, respectively. Limb salvage rates were 60% to 71%, with rates of major amputation of 20% to 28.5%
- Conclusion: DVA may be undertaken for patients with rest pain or nonhealing wounds who lack distal arterial targets for conventional open or endovascular arterial revascularization. As such, it is considered a final option for limb salvage in contexts in which amputation is the only other appropriate approach

TABLE 1. BYPASS AS THE OPTIMAL MODE OF REVASCULARIZATION

Patient Characteristic	Description
Medical comorbidity	Reasonable life expectancy and level of function
Indication for revascularization	Wound healing (significant tissue loss > 2 cm)
Arterial anatomy	<ul style="list-style-type: none"> Long-segment tibial occlusive disease (TASC D) Femoral bifurcation disease (especially if the profunda femoris artery involved) Popliteal (P2, P3) occlusive disease
Angiosome revascularization	To revascularize the appropriate wound angiosome
Failed endovascular therapy	<ul style="list-style-type: none"> History of failed endovascular therapy (repeated attempts) Lack of healing or symptom relief despite endovascular therapy

was performed over 4 years. The analysis included > 72,000 patients after an initial diagnosis related to CLI. There was a significant improvement in survival for patients undergoing surgical bypass (40%; median, 2.9 years) and endovascular revascularization (38%; median, 2.7 years) as compared with amputation (23%; median, 1.3 years; $P < .001$).¹⁶ Cost per patient-year during follow-up was significantly lower for both surgical (\$49,200) and endovascular (\$49,700) revascularization, with major amputation associated with the most expense (\$55,700) to the health system. This analysis supports the concept that revascularization by appropriate means is superior to amputation in terms of patient survival and financial implications to the health system.

When evaluating current studies, it is important to remember most are retrospective and often do not take into account confounding clinical variables that would add selection bias to those receiving a particular type of intervention. The BEST-CLI and BASIL-2 studies are international, multicenter, prospective trials that will add much to our understanding of lower extremity revascularization.

CONCLUSION

A subset of patients in need of revascularization for CLI has been identified that we believe is best treated with surgical bypass (Table 1). This cohort is approximately 25% of our tertiary care limb preservation practice. Advances in technology and technique continue at a rapid pace and will certainly impact future clinical decisions. Without a doubt, health care costs will also factor into this process. Hopefully the future will also bring additional information from dedicated prospective trials such as BEST-CLI and BASIL-2 to

add clarity to managing this disease process. Currently, close communication between interventionalists and bypass surgeons is paramount to providing the optimal care for patients with CLI. ■

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