Does anybody remember how to do distal bypass? When and how?

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Historical Perspective

- 1906 - Technique of vascular anastomosis described
  (Carrel A, Guthrie CC. Surg Gynecol Obstet 2:266, 1906)

- 1948 - First successful femoral popliteal bypass using reversed GSV in a patient with PAD
  (Kunlin J. Rev Chir Paris 70:206-236, 1951)
Revascularization Options

- Open Vascular Surgery
- Endovascular Therapy
- Hybrid Procedure

Hirsch AT et al. J Am Coll Cardiol 2006;47:1239-131
Conte MS and Farber A. BJS 2015;102:1007-1009
**Infrainguinal Bypass Surgery for CLI**

- Bypass with autogenous vein has historically been considered the “gold standard”
- Results well documented in hundreds of reports: anecdotal > retrospective > randomized trials
- Versatile: results in complex situations well established
- Low mortality, good durability
- **BUT**—there are limitations and risks:
  - Wound and other complications
  - Prolonged recovery
  - Vein quality and availability
  - Surveillance and reintervention
  - Technically demanding procedures
Key Factors to Consider

Old frail $\rightarrow$ Endo

Young, healthy, good vein $\rightarrow$ Open
Relevant Domains

Patient

Limb

Anatomy
Limb Factors

Rutherford → WIfI Index
The Society for Vascular Surgery Lower Extremity Threatened Limb Classification System: Risk stratification based on Wound, Ischemia, and foot Infection (WIfI)

Joseph L. Mills, Sr, MD, Michael S. Conte, MD, David G. Armstrong, DPM, MD, PhD, Frank B. Pomposelli, MD, Andres Schanzer, MD, Anton N. Sidawy, MD, MPH, and George Andros, MD, on behalf of the Society for Vascular Surgery Lower Extremity Guidelines Committee, Tucson, Ariz; San Francisco and Van Nuys, Calif; Brighton and Worcester, Mass; and Washington, D.C.

Critical limb ischemia, first defined in 1982, was intended to delineate a subgroup of patients with a threatened lower extremity primarily because of chronic ischemia. It was the intent of the original authors that patients with diabetes be excluded or analyzed separately. The Fontaine and Rutherford Systems have been used to classify risk of amputation and likelihood of benefit from revascularization by subcategorizing patients into two groups: ischemic rest pain and tissue loss. Due to demographic shifts over the last 40 years, especially a dramatic rise in the incidence of diabetes mellitus and rapidly expanding techniques of revascularization, it has become increasingly difficult to perform meaningful outcomes analysis for patients with threatened limbs using these existing classification systems. Particularly in patients with diabetes, limb threat is part of a broad disease spectrum. Perfusion is only one determinant of outcome; wound extent and the presence and severity of infection also greatly impact the threat to a limb. Therefore, the Society for Vascular Surgery Lower Extremity Guidelines Committee undertook the task of creating a new classification of the threatened lower extremity that reflects these important considerations. We term this new framework, the Society for Vascular Surgery Lower Extremity Threatened Limb Classification System. Risk stratification is based on three major factors that impact amputation risk and clinical management: Wound, Ischemia, and foot Infection (WIfI). The implementation of this classification system is intended to permit more meaningful analysis of outcomes for various forms of therapy in this challenging, but heterogeneous population. (J Vasc Surg 2014;59:220-34.)

- **Wound**: extent and depth
- **Ischemia**: perfusion/flow
- **Foot Infection**: presence and extent
Preoperative Patient Preparation

- History and physical examination
- Physiological noninvasive vascular studies
- Risk factor modification
  - Smoking cessation paramount
  - Aspirin, statin
  - Clopidogrel +/- stopped
- MRA vs CTA +/- angiogram
- Iliac disease often treated at time of angiogram to minimize bypass OR time
Preoperative Planning of Operation

Infrainguinal bypass procedure should be meticulously planned before patient is in OR

– Guiding principle: Time in OR needs to be minimized through thoughtful execution of pre-operative plan

**Shorter Duration of Femoral-Popliteal Bypass Is Associated with Decreased Surgical Site Infection and Shorter Hospital Length of Stay**

Tze-Woei Tan, MD, Jeffrey M Kalish, MD, Naomi M Hamburg, MD, Denis Rybin, MS, Gheorghe Doros, PhD, Robert T Eberhardt, MD, Alik Farber, MD

<table>
<thead>
<tr>
<th>BACKGROUND:</th>
<th>Duration of femoral-popliteal bypass is based on multiple patient-specific, system-specific, and surgeon-specific factors, and is subject to considerable variability. We hypothesized that shorter operative duration is associated with improved outcomes and might represent a potential quality-improvement measure.</th>
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<tbody>
<tr>
<td>STUDY DESIGN:</td>
<td>Patients who underwent primary femoral-popliteal bypass with autogenous vein between 2005 and 2009 were identified from the American College of Surgeons NSQIP dataset using ICD-9 codes. Operative duration quartiles (Q) were determined (Q1: ≤149 minutes, Q2: 150 to 192 minutes, Q3: 193 to 268 minutes, and Q4: ≥269 minutes). Perioperative outcomes included mortality, surgical site infection, cardiopulmonary complications, and length of hospital stay. Relevant patient-specific and system-specific confounders, including age, body mass index, smoking, diabetes, end-stage renal disease, indication, American Society of Anesthesiologists' class, type of anesthesia, intraoperative transfusion, nonoperative time in the operating room, and participation of a trainee during the procedure, were adjusted for using multivariable regression.</td>
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<td>RESULTS:</td>
<td>There were 2,644 femoral-popliteal bypass procedures in our study. Mean age was 65.9 years and 62% of patients were male. Longer duration of surgery was associated with increased perioperative surgical site infection (Q1: 6.3%; Q2: 9.0%; Q3: 16.1%; and Q4: 13.9%; p &lt; 0.001) and longer length of stay (5.4 ± 6.8 days; 6.1 ± 6.7 days; 7.0 ± 11.3 days; 8.1 ± 6.0 days, respectively; p &lt; 0.001). In multivariable analysis, longer operative duration was independently associated with higher surgical site infection and longer hospital length of stay. Operative duration of ≥260 minutes increased the risk of surgical site infection by 50% compared with operative time of 150 minutes.</td>
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<td>CONCLUSIONS:</td>
<td>Longer duration of femoral-popliteal bypass with autogenous vein was associated with a significantly higher risk of perioperative surgical site infection and longer hospital length of stay. Surgeon-specific parameters that lead to faster operative time might lead to improved clinical outcomes and more efficient hospital resource use. (J Am Coll Surg 2012;215:512-518. © 2012 by the American College of Surgeons)</td>
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The association between operative duration of femoral-popliteal bypass and surgical site infection.

- **95% Confidence Bounds:**
- **Estimated Relative Risk:**

![Graph showing the association between surgery duration and surgical site infection](image-url)
Conduit

• **Evaluation**
  – Pre-op vein mapping is performed in vascular lab
  – Minimum 2.5 mm acceptable
  – Contralateral GSV, short saphenous, arm vein

• **Choice**
  – Single segment GSV is favored
  – If not available, choice of composite vs arm vein vs prosthetic a judgment call
Choice of Target

• Based on judgment
  – technical suitability AND likelihood of graft to stay open
• Adequate diameter
• Adequate length
• Relative freedom from calcification
• Any and all potential targets in play:
  – Peroneal, AT, Tibioperoneal trunk
  – DP or PT

• No fear of the foot
  – DP tarsal branches
  – PT plantar branches
Popliteal-pedal bypass
“It’s all about the vein”

• Distal vein is cannulated and gently insufflated with heparinized saline
Endarterectomy with bovine patch angioplasty

Proximal and distal anastomosis

5.0 or 6.0 or 7.0 Prolene suture

Meticulous technique

Completion

Doppler

Duplex

+/− Angiogram

The Operation:
### Greater Saphenous Vein

<table>
<thead>
<tr>
<th></th>
<th>Primary Graft Patency @ 5 years</th>
<th>Secondary Graft Patency @ 5 years</th>
<th>Limb Salvage @ 5 years</th>
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</thead>
<tbody>
<tr>
<td><strong>Taylor et al.</strong></td>
<td>80%</td>
<td>84%</td>
<td>90%</td>
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<td><em>(JVS 1990)</em></td>
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<tr>
<td>n = 300 reversed GSV</td>
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<tr>
<td><strong>Shah et al.</strong></td>
<td>72%</td>
<td>81%</td>
<td>95%</td>
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<tr>
<td><em>(Ann Surg 1995)</em></td>
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<tr>
<td>n = 2048 in situ GSV</td>
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Perioperative mortality: 2-6%
# Alternative Autogenous Vein

<table>
<thead>
<tr>
<th>Study</th>
<th>1° Graft Patency</th>
<th>2° Graft Patency</th>
<th>Limb Salvage</th>
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</thead>
<tbody>
<tr>
<td>Arm Vein</td>
<td><strong>Faries et al.</strong> (JVS 2000)</td>
<td>55% @ 5 years</td>
<td>58% @ 5 years</td>
</tr>
<tr>
<td>Lesser Saphenous Vein</td>
<td><strong>Chang et al.</strong> (JVS 1992)</td>
<td>55% @ 3 years</td>
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</table>
Healing of Ischemic Wounds: Comparison of Endovascular Therapy and Bypass
Neville et al. J Vasc Surg; 11-12S, June 2010

- 290 pts with ischemic wounds
- Rx: LEB vs EV

- Total wound healing: 76 vs 41% (p = .013)
- Large wounds: 70 vs 27% (p = .02)
- Shorter median time to healing: 98 vs 132 days (p = .048)
A decade of experience with dorsalis pedis artery bypass: Analysis of outcome in more than 1000 cases

Frank B. Pomposelli, MD, Nikhil Kansal, MD, Alan D. Hamdan, MD, Alana Belfield, BA, Malachi Sheahan, MD, David R. Campbell, MD, John J. Skillman, MD, and Frank W. Logerfo, MD, Boston, Mass

Objective: The purpose of this study was to review our experience over the last decade with the dorsalis pedis bypass for ischemic limb salvage in patients with diabetes mellitus.

Methods: The study was a retrospective analysis of a computerized vascular registry and chart review. From January 10, 1990 to January 11, 2000, 1032 bypasses to the dorsalis pedis artery were performed in 865 patients (27.6% of the 3731 lower extremity arterial bypass procedures performed in that time period). Five hundred ninety-seven patients (69%) were male, with a mean age of 66.8 years. Ninety-two percent had diabetes mellitus. All procedures were done for limb salvage. Conduits included 317 nonreversed saphenous vein (30.7%), 273 in situ (26.4%), 235 reversed vein (22.8%), 170 arm vein (16.5%), 35 other vein (3.4%), and two polytetrafluoroethylene (0.2%) grafts. The inflow arteries were as follows: 294 common femoral (28.5%), 550 popliteal (53.2%), 114 superficial femoral (11%), and 74 other (7.2%).

Results: The mortality rate within 1 month of surgery was 0.9%, and 42 grafts (4.2%) failed in the same interval, although 13 were successfully revised. In a follow-up period that ranged from 1 to 120 months (mean, 23.6 months), primary patency, secondary patency, limb salvage, and patient survival rates were 56.8%, 62.7%, 78.2%, and 48.6%, respectively at 5 years and 37.7%, 41.7%, 57.7%, and 23.8% at 10 years. Both polytetrafluoroethylene grafts failed in less than 1 year. Primary graft patency was worse in female patients (46.5% female versus 61.6% male at 5 years; \( P < .009 \)) but better in patients with diabetes (65.9% diabetes mellitus versus 56.3% non-diabetes mellitus at 4 years; \( P < .04 \)). Saphenous vein grafts performed better than all other conduits with a secondary patency rate of 67.6% versus 46.3% at 5 years (\( P < .0001 \)). Multivariate analysis showed that length of stay greater than 10 days and dorsalis pedis bypass for the surgical indication of previous graft occlusion were independently predictive of worse graft patency at 1 year and use of saphenous vein as conduit was predictive of better patency.

Conclusion: Dorsalis pedis bypass is durable with a high likelihood of ischemic foot salvage over many years. Saphenous vein is the preferred conduit when available. Short vein grafts from distal inflow sites are possible in more than 50% of cases. These results justify the routine use of pedal arterial reconstruction for patients with diabetes with ischemic foot complications. (J Vasc Surg 2003;37:307-15.)
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Method: The study was a retrospective analysis of a computerized vascular registry and chart review. From January 1, 2010, to December 31, 2019, a total of 1000 patients underwent 1000 procedures. The primary outcome measure was the 30-day mortality rate.

- 30-day mortality – 0.9%
- 5-year limb salvage rate – 78%
- (5 year amputation rate – 22%)

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Conclusions

• If surgeon is motivated and patient has good inflow and outflow, distal bypass can be performed efficiently, with acceptable morbidity, and with excellent long-term durability.

• Remains the gold standard for many patients, particularly those with complex disease and/or large wounds.

• Greater saphenous vein is the preferred conduit when available.

• Prosthetic grafts are acceptable alternatives.
Summary

• Total, lifelong, multidisciplinary care of complex PAD patients is vital for limb preservation

• All patients should be considered for surgery, endovascular Rx, and hybrid options.
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