Conventional treatment of the diabetic foot

Distal By-Pass procedures can reduce limb loss

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PAD and DM

- DM is not just a major predisposing factor for PAD

- PAD in diabetics comes earlier, is more profound and is extended to distal arteries including profunda femoris and distal below knee arteries.

- Has worse prognosis and prompt surgical therapy is mandatory for limb salvage

- DM predisposes to foot infection even upon «normal» distal arterial flow
PAD localization

- Aortoiliac
- Femoropopliteal
- Distal
- Multifocal
- Combined (with Coronary artery disease, carotid artery disease, renal artery disease and..)
• Diabetics usually have multilevel occlusive disease
• Moderate inflow disease
• Including moderate diseased or poor profunda
• Poor outflow vessels in the mid tibia but usually reconstructed distally
• Rarely aortobifemoral reconstruction alone suffice
• In diabetic infection or gangrene (stage II B complicated, III and IV meaning CLI) an adjunctive procedure is usually needed (profundoplasty, SFA stenting, by pass?, distal PTA, distal by pass)
In Diabetics, in distal tibia, run off vessels usually are patent and might suffice to accommodate a distal bypass.

- Ant Tibial or Dorsalis Pedis
- Post Tibial
- Peroneal (fibularis)
Indications for distal bypass in Diabetics

- CLI (Fontaine 3 and 4, Rutherford 4-6)
  Unrelieved (under opiate analgesia) rest pain > 2 weeks + ankle systolic pressure lower than 50 mm Hg and/or toe systolic pressure lower than 30 mm Hg.
  Or ulceration or gangrene of the foot or toes and ankle systolic pressure lower than 50 mm Hg or toe systolic pressure lower than 30 mm Hg (or absent pedal pulses in diabetics).

- Fontaine II B complicated in diabetics
Fig. A5. Fate of the patients presenting with chronic critical leg ischemia. CLI – critical limb ischemia.
Co morbidities

- Coronary artery disease (CAD): Perioperative AMI in PAD is 2-6% 70% of periop and late mortality from CAD 25% of patients with PAD have CAD (>70% stenosis)

- CRI, Carotid artery disease, CHF
Revascularization in patients with diabetic foot
Operative strategy

- Wet purulent gangrene,
- Abscess, Deep infection,
- Closed cavities with pus

Prompt Debridement
Drain infection
Guillotine amputation

Healing potential?
- Poor
  - Wound care and wait for closure
  - Revascularization potential
  - Proximal closed amputation

- Good
  - Heals
  - Preventive Foot care

- Persistent infection?
  - No
    - Fails
      - Revascularize and await for closure
      - Avoid synthetic grafts
        - Proximal closed amputation
  
  - Yes
    - Heals

Dry gangrene (sphacelus)
Dry ulcer

Revascularization potential
Iv antibiotics

Proximal closed amputation
Avoid synthetic grafts
Preventive Foot care
Revascularization in patients with diabetic foot

• Open reconstruction
• Endovascular procedures
• Hybrid
Type A lesions
- Unilateral or bilateral stenoses of CIA
- Unilateral or bilateral single short (≤3 cm) stenosis of EIA

Type B lesions:
- Short (≤3 cm) stenosis of infrarenal aorta
- Unilateral CIA occlusion
- Single or multiple stenosis totaling 3–10 cm involving the EIA not extending into the CFA
- Unilateral EIA occlusion not involving the origins of internal iliac or CFA

Type C lesions
- Bilateral CIA occlusions
- Bilateral EIA stenoses 3–10 cm long not extending into the CFA
- Unilateral EIA stenosis extending into the CFA
- Unilateral EIA occlusion that involves the origins of internal iliac and/or CFA
- Heavily calcified unilateral EIA occlusion with or without involvement of origins of internal iliac and/or CFA

Type D lesions
- Intra-renal aortoiliac occlusion
- Diffuse disease involving the aorta and both iliac arteries requiring treatment
- Diffuse multiple stenoses involving the unilateral CIA, EIA, and CFA
- Unilateral occlusions of both CIA and EIA
- Bilateral occlusions of EIA
- Iliac stenoses in patients with AAA requiring treatment and not amenable to endograft placement or other lesions requiring open aortic or iliac surgery
Recommendation 36. Treatment of aortoiliac lesions

- TASC A and D lesions: Endovascular therapy is the treatment of choice for type A lesions and surgery is the treatment of choice for type D lesions [C].
- TASC B and C lesions: Endovascular treatment is the preferred treatment for type B lesions and surgery is the preferred treatment for good-risk patients with type C lesions. The patient’s co-morbidities, fully informed patient preference and the local operator’s long-term success rates must be considered when making treatment recommendations for type B and type C lesions [C].
**BE stents**
- Metal alloy (usually Stainless steel)
- Mounted over a Pta balloon
- Reach a pre-designed diameter (atm)
- High radial force
- Low conformability in tortuosity
- Good for aortic stenosis

**Stents**

**SE stents**
- Metal alloy usually nitinol
- Mounted inside a retrievable catheter
- Reach a pre-designed diameter
- Lw radial force
- High conformability in tortuosity
- Poor indication for aortic stenosis, good for iliacs
• Drug eluting stents
• Absorbable stents
Atherectomy

1. Directional atherectomy

2. Rotational atherectomy

3. Excisional atherectomy

4. Excimer laser atherectomy
Moll cutter endarterectomy (Hybrid)
Open surgical reconstruction for fem-pop and distal obstructive disease

• Femoro-popliteal by-pass (reg/short)

• Femoro-distal by-pass (reg/short)

• Distal by pass (popliteal-crural by-pass)
Graft of choice

- **Vein**
  - In situ + valvulotomy or Reversed
  - Great or Lesser saphenous
  - Umbilical vein

- **Prosthetic (PTFE)**
  - Carbon, Heparin, thin wall
  - Pre cuff (distaflo) or
  - Modified distal anastomosis
Figure 81-7 The Miller cuff technique is an adjunct in a controlled, randomized clinical trial.

Figure 81-9 The St. Mary’s boot or prosthesis technique.
### Reversed vs In Situ By-pass

<table>
<thead>
<tr>
<th>First Author (Year), Graft Type (No. of Grafts)</th>
<th>PATENCY (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>RVG</td>
</tr>
<tr>
<td>Watelet [144] (1986): AK/BK popliteal (n = 100 grafts)*</td>
<td>88</td>
</tr>
<tr>
<td>Harris [143] (1993): AK/BK popliteal (n = 215 grafts)*</td>
<td>77</td>
</tr>
<tr>
<td>Veterans Administration Cooperative Study Group 141 [140] (1988) (n= 461 grafts)†</td>
<td>75</td>
</tr>
<tr>
<td>BK popliteal</td>
<td>67</td>
</tr>
<tr>
<td>Infrapopliteal</td>
<td>67</td>
</tr>
<tr>
<td>Wengerter [144] (1991) (n = 125 grafts) ‡</td>
<td>67</td>
</tr>
<tr>
<td>Overall</td>
<td>37</td>
</tr>
<tr>
<td>&lt;3-mm veins</td>
<td>70.2</td>
</tr>
</tbody>
</table>

NS, not significant; AK, above knee; BK, below knee; RVG, reversed vein grafts.

* Values at 36 months.
† Values at 24 months.
‡ Values at 30 months.
§ Ten-year results.

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In Situ By-pass vs Reversed
Fem-Pop by-pass

vein
Pre cuff PTFE, (distaflo)
Below Knee Fem Pop by-pass
(Vein vs PTFE patency)

TABLE 81-4 -- Below-Knee Femoropopliteal Grafts

<table>
<thead>
<tr>
<th></th>
<th>PATENCY*</th>
<th>1 MO</th>
<th>6 MO</th>
<th>1 YR</th>
<th>2 YR</th>
<th>3 YR</th>
<th>4 YR</th>
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<tr>
<td>Primary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reverse saphenous vein</td>
<td>98</td>
<td>90</td>
<td>84</td>
<td>79</td>
<td>78</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>In-situ vein bypass</td>
<td>95</td>
<td>87</td>
<td>80</td>
<td>76</td>
<td>73</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>Secondary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-situ vein bypass</td>
<td>97</td>
<td>96</td>
<td>96</td>
<td>89</td>
<td>86</td>
<td>81</td>
<td></td>
</tr>
<tr>
<td>Arm vein</td>
<td>97</td>
<td>—</td>
<td>83</td>
<td>83</td>
<td>73</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Human umbilical vein</td>
<td>88</td>
<td>82</td>
<td>77</td>
<td>70</td>
<td>61</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Polytetrafluoroethylene</td>
<td>96</td>
<td>80</td>
<td>68</td>
<td>61</td>
<td>44</td>
<td>40</td>
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<tr>
<td>Limb salvage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Reverse saphenous vein</td>
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<td>90</td>
<td>88</td>
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<td>84</td>
<td>83</td>
<td>—</td>
<td></td>
</tr>
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</table>

* All patencies are expressed as percentages; all series published since 1981.
### Infrapopliteal by-pass

(Vein vs PTFE patency)

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<thead>
<tr>
<th></th>
<th>PATENCY</th>
<th>1 MO</th>
<th>6 MO</th>
<th>1 YR</th>
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<th>3 YR</th>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>66</td>
<td>62</td>
<td></td>
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<tr>
<td>In-situ vein bypass</td>
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<td>84</td>
<td>82</td>
<td>76</td>
<td>74</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>76</td>
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<td>58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Human umbilical vein</td>
<td>80</td>
<td>65</td>
<td>52</td>
<td>46</td>
<td>40</td>
<td>37</td>
<td></td>
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<tr>
<td>Polytetrafluoroethylene</td>
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<td>46</td>
<td>32</td>
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<td>21</td>
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<tr>
<td><strong>Limb salvage</strong></td>
<td></td>
<td></td>
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<td>68</td>
<td>60</td>
<td>56</td>
<td></td>
</tr>
</tbody>
</table>

*All patencies are expressed as percentages; all series published since 1981.*
Fem-distal by-pass

vein

PTFE
Distal by-pass (popliteal-crural by-pass)
Medial approach
Distal bypass (popliteal-crural by-pass)
Posterior approach

To posterior tibial art.  To peronial art. (fibularis)

Lesser saphenous vein
Great saphenous vein
**Distal at or below ankle grafts**

**(crural by-pass)**

<table>
<thead>
<tr>
<th>TABLE 81-6 -- At or Below-Ankle Grafts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PATENCY</strong></td>
</tr>
<tr>
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</tr>
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</tr>
<tr>
<td>Secondary</td>
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<tr>
<td>Reverse saphenous vein</td>
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<tr>
<td>In-situ vein bypass</td>
</tr>
<tr>
<td>Foot salvage</td>
</tr>
<tr>
<td>* All patencies are expressed as percentages; all series published since 1981.</td>
</tr>
</tbody>
</table>

Short bypass grafting from popliteal to tibial and pedal arteries

a concept first described by F. Veith in 1981

• special pattern of atherosclerosis is prevalent with disease limited to the infrageniculate arteries but sparing inflow vessels and distal tibial and pedal arteries.
• 124 diabetics, 140 vein bypass grafts for limb salvage,
• 95.7% for foot necrosis.
• Operative mortality rate was 1.4%,
• major morbidity rate was 9.3%,
• early graft failure rate 8.5% and
• early amputation rate was 3.8%.
• 2 year primary patency, primary assisted patency, secondary patency rates and limb salvage were 73.3%, 75.7%, 76.4% and 87.2%.
• 5 years results were 63.6%, 69.2%, 70.0% and 81.9% respectively.
• Compared to long femorodistal grafts there was no difference in longterm patency.

Revascularization of the ischemic diabetic foot by popliteal-to-distal bypass

- 15 ischemic feet with gangrenous lesions
- popliteal artery trifurcation disease
- autogenous inverted saphenous vein.
- No operative death
- mean follow-up of 35 +/- 23 months
- One major amputation
- at 2 years cumulative primary / secondary patency and limb salvage rates were 79.3%, 86.2% and 93.1% respectively

How can we improve the prognosis of infra-popliteal by-pass in DM?

- Postoperative mortality in diabetics with PAD, submitted to distal by-pass is 3 to 10%, depending on age, cardiovascular disease, diabetes mellitus, carotid, end-stage renal disease.

- Pre-op evaluation and risk factors modification

Fichelle JM. How can we improve the prognosis of infrapopliteal bypasses? J Mal Vasc. 2011 May 4.
How can we improve the prognosis of infrapopliteal by-pass in DM?

- **Inflammation control**: Previous treatment of septic lesions, before revascularization.

- **Imaging**: Technical aspects from preop duplex scan, MRA and DSA, with lateral views for optimum decision making.

- **Graft selection**: duplex scan to evaluate the quality and the length of the ipsilateral or contralateral long saphenous vein, allowing an appropriate choice among bypass modalities.

- **In flow**: In case of SFA or Iliac localized stenosis, a combined strategy with angioplasty and distal bypass is a safe therapeutic option.

- **Proximal anastomosis**: surgically safe portion, free of porcelain disease, free of proximal hemodynamic lesions, (CFA, SFA, popliteal or tibial artery).

  If poor distal run off, and high peripheral resistances (diabetic foot, end-stage renal disease, foot infections) the proximal anastomosis must be made as distal as possible, on the popliteal or tibial artery.

*Fichelle JM. How can we improve the prognosis of infrapopliteal bypasses? J Mal Vasc, 2011 May 4.*
How can we improve the prognosis of infra-popliteal by-pass?

- **distal anastomosis**: on an artery in continuity with the foot, and the plantar arch. In diabetic patients, the best artery is often the pedal artery.

- **The graft of choice**: venous, better than prosthetic. long saphenous vein in situ or reversed, or transposed. (3 years primary patency of PTFE is low, between 30 and 50%. If used combine with venous patch, venous cuff)

- **Improving outflow**: distal arteriovenous fistula improves flow in the grafts, but increases distal resistances. Free tissue transfer increases outflow, allowing treatment of major tissue loss

- **Postop therapy**: systemic heparinisation, until the patient is able to have a muscular activity. Antiplatelet therapy with aspirin is warranted for venous grafts. For prosthetic by-pass, some studies have shown that coumadin therapy provides a benefit. Statins.

- **Follow-up**: duplex scan at 1, 6, 12 months and then annually to search for stenosis of the venous grafts

- **Reoperation**: If a significant hemodynamic lesion is found
  
  In acute occlusions of the graft, aggressive approach (thrombectomy, thrombolysis and distal angioplasty)

Fichelle JM. How can we improve the prognosis of infrapopliteal bypasses? J Mal Vasc. 2011 May 4.
Figure 81-12 Completion arteriography identified a significant distal anastomotic defect (A) despite a good graft pulse and distal continuous-wave Doppler signal. The anastomosis was re-explored, the defect was corrected (B), and the graft is patent at 3 years.
Follow-up: duplex scan at 1, 6, 12 months
Conclusions

• DM predispose to more severe, multilevel and distally distributed PAD

• Distal by-pass is an efficacious procedure offering high limb salvage rate in diabetics