Conventional treatment
of the diabetic foot

Distal By-Pass procedures can reduce limb loss

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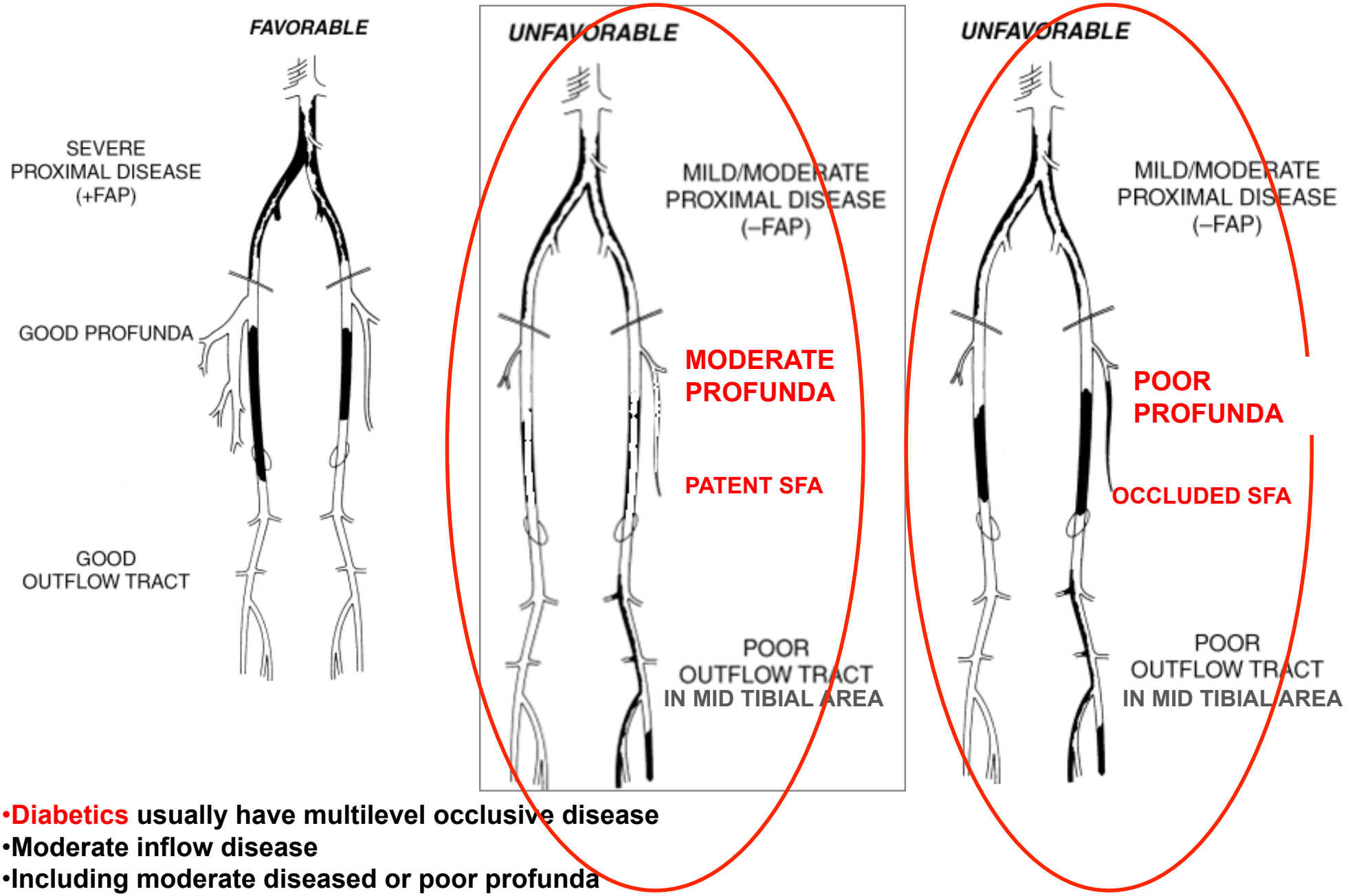
PAD and DM

- 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 profounda 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

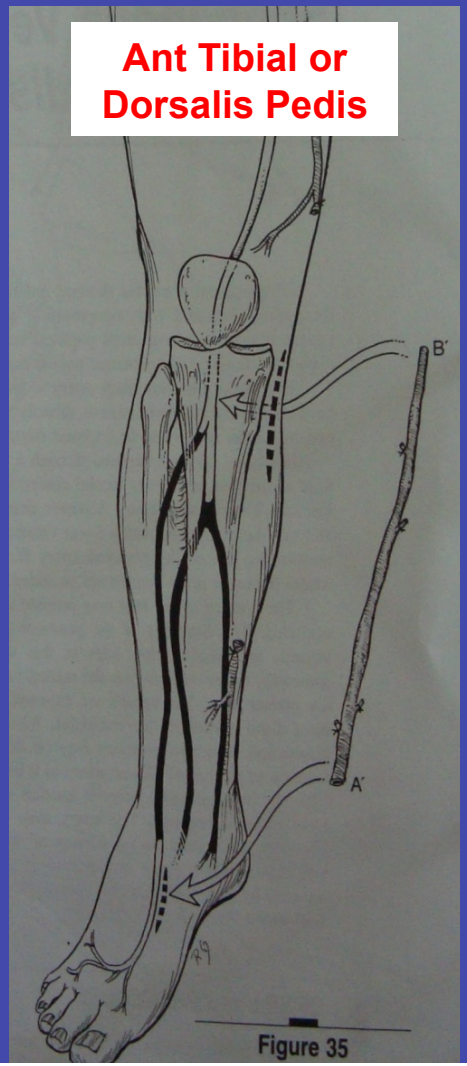
PAD localization

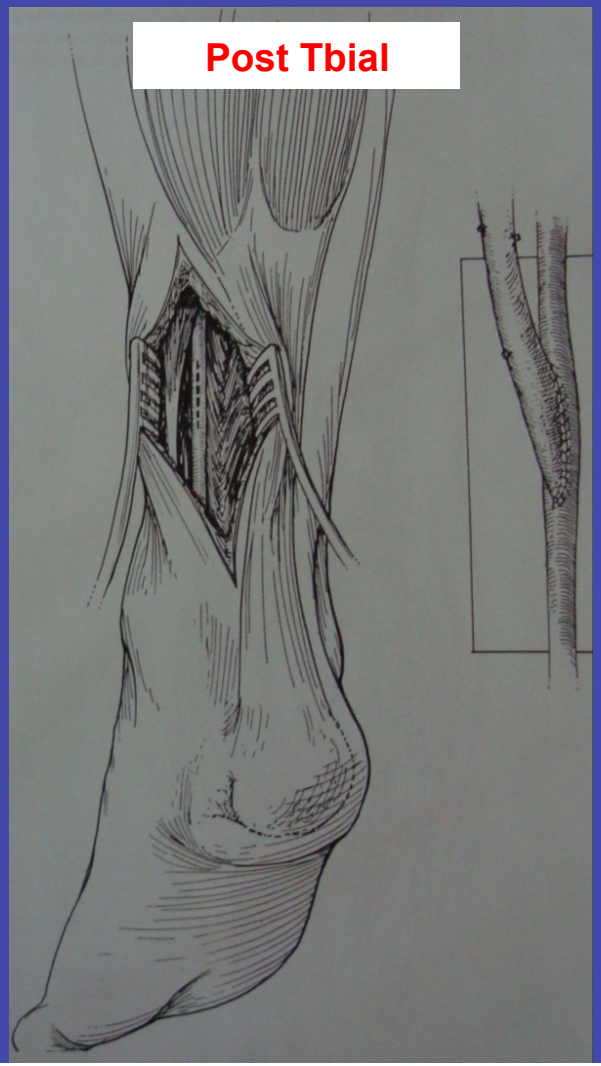
- Aortoiliac
- Femoropopliteal
- Distal
- Multifocal
- Combined (with Coronary artery disease, carotid artery disease, renal artery disease and..)

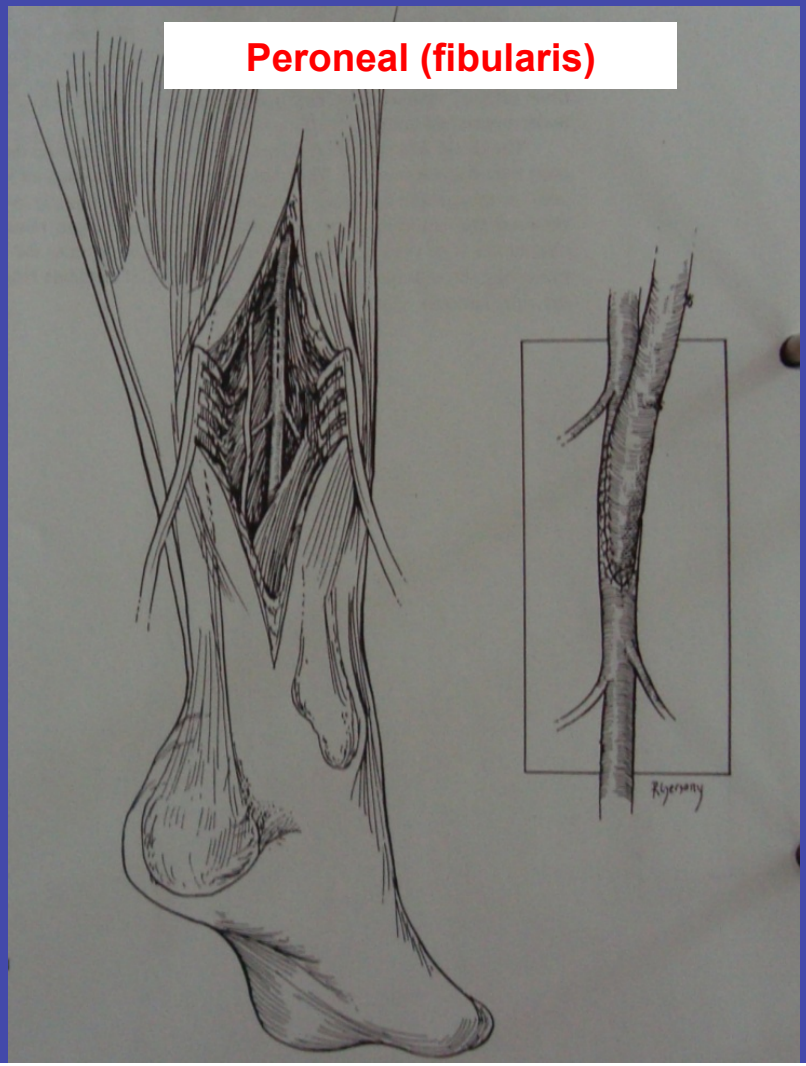


- **Diabetics usually have multilevel occlusive disease**
- **Moderate inflow disease**
- **Including moderate diseased or poor profunda**
- **Poor outflow vessels in the mid tibia but usually reconstructed distally**
- **Rarely aortobifemoral reconstruction alone sufice**
- **In diabetic infection or 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 by pass.







Indications for distal by pass 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

Fate of patient with CLI (TASC II)

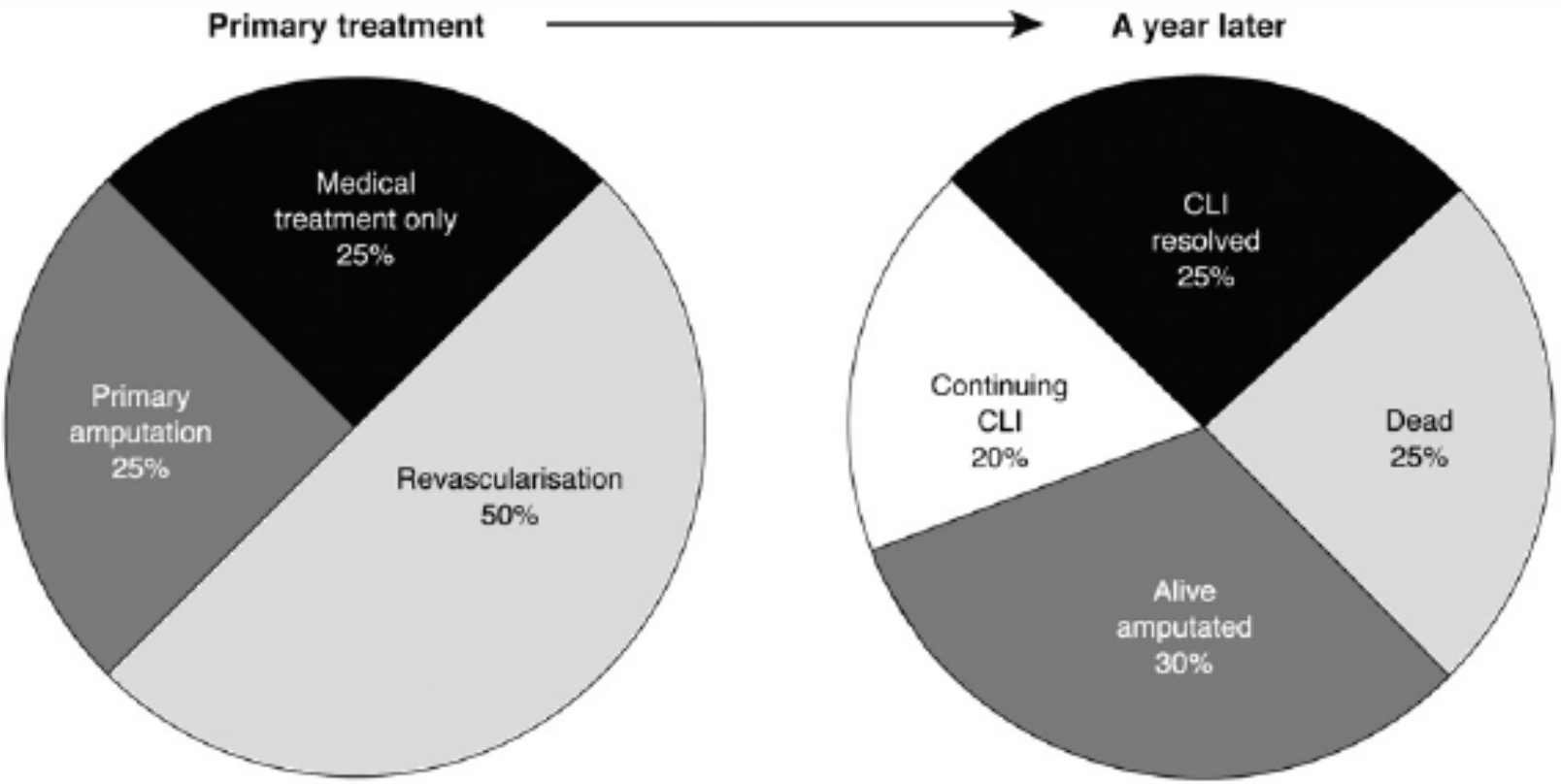


Fig. A5. Fate of the patients presenting with chronic critical leg ischemia. CLI – critical limb ischemia.

Co morbidities

- Coronary artery disease (CAD):

Perioperative AMI in PAD is 2-6%

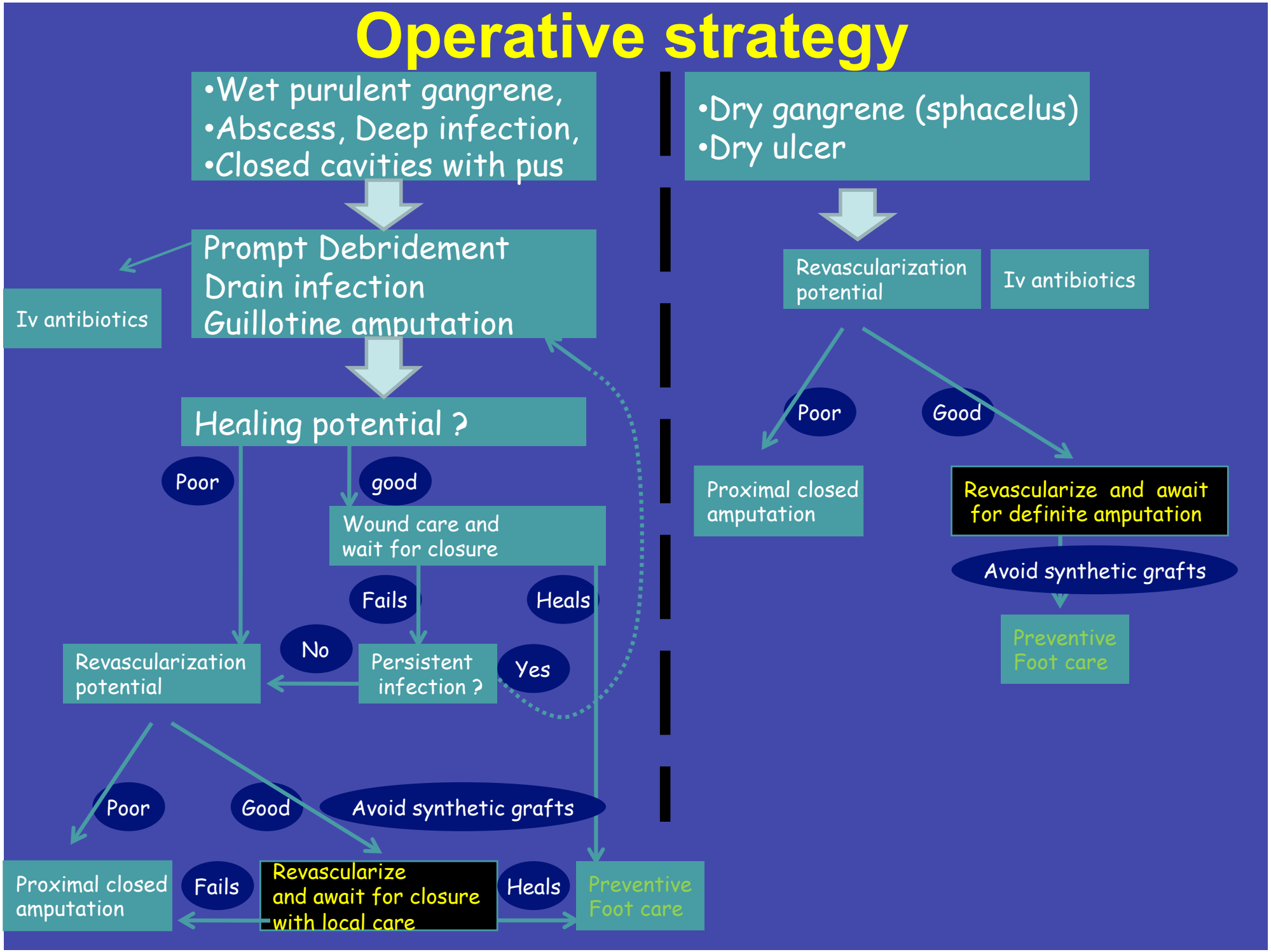
70% of periop and late mortality from CAD

25% of patients with PAD have CAD (>70% stenosis)

- CRI, Carotid artery disease, CHF

Revascularization in patients with diabetic foot

Operative strategy

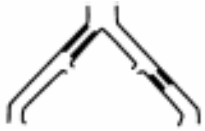


Revascularization in patients with diabetic foot

- Open reconstruction
- Endovascular procedures
- Hybrid

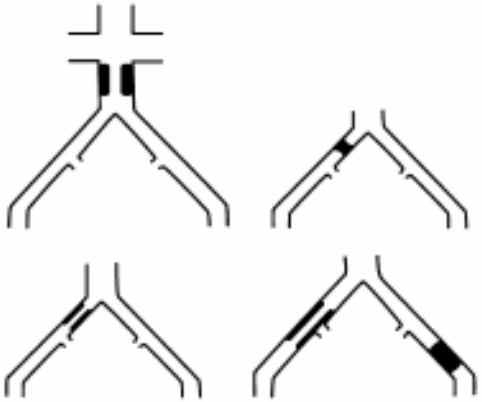
Type A lesions

- Unilateral or bilateral stenoses of CIA
- Unilateral or bilateral single short (≤3 cm) stenosis of EIA



Type B lesions:

- Short (≤3cm) 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

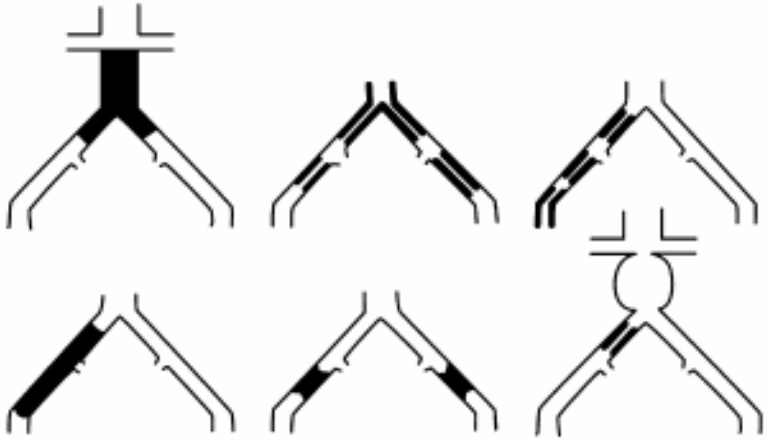


Type C lesions

- 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

- Infra-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

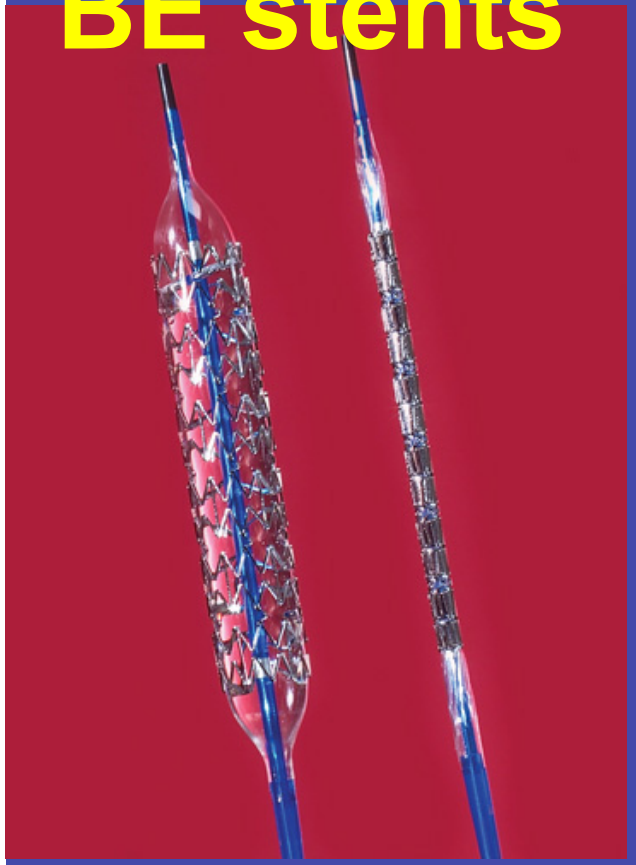


Recommendation 36. Treatment of aortoiliac lesions

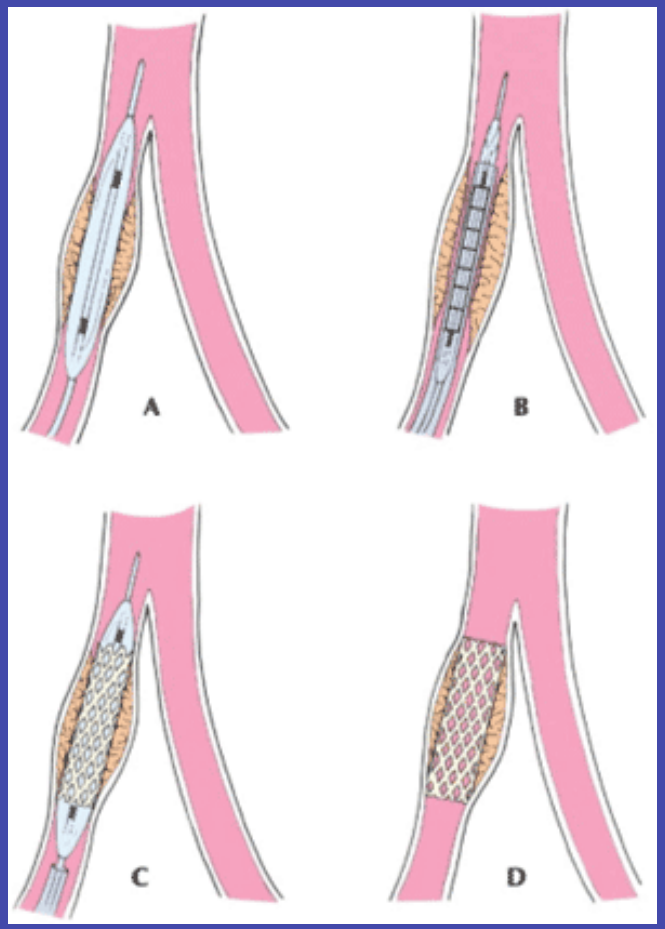
- TASC A and D lesions: Endovascular therapy is the treatment of choice for type A lesions and surgery is the treatment of choice for type D lesions [C].
- TASC B and C lesions: Endovascular treatment is the preferred treatment for type B lesions and surgery is the preferred treatment for good-risk patients 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].

Stents

BE stents



- Metal alloy (usually Stainless steel)
- Mounted over a Pta balloon
- Reach a pre-designed diameter (atm)
- High radial force
- Low conformability in tortouosity
- Good for aortic stenosis



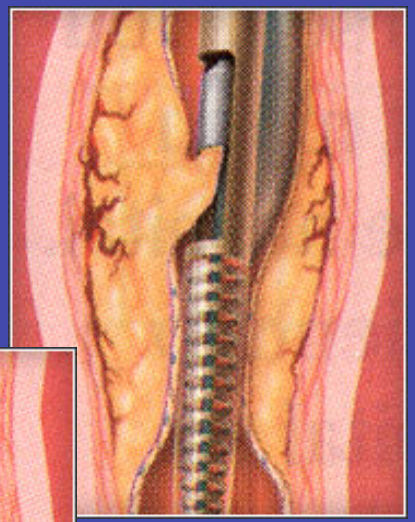
SE stents

- Metal alloy usually nitinol
- Mounted inside a retrievable catheter
- Reach a pre-designed diameter
- Lw radial force
- High conformability in tortouosity
- Poor indication for aortic stenosis, good for iliacs

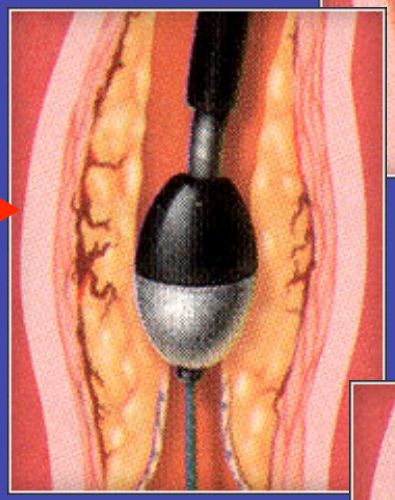
- Drug eluting stents
- Absorbable stents

Atherectomy

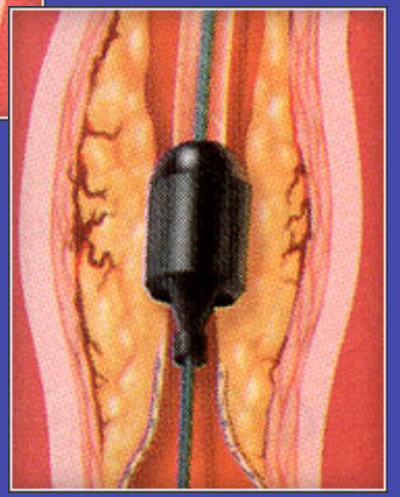
1.Directional atherectomy



2.Rotational atherectomy

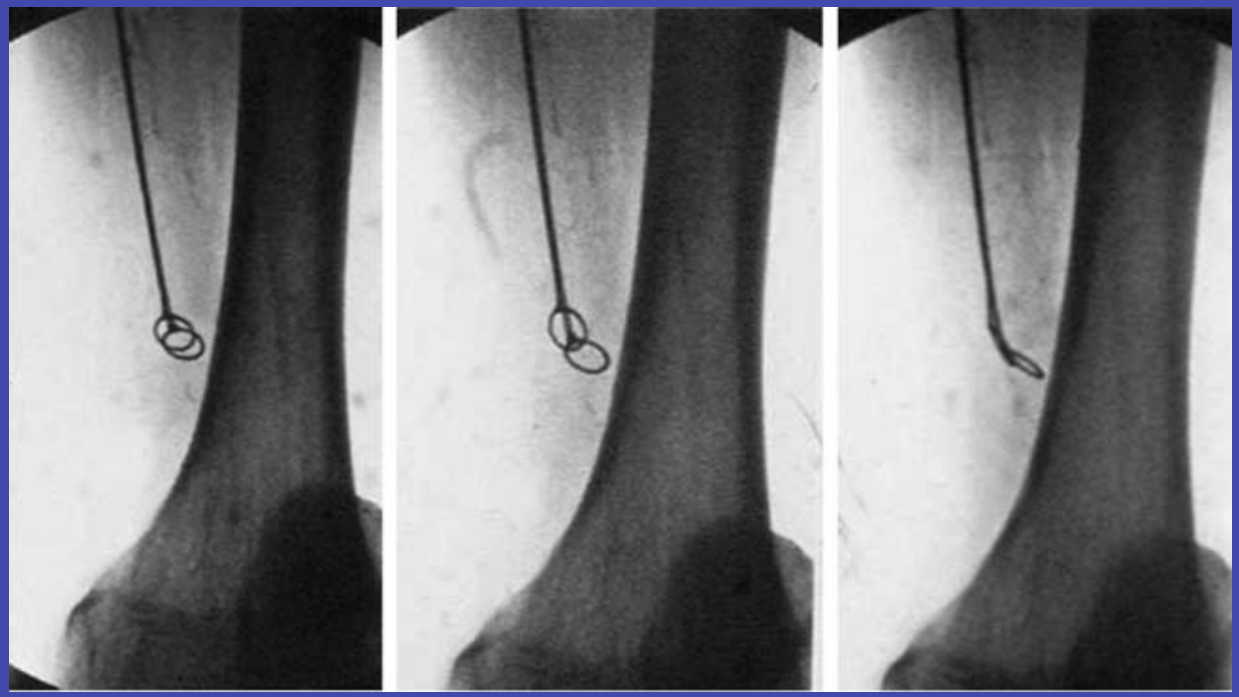


3.Excisional atherectomy



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

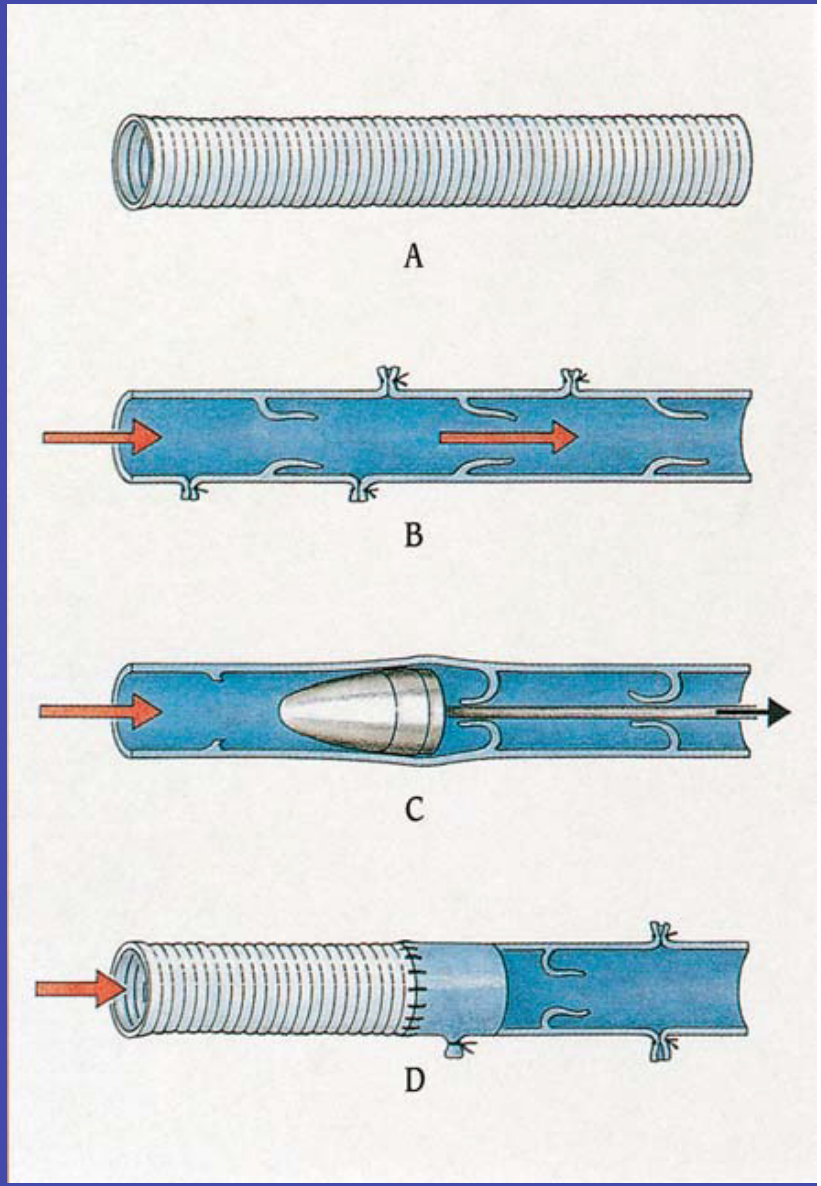
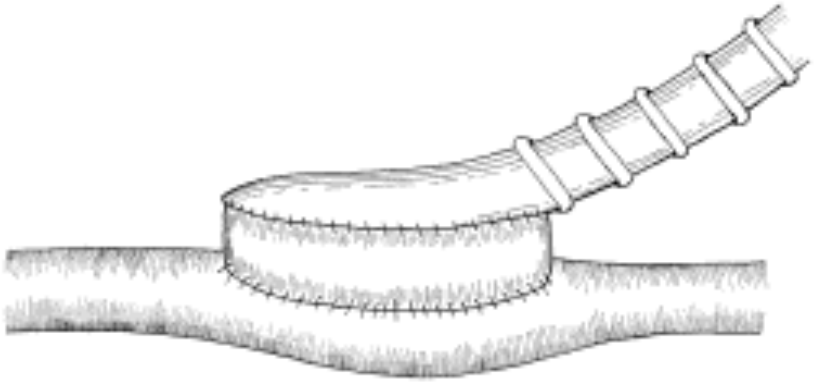
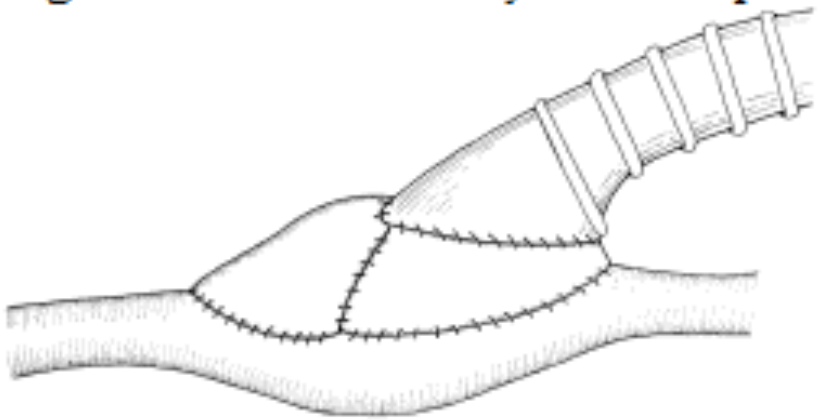


Figure 81-7 The Miller cuff technique[92] [illegible]
adjunct in a controlled, randomized clinica



The Taylor patch technique

Figure 81-9 The St. Mary's boot or pros



Sayers RD, Raptis S, Berce M, Miller JH: Long-term results of femorotibial bypass with vein or polytetrafluoroethylene. Br J Surg 85:934–938, 1998.
Taylor RS, Loh A, McFarland RJ, et al: Improved techniques for polytetrafluoroethylene bypass grafting: Long-term results using anastomotic vein patches. Br J Surg 79:348–354, 1992.
Tyrrell MR, Wolfe JHN: New prosthetic venous collar anastomotic technique: Combining the best of other procedures. Br J Surg 78:1016–1017, 1991.
Yeung KK, Mills JL, Hughes JD, et al: Improved patency of infrainguinal polytetrafluoroethylene bypass grafts using a distal Taylor vein patch. Am J Surg 182:578–583, 2001.
Stonebridge PA, Prescott RJ, Ruckley CV: Randomized trial comparing infrainguinal polytetrafluoroethylene bypass grafting with and without vein interposition cuff at the distal anastomosis. J Vasc Surg 26:543–550, 1997.

Reversed vs In Situ By-pass

FIRST AUTHOR (YEAR), GRAFT TYPE (NO. OF GRAFTS)	PATENCY (%)		
	RVG	In Situ	P Value
Watelet[144] (1986): AK/BK popliteal (n = 100 grafts)*	88	71	NS
Harris[143] (1993): AK/BK popliteal (n = 215 grafts)*	77	68	NS
Veterans Administration Cooperative Study Group 141[140] (1988) (n = 461 grafts)†			
BK popliteal	75	78	NS
Infrapopliteal	67	76	NS
Wengerter[146] (1991) (n = 125 grafts)‡			
Overall	67	69	NS
<3-mm veins	37	61	NS
Watelet[145] (1997) (n = 91 grafts)§	70.2	64.8	NS

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.

140. Veterans Administration Cooperative Study Group 141: Comparative evaluation of prosthetic, reversed, and in situ vein bypass grafts in distal popliteal and tibial-peroneal revascularization. Arch Surg 123:434–438, 1988.
143. Harris PL, Veith FJ, Shanik GD, et al: Prospective randomized comparison of in situ and reversed infrapopliteal vein grafts. Br J Surg 80:173–176, 1993.
144. Watelet J, Cheysson E, Poels D: In situ versus reversed saphenous vein for femoropopliteal bypass: A prospective randomized study of 100 cases. Ann Vasc Surg 1:441–452, 1986.
145. Watelet J, Soury P, Menard JF, et al: Femoropopliteal bypass: In situ or reversed vein grafts? Ten-year results of a randomized prospective study. Ann Vasc Surg 11:510–519, 1997.
146. Wengerter KR, Veith FJ, Gupta SK: Prospective randomized multicenter comparison of in situ and reversed vein infrapopliteal bypasses. J Vasc Surg 13:189–199, 1991.

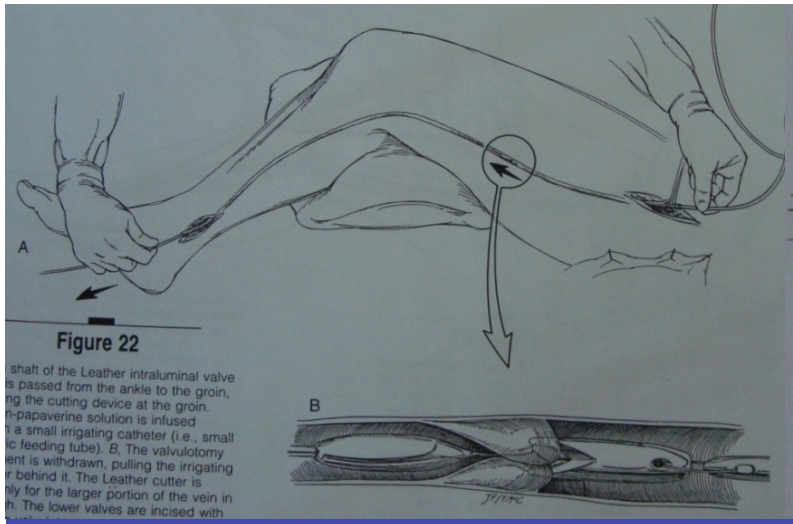


Figure 22

shaft of the Leather intraluminal valve
is passed from the ankle to the groin,
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In Situ By-pass vs Reversed

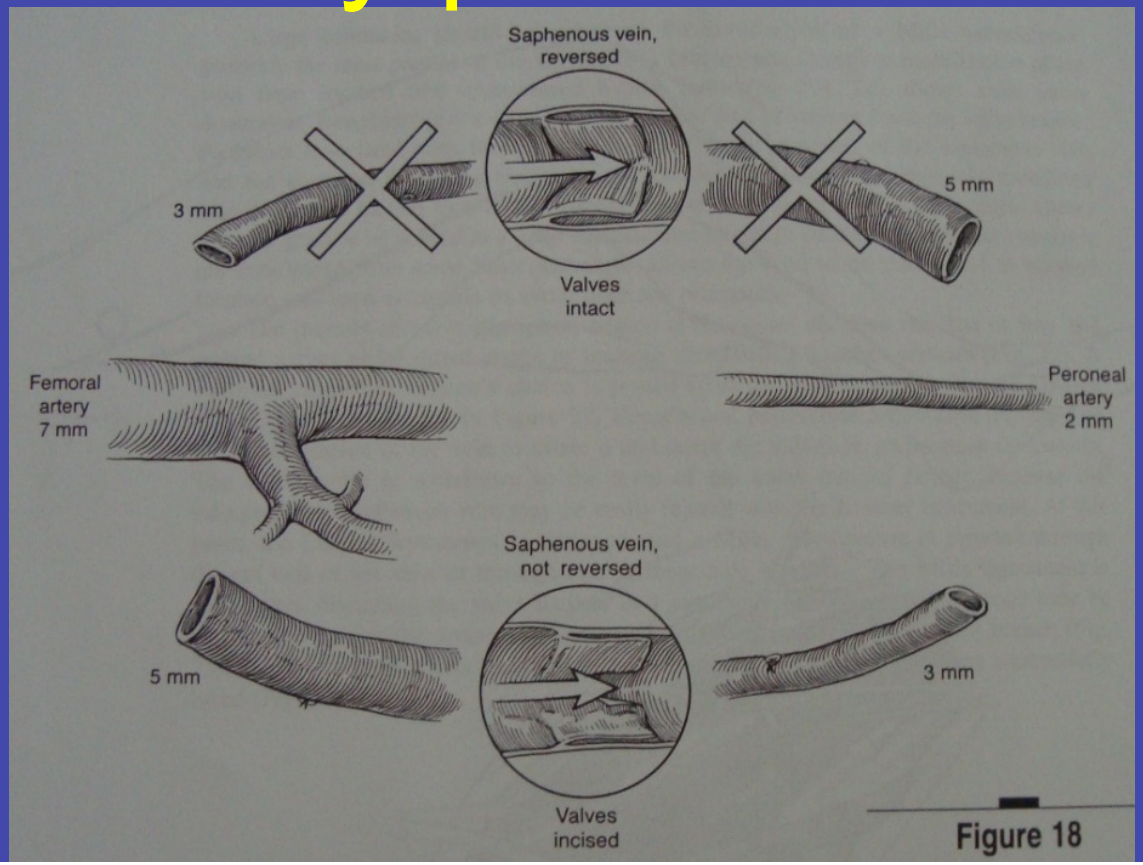
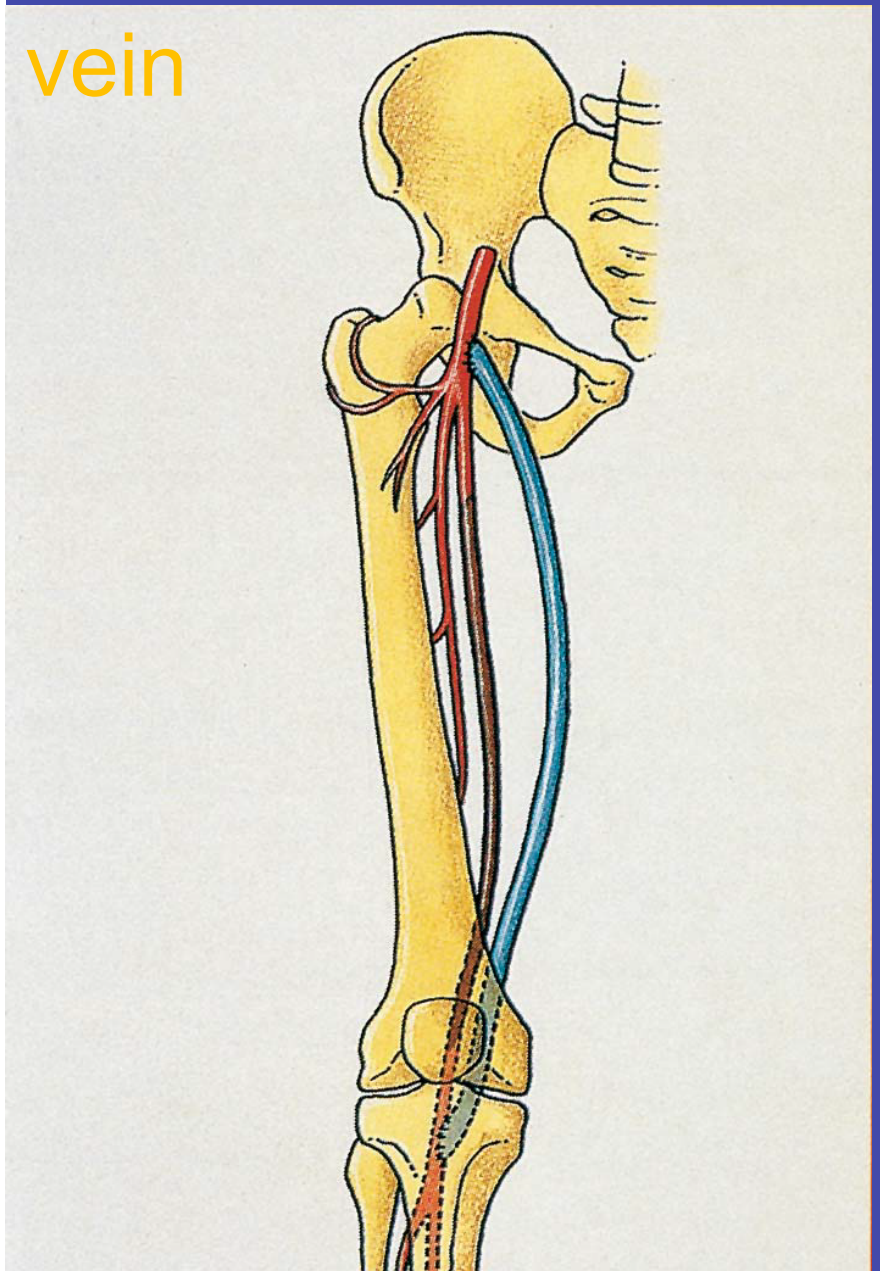
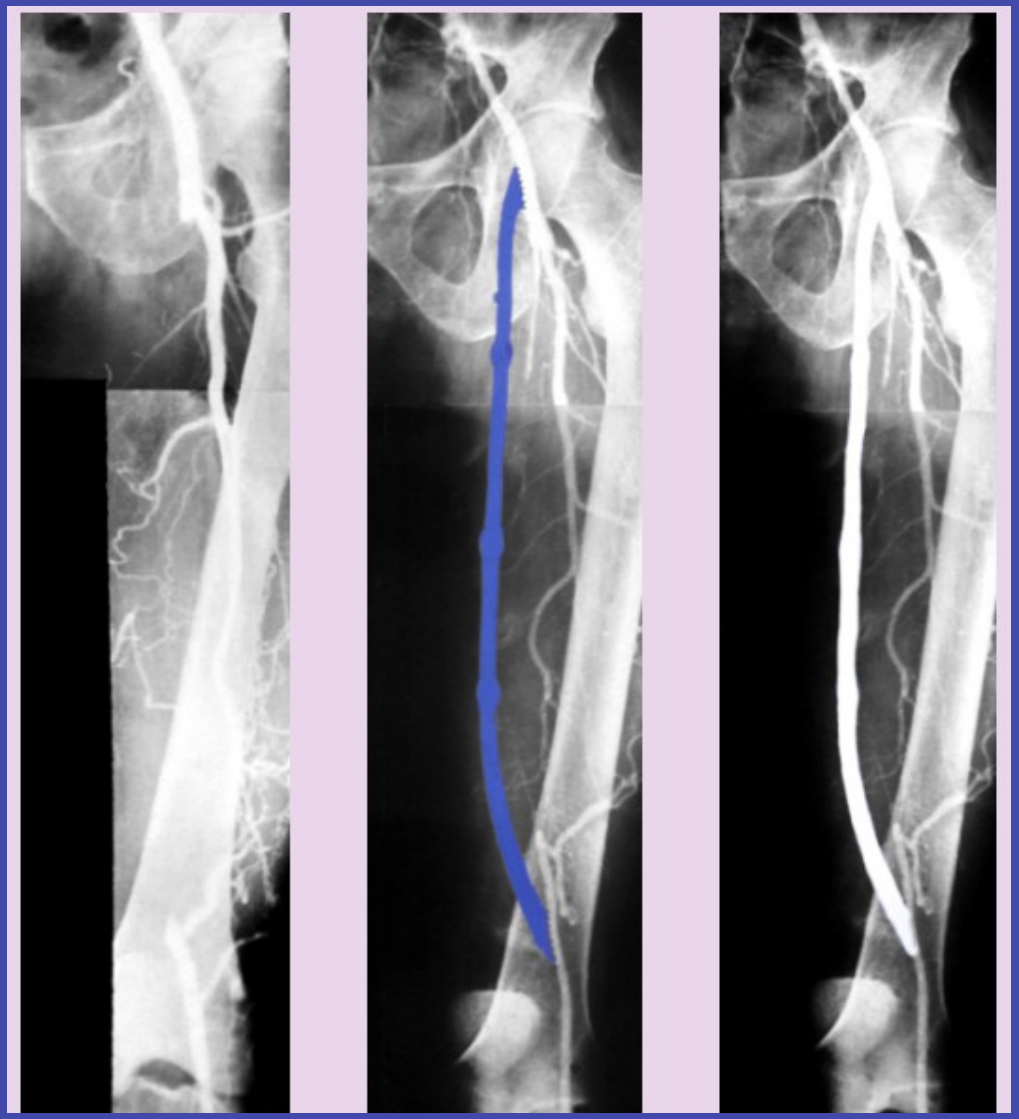


Figure 18

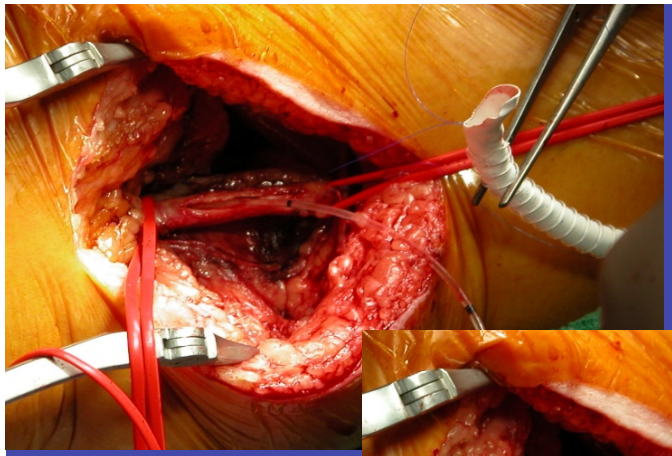
Fem-Pop by-pass

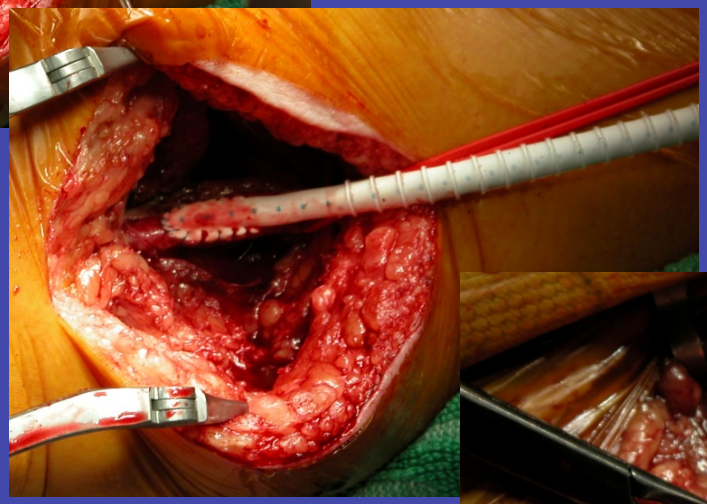
vein

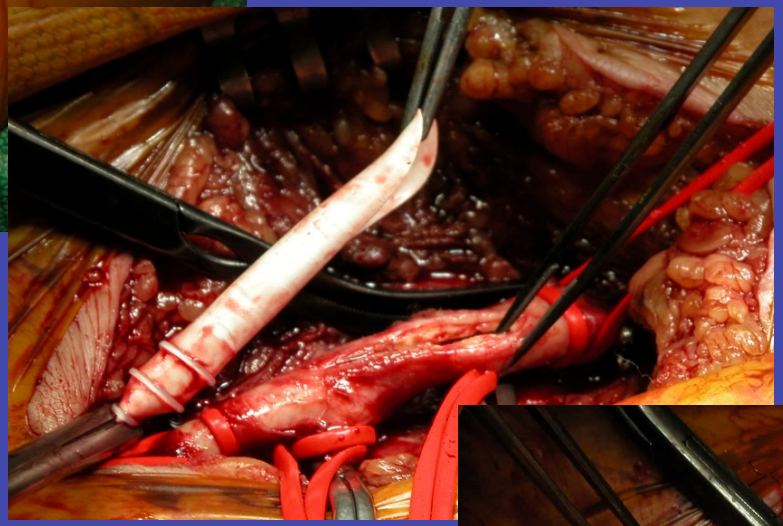


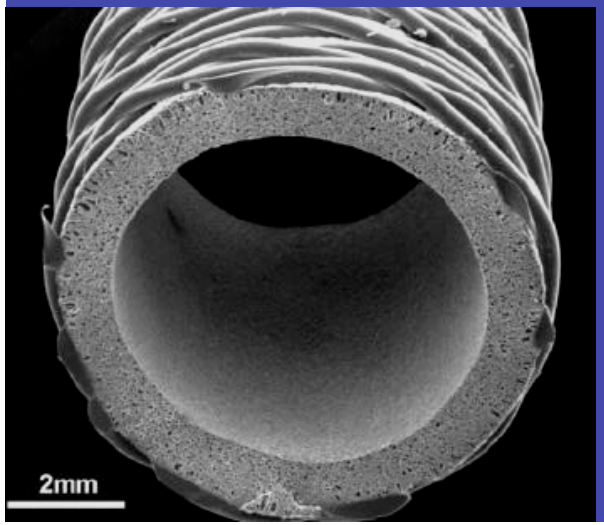


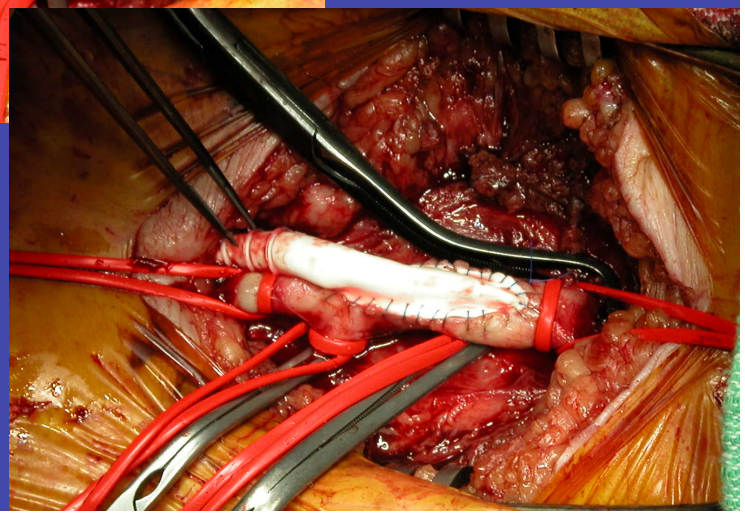
PTFE



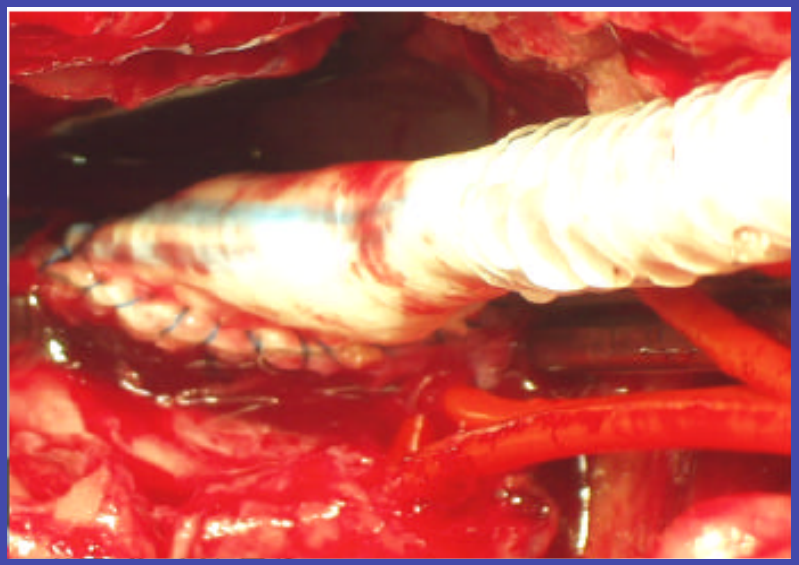


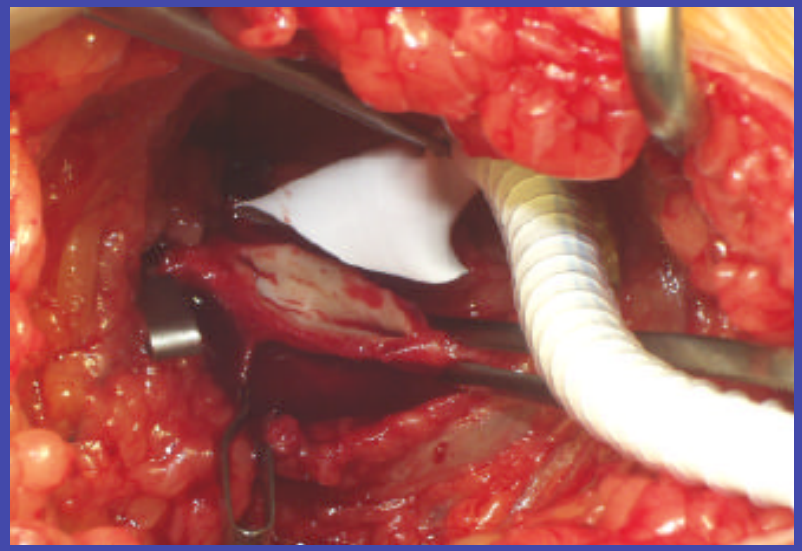


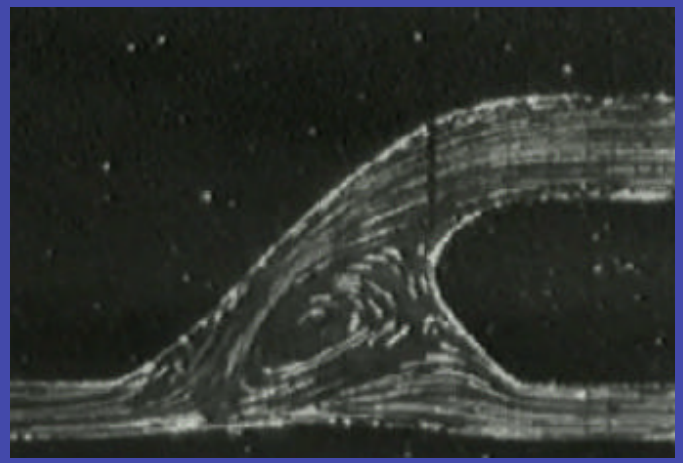




Pre cuf PTFE, (distaflo)







Below Knee Fem Pop by-pass (Vein vs PTFE patency)

TABLE 81-4 -- Below-Knee Femoropopliteal Grafts

PATENCY[*]	*1 MO*	*6 MO*	*1 YR*	*2 YR*	*3 YR*	*4 YR*
Primary						
Reverse saphenous vein	98	90	84	79	78	77
In-situ vein bypass	95	87	80	76	73	68
Secondary						
In-situ vein bypass	97	96	96	89	86	81
Arm vein	97	—	83	83	73	70
Human umbilical vein	88	82	77	70	61	60
Polytetrafluoroethylene	96	80	68	61	44	40
Limb salvage						
Reverse saphenous vein	100	92	90	88	86	75
In-situ vein bypass	97	96	94	84	83	—

* All patencies are expressed as percentages; all series published since 1981.

Dalman RL: Expected outcome: Early results, life table patency, limb salvage. In Mills JL (ed): Management of Chronic Lower Limb Ischemia. London, Arnold, 2000, pp 106–112

Infrapopliteal by-pass
(Vein vs PTFE patency)

TABLE 81-5 -- Infrapopliteal Grafts

PATENCY[*]	*1 MO*	*6 MO*	*1 YR*	*2 YR*	*3 YR*	*4 YR*
Primary						
Reverse saphenous vein	92	81	77	70	66	62
In-situ vein bypass	94	84	82	76	74	68
Secondary						
Reverse saphenous vein	93	89	84	80	78	76
In-situ vein bypass	95	90	89	87	84	81
Arm vein	94		73	62	58	—
Human umbilical vein	80	65	52	46	40	37
Polytetrafluoroethylene	89	58	46	32	—	21
Limb salvage						
Reverse saphenous vein	95	88	85	83	82	82
In-situ vein bypass	96	—	91	88	83	83
Polytetrafluoroethylene		76		68	60	56 48

* All patencies are expressed as percentages; all series published since 1981.

Dalman RL: Expected outcome: Early results, life table patency, limb salvage. In Mills JL (ed): Management of Chronic Lower Limb Ischemia. London, Arnold, 2000, pp 106–112

Fem-distal by-pass

vein

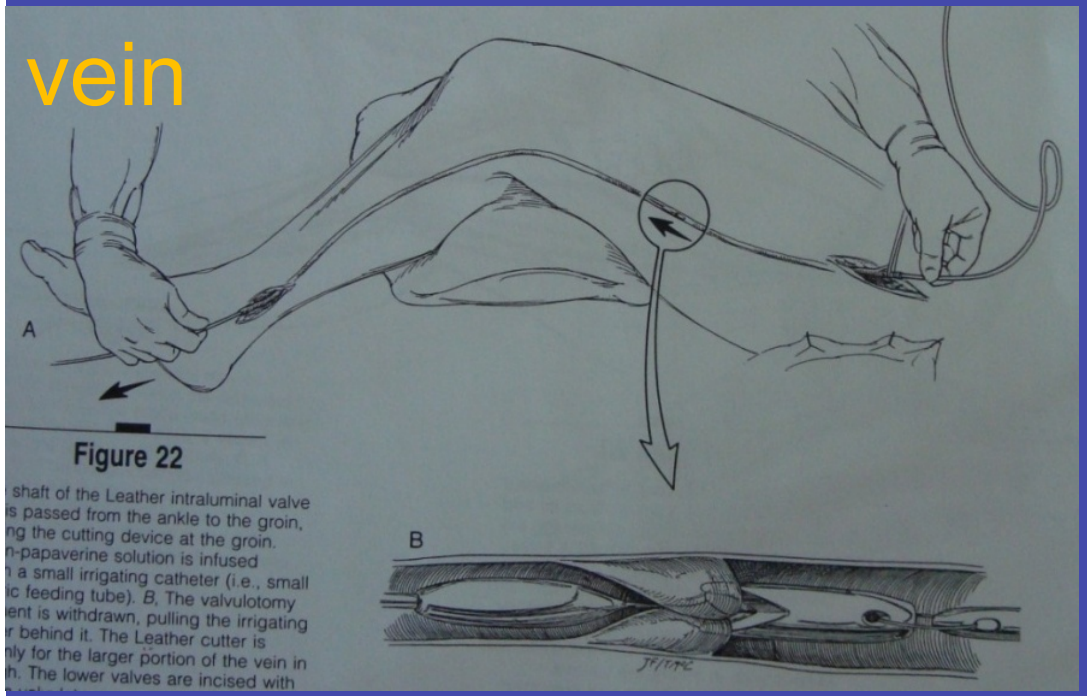


Figure 22

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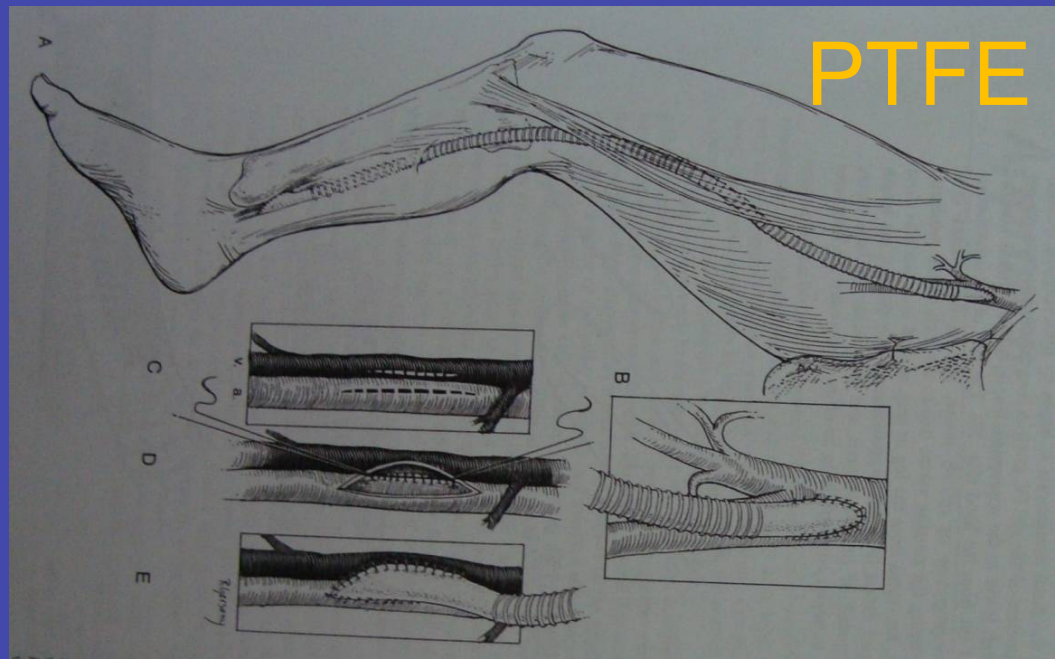
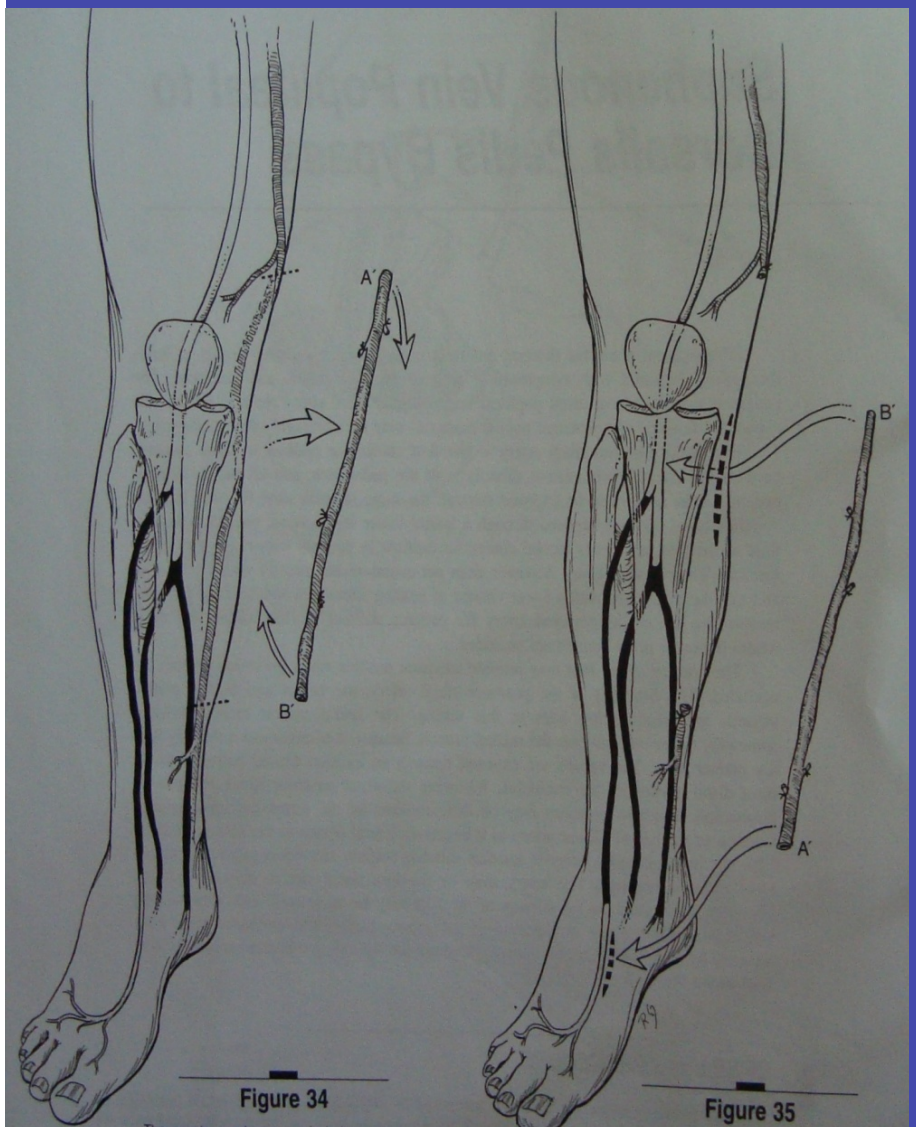
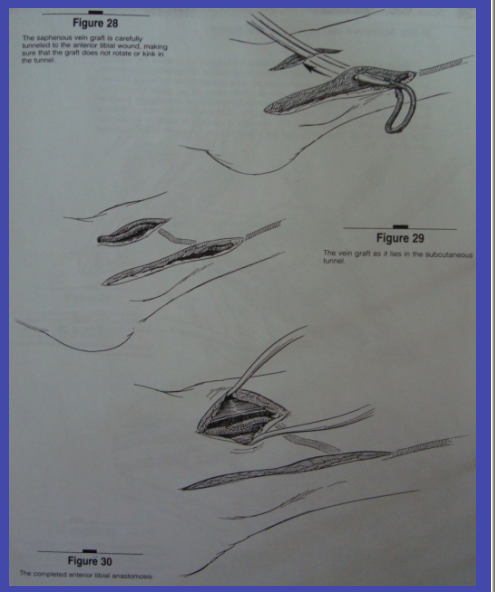
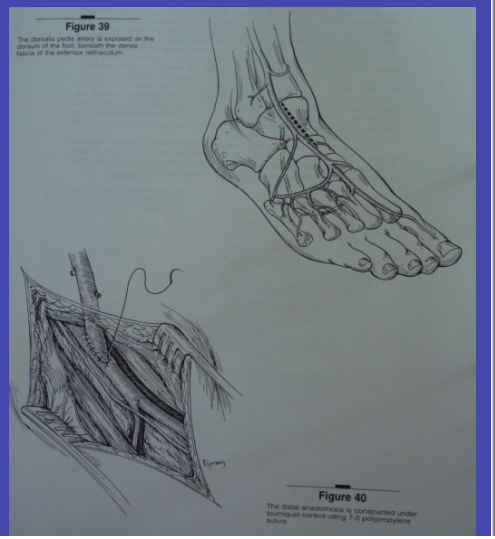
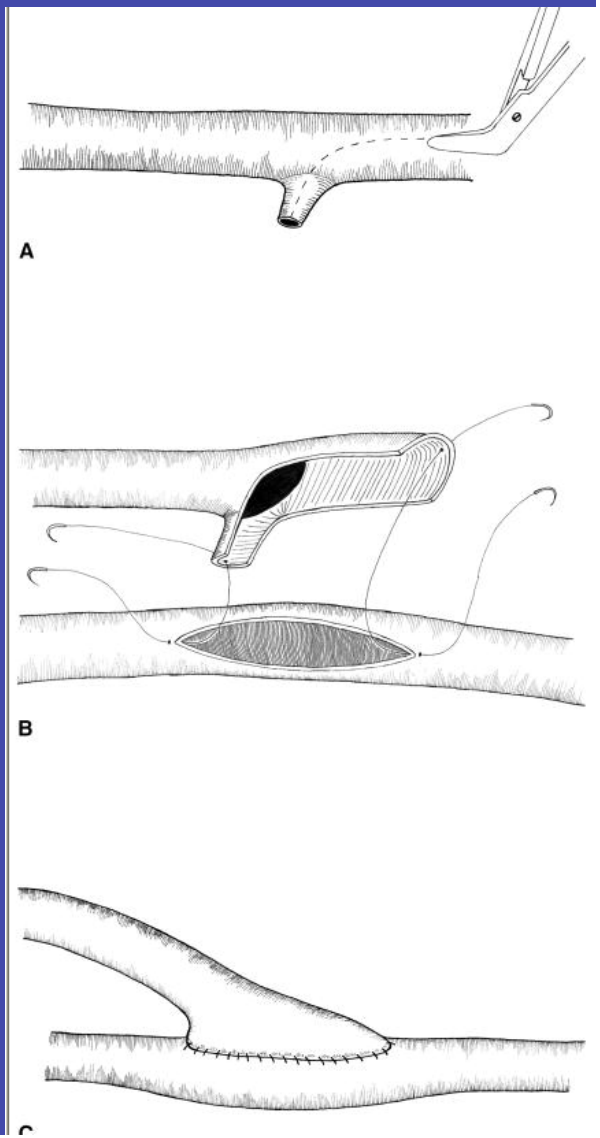


Distal by-pass (popliteal-crural by-pass)
Medial approach



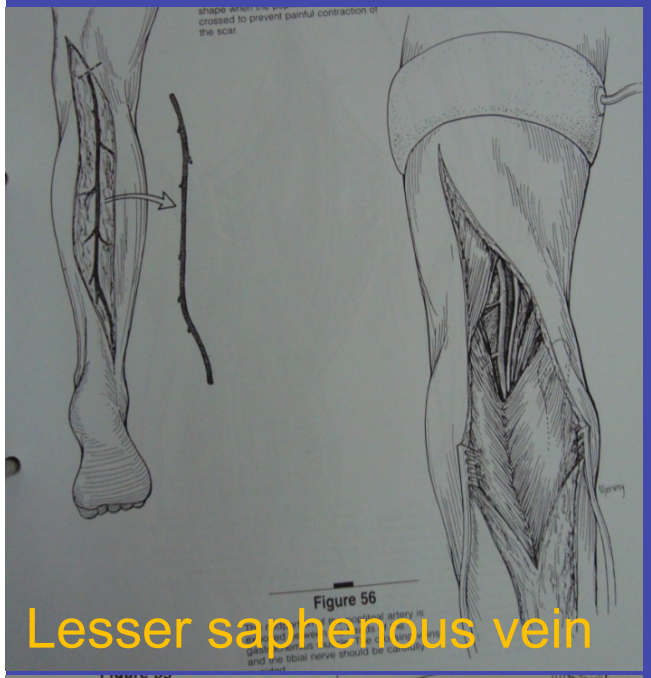




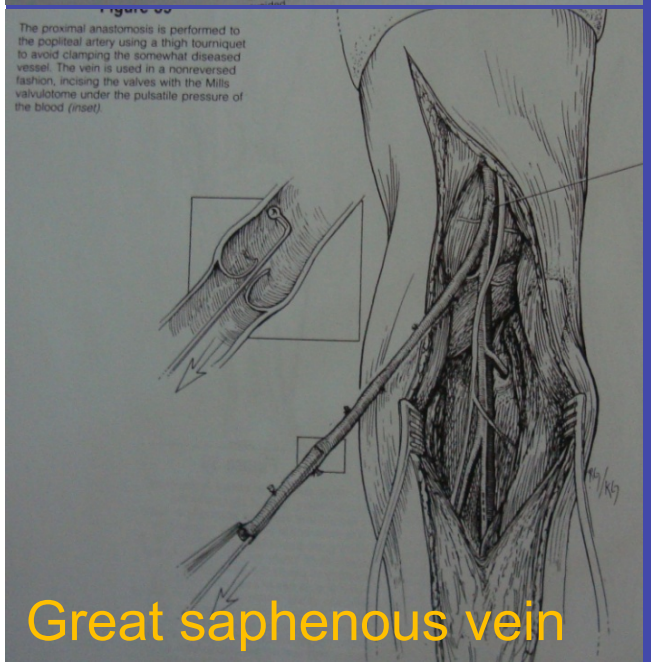


Distal by pass (popliteal-crural by-pass)

Posterior approach

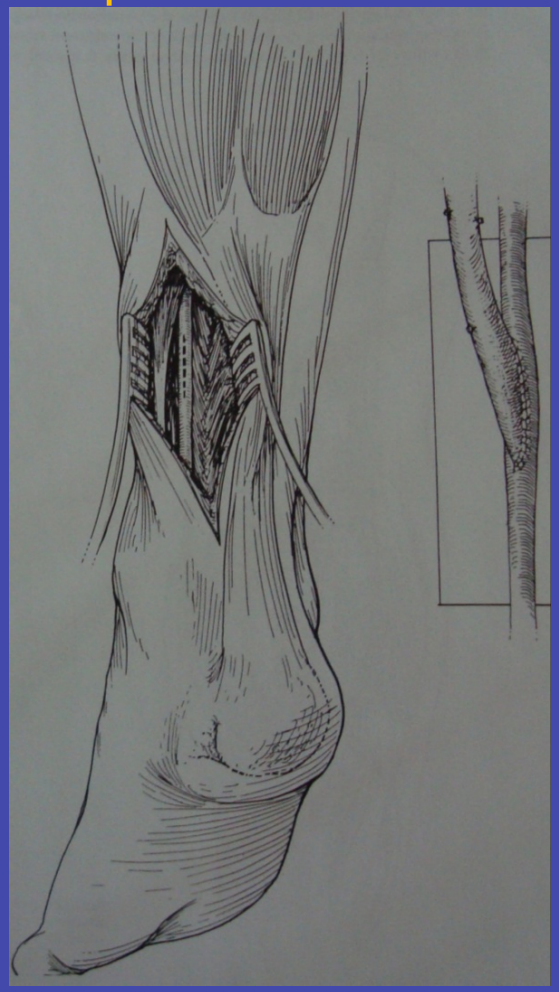


Lesser saphenous vein

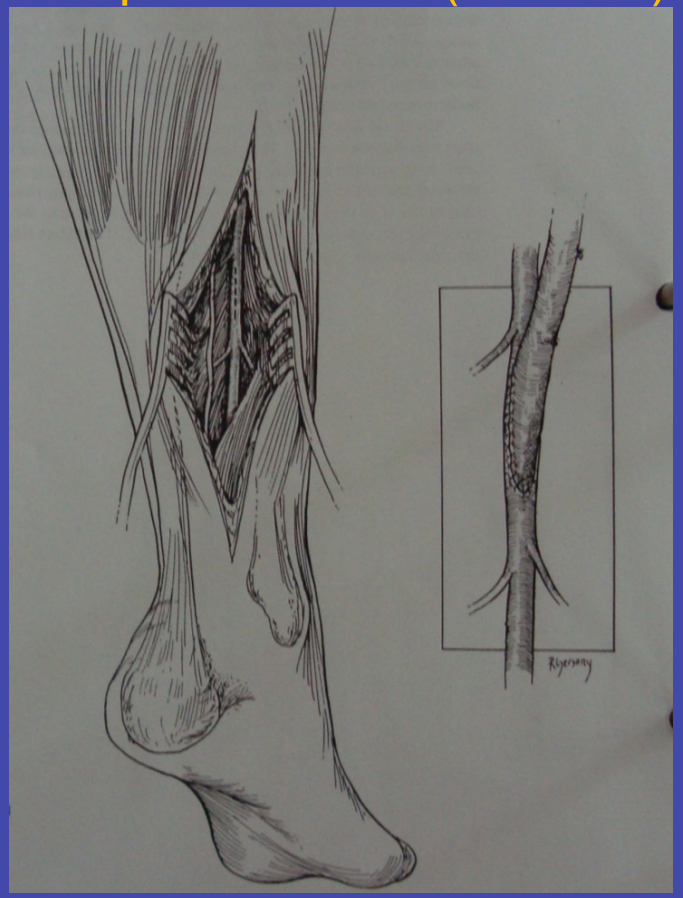


Great saphenous vein

To posterior tibial art.



To peronial art. (fibularis)




LATERAL FOOT
R


PROX FEM
POP ANAST
D


E

Distal at or below ankle grafts (crural by-pass)

TABLE 81-6 -- At or Below-Ankle Grafts

PATENCY[*]	*1 MO*	*6 MO*	*1 YR*	*2 YR*	*3 YR*
Primary					
Reverse saphenous vein	95	85	81	—	—
Secondary					
Reverse saphenous vein	96	90	85	81	76
In-situ vein bypass	93	93	92	82	72
Foot salvage	99	94	93	87	84

* All patencies are expressed as percentages; all series published since 1981.

Dalman RL: Expected outcome: Early results, life table patency, limb salvage. In Mills JL (ed): Management of Chronic Lower Limb Ischemia. London, Arnold, 2000, pp 106–112

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.

Schmiedt W, et al. Short distal origin vein graft in diabetic foot syndrome. Zentralbl Chir. 2003 Sep;128(9):720-5.

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

Cavallini M, et al. Revascularization of the ischemic diabetic foot by popliteal-to-distal bypass. Minerva Cardioangiol. 1999 Jan-Feb;47(1-2):7-13.

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
  - 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.

Completion angiography

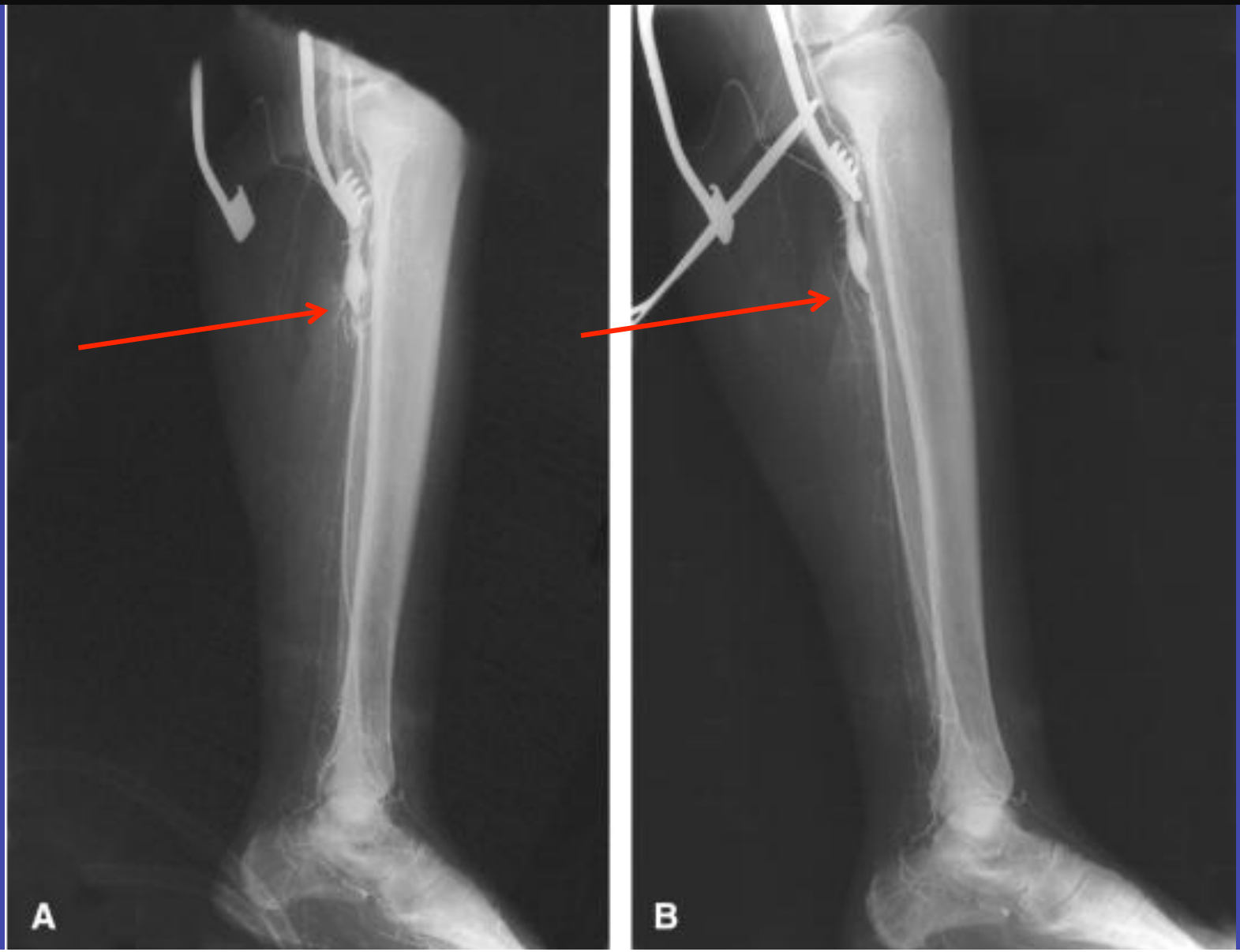
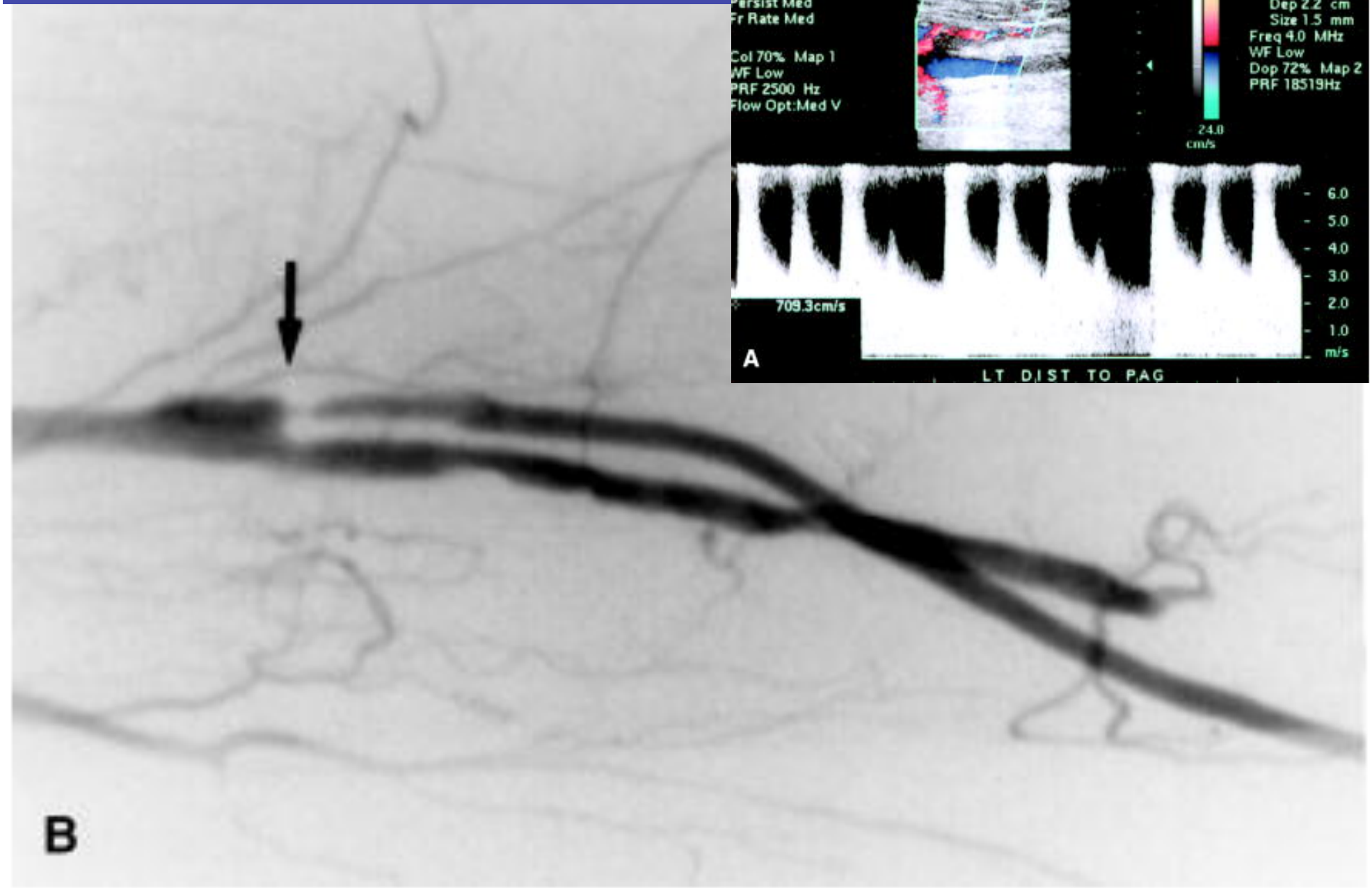


Figure 81-12 Completion arteriography identified a significant distal anastomotic defect (***A***) despite a good graft pulse and distal continuous-wave Doppler signal. The anastomosis was re-explored, the defect was corrected (***B***), and the graft is patent at 3 years.

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