Direct Revascularization (DR) to improve wound healing and prevent major amputations in CLI patients with below-the-knee PAD

Case presentations and literature review

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Disclosure

Speaker Name: Ammar Safar, MD

I have the following potential conflicts of interest to report:

- [ ] Consulting
- [ ] Employment in industry
- [ ] Stockholder of a healthcare company
- [ ] Owner of a healthcare company
- [ ] Other(s)

- [X] I do not have any potential conflict of interest
Introduction/Background

- **Angiosome concept**
  - Anatomic unit/structure fed by a source artery

- **Direct Revascularization (DR)**
  Vascularizing the artery giving perfusion to the angiosome in which a wound/ulcer is located

- There has been much discussion regarding the angiosome concept and direct revascularization thorough many published case series and metanalyses

Angiosome revascularization (Bypass)

- 60 ischemic lower extremity wounds
- Bypass surgery for revascularization (65% SVG)
- Followed for 2 years


- Direct Revascularization (DR):
  Bypass to the artery perfusing the angiosome in which the wound was located

- Indirect Revascularization (IR):
  Bypass to an artery not directly perfusing the angiosome in which the wound was located

47% Direct
53% Indirect
Angiosome revascularization (Bypass)

Complete healing

Direct revascularization

Indirect revascularization

91%

62%

P = 0.03

Angiosomes Revascularization (EVT)

• 203 ischemic ulcers
  – 50% ESRD on HD
  – Followed up to 4 years

• Procedures
  – Iliac PTA 17%
  – SFA stenting 54%
  – Tibial PTA 82%

• Healing/freedom from amputation
  – DR 86%
  – IR 69%

Angiosomes Revascularization (EVT)

- 250 diabetic patients with ischemic ulcers (Helsinki University Central Hospital)
- Infra-popliteal endovascular revascularization (EVT)

- **Healing at 12 months** (p < .001)
  - DR 72%
  - IR 45%

Pedal arch patency and not direct-angiosome revascularization predicts outcomes of endovascular interventions in diabetic patients with critical limb ischemia

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- 93 diabetic foot wounds
- PTA at least one tibial vessel
- 3 months healing and 1 year outcome

Pedal Arch Patency

Freedom from minor amputation

Limb salvage

Survival

Figure 3.—Follow-up outcomes (CPA vs. IPA vs. APA): estimated 1-year Kaplan-Meier curves.

We present 2 cases of patients with significant tissue loss (Rutherford 5 and 6) due to gangrene and ulcers, who made a remarkable recovery after direct revascularization of chronic total occlusion (CTO) of the angiosome related artery.
Case 1

• 59-year-old male
• Medical history:
  – CAD status post MI
  – Ischemic Cardiomyopathy
  – DM-2 on insulin
  – Hyperlipidemia
  – Hypertension
  – Significant CKD, not ESRD

• Referred to the wound center with infected foot ulcer on the lateral aspect of the left forefoot
Case 1

- The foot ulcer progressed within few weeks to osteomyelitis and gangrene in that area of the foot.
Case 1

- Evaluation by multidisciplinary team was done
- Due to OM: Urgent surgical debridement/partial amputation was performed.
Angiogram

- Contralateral retrograde access
- Patent left common and external iliac
- Patent left Superficial femoral Artery (SFA)

- Patent Popliteal
- Patent left Superficial femoral Artery (SFA)
- Patent Popliteal
• Ant. Tibial (AT): CTO, proximal

• Post. Tibial (PT): CTO, ostial/flush

• Peroneal (PA): Sub-total, short segment, followed by severe stenosis in mid
• PA terminates at the ankle

• Recon of AT and PT distally via communicating branches from PA
• Crossed the PA with 0.014 wire, along with 0.018 support catheter

• PTA of PA:
  – 2.5 x 200 mm balloon
  – 3 x 60 mm balloon
  – 3.5 x 40 mm balloon, proximal
• PA after PTA:
  – Good flow, no significant angiographic dissection and no significant residual stenosis
• Flow to the ankle via PA into communication branches to both distal PT and distal AT

• **IR achieved!**

• Due to concern for contrast-induced nephropathy (CIN) with his underlying significant CKD, we decided to end the procedure, and stage him in few days
• Antegrade left CFA Access (I perform universally on ALL patients with BTK CTO)
  – Combination (US and Fluro) guided
  – Micro puncture 4 F system
  – Fluro to direct the micro wire into the SFA (wire tends to like the PFA)

• Long flexible braided, 6F sheath
  – Does not kink from the angle of the antegrade access into the SFA
  – Long enough to give me support for straight line pushability

• Angio:
  – Patent TPT and PA
  – AT: Long CTO very proximal
• Retrograde (Pedal) access:
  – US guided
  – Distal AT
  – Micro puncture system
  – Pedal (2.9F) sheath
  – Inject retrograde
Come from below with 0.014 CTO wire with 0.018 support catheter close to the tip (5-10 mm from the tip of the wire) and push as one system, with occasional drilling technique of the wire.

Come from top with 0.014, followed by 0.018 CTO (12 gram) wire, along with 0.018 catheter close to the tip and push as one system (Rendezvous technique).
Come from below with 0.014 CTO wire with 0.018 support catheter close to the tip (5-10 mm from the wire tip) and push as one system, with occasional drilling technique of the wire.

Come from top with 0.014, followed by 0.018 CTO (12 gram) wire, along with 0.018 catheter close to the tip and push as one system.

Why I use support catheters:

[Graph showing tip stiffness (gfs) vs. length extending from the tip of a microcatheter. The graph is extrapolated by using the 2nd order fitness function.]

- Conquest-Pro12
- Miracle3
- BMW

Tip Stiffness (gfs):
- Conquest-Pro12: 61 gfs at 0 length
- Miracle3: 24 gfs at 0 length
- BMW: 2.4 gfs at 0 length
• Successful crossing using both retrograde and antegrade wires into the true lumen (Bidirectional)

• Externalized the retrograde wire through the antegrade sheath:
  
  – Wire through the 0.018 support catheter retrograde close to the tip of the antegrade sheath
  
  – Direct the wire into either angled catheter from top or to the sheath under fluro then insert a 6 F MP catheter (or any straight 6F catheter) into the valve of the sheath and direct the wire into the catheter lumen until out of the sheath and pull the catheter out to expose the wire!
• Orbital Atherectomy (OA) of the entire AT:
  – CSI, 1.25 mm micro burr
  – Low and medium speeds
  – Very slow
  – Short strokes
  – 1:1 on/off times

• BTK vessels with long CTOs are almost universally, significantly calcified (Age, DM, CKD)
Why I use OA/vessel prep in BTK

Calcium:

- Prevents optimal dilation
- Causes severe dissections
- Prevents optimal drug absorption (in case of DCB/DCS)
- Underestimated by angio
• PTA of the AT:
  – 2.5 x 100 mm balloon
  – 3 x 200 mm balloon
Final results:

AT is wide open with excellent flow to the distal foot
• Final results:

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Final results:

AT is wide open with excellent flow to the distal foot
Case 2

- 60-year-old AA male
- Medical history:
  - PAD s/p prior PTA of left SFA and popliteal artery
  - CAD
  - Ischemic Cardiomyopathy
  - Hypertension
  - DM-2 on insulin
  - CKD
  - Chronic Venous Insufficiency
  - History of venous ulcers

- Developed an ulcer on the dorsal proximal left foot.

- This ulcer progressed into a full-thickness tissue loss into the deep tissues.
– Initial presentation:
  Deep, full thickness ulcer, dorsal proximal foot (ankle level)
Prior Angio:
- Contralateral access:
- Patent CFA, SFA and popliteal
• Antegrade access:
  – US and Furo guided
  – Braded, longer sheath

• Below the knee vessels:
  – AT: CTO proximal (long segment)
  – TP Trunk into PA: CTO ostial (short segment)
  – PT: CTO ostial (long segment)
• Successful crossing into the PA:
  – Coming from top
  – 0.014 CTO wire with 0.018 support catheter as one system
  – Exchange the wire with work horse 0.014 wire

• PTA: 3 x 80 mm balloon
- Selective injection in the distal PA through the 0.018 catheter: DP patent

- IR achieved!
• Retrograde access with micro puncture sheath

• Crossed the AT retrograde:
  – 0.014 initially, followed by 0.018 (12 gram tip) wire with 0.018 support catheter

• Externalized the wire through the antegrade sheath:
  – Same steps explained earlier

• Orbital atherectomy (OA) of the AT using CSI, 1.25 mm micro burr
• PTA of the AT:
  – 2.5 - 3 x 200 mm tapered balloon
• The angle between the origin of AT and TP Trunk was acute, which may risk shifting plaque into the TPT

• Repeated PTA of the TPT and proximal PA
– Final Angio:
  Inline flow to the DP
Conclusions

• In patients with CLI, in particular diabetic patients, as in our examples, DR of the wound angiosome to establish direct inline flow, leads to increased healing and avoidance of major amputations in these functioning patients.

• CLI/BTK operators should try to identify the source artery of the wound area.
  – If this is possible, it should be the target vessel in which to intervene.
  – In case that is not possible, every effort should be undertaken to restore the most blood flow possible down to the foot (collaterals).
Conclusions

• CLI/BTK operators should:
  – Be comfortable with **antegrade femoral** access
  – Be familiar with the **toolbox** of wires and micro catheters
  – Combine wires with **support catheters**
  – Quickly **escalate** strategies/retrograde access: retrograde pedal, retrograde distal SFA
  – Become familiar with **alternative techniques**:
    • Double approach (antegrade–retrograde)
    • Trans-collateral angioplasty
    • Pedal-plantar loop interventions
    • Direct puncture of the transmetatarsal arteries or the plantar arch
Thank You!
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