The Future of Heart and Vascular Care: An Update for the Practitioner

Saturday, September 6, 2014
Loews Ventana Canyon

Directors: Scott S. Berman, MD; Derek von Haag, MD and Michael Hecht, MD

Management of Critical Limb Ischemia

Bernardo Mendoza, MD
Carondelet Heart and Vascular Institute
Vascular and Endovascular Surgery
September 6, 2014
Definitions

• Critical limb ischemia (CLI)
  • Greater than two weeks of rest pain, ulcers, or tissue loss attributed to arterial occlusive disease that is associated with great risk of limb loss

Therapeutic Goals in Treating Patients with CLI

• Reduce cardiovascular risk factors
• Relieve ischemic pain
• Heal areas of ulceration
• Preventing major amputation
• Improving quality of life
• Increasing survival
Therapeutic Options for Patients with CLI

• Medical therapy

• Revascularization

• Amputation

Medical Treatment For CLI

• Analgesics
• Local wound care
• Pressure relief
• Treatment of infection
• Aggressive therapy to modify atherosclerotic risk factors
Invasive Treatments

• Surgical repair
  • Patients who are relatively fit and able to withstand the rigors of an open procedure may benefit from the long-term durability of

• Endovascular reconstruction
  • Frail patients with a limited life expectancy may experience better outcomes with

• Hybrid therapy

Amputation

• Non-ambulatory

• Demented

• Unfit to undergo revascularization
Historical Perspective

• 1960 to 1970s
  • Below knee or above-knee amputation was regarded as the safest and best treatment for gangrene and ulceration from arteriosclerotic occlusive disease below the inguinal ligament

• After aggressive treatment was implemented
  • Successful foot salvage was achieved in 80% to 95% of patients
Historical Perspective

• ~50% of these limb salvage patients died within 5 years of the original bypass
  • Due to comorbid conditions

• Patients who lived beyond 5 years
  • More than 60% retained a useable limb

• Limb salvage requires some form of reoperation or re-intervention

Limb Salvage

• Improvements in surgical techniques and other methods to facilitate the many reoperations

• Percutaneous transluminal angioplasty (PTA)
  • Initially was used to correct hemodynamically significant iliac artery stenosis
  • It was often combined with some form of infrainguinal bypass

• Endovascular techniques could be used to help in the treatment of patients with failed or failing bypasses
Limb Salvage Historical Perspective

• Improvements in surgical techniques and other methods to facilitate the many reoperations

• Endovascular techniques are used to help in the treatment of patients with failed or failing bypasses

Revascularization Philosophy

• Patient-oriented goals
  • Maintenance of independent living
  • Ambulation (with or without a prosthesis)

• Physician-oriented goals
  • Graft patency
  • Limb salvage
    » the primary criteria for success in vascular surgery for decades
The treatment should fit the patient’s medical condition

Rutherford Classification

- Stage 0 – Asymptomatic
- Stage 1 – Mild claudication
- Stage 2 – Moderate claudication
  - The distance that delineates mild, moderate and severe claudication is not specified in the Rutherford classification
  - In the Fontaine classification as 200 meters. Stage
- Stage 3 – Severe claudication
- Stage 4 – Rest pain
- Stage 5 – Ischemic ulceration not exceeding ulcer of the digits of the foot
- Stage 6 – Severe ischemic ulcers or frank gangrene
The Diabetic Patient

- Patients with diabetes aged ≥40 years
  - two to three times more likely to suffer from PAD than those without diabetes
- Prone to develop PAD at earlier ages
- More progressive and severe disease
- More likely to undergo surgery and amputation for CLI
- The lifetime risk of foot ulceration is 15% to 25%
  - Annual incidence between 1% and 4%

The Diabetic Patient

- The functional benefits of revascularization appear to be linked to its influence on wound healing
  - Revascularization in the absence of healing is of little functional benefit to the patient
- Patients with diabetes tend to have a more distal distribution of PAD
  - most frequently afflicting the infrapopliteal vessels
  - likely to benefit less from revascularization efforts than patients without diabetes
The Diabetic Patient

• Patients with isolated tibial disease are more likely to be diabetic
  • Present with more advanced ischemia than patients who have multilevel disease

• Significantly lower rates
  • Survival
  • Limb salvage
  • Maintenance of ambulation
  • Maintenance of independence
  • Secondary patency

Strategies for the Treatment of Critical Limb Ischemia
TASC Classification
Femoro-Popliteal Lesions

• Type A
  • Single stenosis < 3 cm

• Type B
  • Single stenosis 3 to 10 cm long, not involving the distal popliteal artery
  • Heavily calcified stenosis up to 3 cm
  • Multiple lesions, each < 3 cm (stenosis or occlusion)
  • Single or multiple lesions in the absence of tibial runoff to improve inflow for distal surgical

• Type C
  • Single stenosis or occlusion > 5 cm long
  • Multiple stenoses or occlusions, each 3 to 5 cm

• Type D
  • Occlusion of the common femoral artery, popliteal artery, proximal trifurcation arteries
  • Occlusion of the superficial femoral artery > 10 cm long
Strategy for Limb Salvage

• Endovascular treatments for critical limb ischemia have become the first option to treat chronic obstructive arteriosclerosis at all levels
  • some maintain that if a limb cannot be salvaged by endovascular treatment, the next option should be a major amputation
  • improvements in catheter, guidewire, stent, and stent-graft technology have transformed the treatment of lower limb ischemia

• There are still some indications for open surgical bypasses for limb threatening ischemia

• 20% to 35% of patients with critical ischemia will require open surgery at some point
  • The procedures will usually be indicated after failures of one more endovascular treatments

• A true concern is the expertise to do a bypass
  • Fewer bypasses will be required
  • Fewer surgeons will be skilled in these demanding bypass techniques
  • Referral centers for bypasses may be established
Open Surgical Revascularization Procedures

• Bypass procedures
  • Femoro-popliteal bypass
  • Femoral to tibioperoneal trunk bypass
  • Femoral to tibial / pedal bypass

• Thrombectomy and revision of failed (thrombosed) bypasses
  • That cannot be rescued by endovascular means.

Conduits for Bypass

• Reversed greater saphenous vein
  • Harvested via skip incisions
  • Endoscopic vein harvest

• Arm vein

• Polytetrafluoroethylene (PTFE) conduit
  • If patients do not have a saphenous vein
  • Arm vein or if their veins are too small
    – (< 3.5 mm in distended diameter)
    – involved with preexisting disease
Tibial and Peroneal Artery Bypasses

- Autologous vein
  - the graft of choice if it is disease free

- The grafts should be as short as possible

- Composite sequential bypass
Tibial and Peroneal Artery Bypasses

- PTFE tibial bypass
  - Patient with critical ischemia is faced with an imminent amputation
  - The patient does not have satisfactory autologous vein
  - An acceptable option
    - 43% 5-year secondary patency
    - 66% 5-year limb salvage

Endoscopic Vein Harvesting: Infrainguinal Revascularization

- Jordan et al. performed
  - 164 saphenous vein EVHs
  - For lower extremity arterial reconstructive procedures
  - 6-year period

- Patency rates using Kaplan-Meier analysis
  - 1 year 85%
  - 3 years 74%
  - 5 years 68%
Endoscopic Vein Harvesting: Infrainguinal Revascularization

Principles and Precautions that Should be Followed for Endovascular Specialists who Perform Interventions for Critical Limb Ischemia
• Preserve a good target outflow artery
  • Leaves the option of an open surgical rescue if the intervention fails

• Do not make an initially patent arterial segments unusable
  • The patient may need a more distal bypass than would have been required before the endovascular procedure

• Collateral vessels should be preserved

Endovascular Treatment of the SFA and Popliteal Artery

• Most occlusions of the SFA and above-knee popliteal artery could be treated endovascularly
  • Intraluminal PTA
  • Subintimal interventions
  • Devices that cross segments of total occlusions
  • Atherectomy devices
  • Stenting
Endovascular Treatment Options

Percutaneous Transluminal Angioplasty

- Indicated for short segment stenosis
- Lesions >7cm
  - 6 month patency rate of 23%
- PTA is a better treatment for short segment stenoses (<3cm)
Subintimal Angioplasty
<table>
<thead>
<tr>
<th>Author</th>
<th>Date</th>
<th># Cases</th>
<th>Segment</th>
<th>Success</th>
<th>F/U</th>
<th>Pat Rate</th>
<th>Limb Salvage</th>
</tr>
</thead>
<tbody>
<tr>
<td>London et al</td>
<td>1994</td>
<td>200</td>
<td>Fem-Pop</td>
<td>159 (80%)</td>
<td>12 mo</td>
<td>71%</td>
<td></td>
</tr>
<tr>
<td>Berengoltz et al</td>
<td>1994</td>
<td>20</td>
<td>Fem-Pop</td>
<td>17 (85%)</td>
<td>12 mo</td>
<td>93%</td>
<td></td>
</tr>
<tr>
<td>Nydahl et al</td>
<td>1991</td>
<td>32</td>
<td>Infra Pop</td>
<td>27 (84%)</td>
<td>12 mo</td>
<td>53%</td>
<td>85%</td>
</tr>
<tr>
<td>McCarthy et al</td>
<td>2001</td>
<td>69</td>
<td>Fem-Pop</td>
<td>51 (74%)</td>
<td>6 mo</td>
<td>77%</td>
<td></td>
</tr>
<tr>
<td>Vraux et al</td>
<td>2000</td>
<td>40</td>
<td>Infra Pop</td>
<td>31 (78%)</td>
<td>12 mo</td>
<td>72%</td>
<td>81%</td>
</tr>
<tr>
<td>Shaw et al</td>
<td>2002</td>
<td>50</td>
<td>Fem-Pop-Tib</td>
<td>39 (78%)</td>
<td>6 mo</td>
<td>64%</td>
<td></td>
</tr>
<tr>
<td>Lipsitz et al</td>
<td>2003</td>
<td>40</td>
<td>SFA</td>
<td>36 (90%)</td>
<td>12 mo</td>
<td>74%</td>
<td></td>
</tr>
</tbody>
</table>
Atherectomy

• Decreasing the volume of the atherosclerotic plaque
• Superior to angioplasty and stenting alone
• Advantage
  • Protecting side branches by minimizing plaque shift
• Disadvantage
  • Risk of debris embolization to the distal vasculature
  • Embolic protection device is recommended

Atherectomy Devices

• Directional
  • SilverHawk and TurboHawk
• Rotational
  • Pathway PV system
  • Orbital (or 360°)
  • Diamondback Orbital atherectomy system
  • Excimer laser
  • For both de novo and restenotic disease
Directional Atherectomy

Rotational Atherectomy
Orbital Atherectomy

Laser Atherectomy
Stents

• Maintain patency of stenotic or occluded blood vessels
  • Provide internal support to the vessel

Stents

• Self-expandable
  • Long lesions or tortuous vessels
    – Ideal for femoral-popliteal lesions
  • Usually metal alloy
  • Flexible
  • Less radial force
  • More crush-resistant
Stents

• Balloon-expandable
  • Precise deployment and stronger radial force

• Typical uses
  • Ostial lesions
  • Calcified lesions
  • Short-segment lesions
Drug Eluting Stents

Despite Our Best Efforts Revascularization Procedures Tend to Fail
Revascularization Failure

- Both endovascular and open surgical procedures eventually fail
  - An ongoing process
  - Intimal hyperplasia
    - Largely a reaction to vascular injury
  - Progression of the arteriosclerotic process

- Six months after revascularization procedure only 65% limbs are threatened again
  - Due to healing of the original lesion
  - Formation of collaterals in the absence of trauma or infection

- Determination of primary procedure failure
  - Physical examination
  - Symptoms
  - Noninvasive testing

- Secondary procedures are generally more difficult and have worse results than primary procedures
Guidelines for Redo Procedures

• Endovascular interventions should be considered the first option in patients requiring a redo procedure
  • Even if the original revascularization was a bypass

• Re-dissection of previously dissected arteries should be avoided (the groin)
  • Technically difficult
  • Prone to a fivefold increased risk of infection

Guidelines for Redo Procedures

• Arteriography should precede any reoperative attempt

• The failed bypass with prosthetic conduit
  • Restore patency percutaneously
  • Mechanical thrombectomy devices a
  • Lytic agents
The lower extremity grading system (LEGS) score

• Based on five categories of clinical factors
  • Arteriographic findings
  • Presentation (claudication versus limb-threatening ischemia)
  • Patient’s functional status
  • Comorbidities
  • Technical factors

The lower extremity grading system (LEGS) score

• Treatment recommendations are made based on patients’ scores
  • 0–9 open intervention
  • 10–19 endovascular intervention
  • ≥20 primary amputation.
The LEGS Score

• Clinical situations in which should not be applied
  • patients who have a non salvageable leg or foot
  • acute and/or severe infection
  • blue-toe syndrome

• Specific clinical factors
  • Preoperative ambulatory status
    – ambulatory
    – ambulatory/homebound
    – nonambulatory/transfer only
    – nonambulatory/bedridden
  • living status
    – independent [residing in an independent dwelling without external assistance]
    – nonindependent [assisted living facility or private residence with external assistance for activities of daily living]

Treatment Modalities

• Balloon Angioplasty
• Stent Implantation
• Atherectomy
• Covered Stent Grafting
• Drug-eluting stents
• Remote endarterectomy
• SAFARI technique
• Pedal-plantar loop technique
• Drug eluting coated balloons
Newer Treatment Modalities

Drug Eluting Balloons
Drug Coated Balloons

• Short-term, nonpolymeric-based local drug delivery
• No permanent metallic scaffold left behind
• Enhanced vessel healing due to the relatively short-term permanence of the drug inside the vessel wall
• Potential for higher drug tissue bioavailability due to the higher drug surface area presented to the vessel wall

Drug Eluting Balloons

• Paclitaxel is transferred into the vessel wall
  • It acts by altering cytoskeletons in cells
  • Irreversibly inhibits arterial smooth muscle cell proliferation

• Transfer of the drug appears to occur within 10 seconds of balloon inflation
Bioabsorbable Stents

• Once they are bioabsorbed
  • leave behind only the healed natural vessel
  • allowing restoration of vasoreactivity with the potential of vessel remodeling.
• Late stent thrombosis is unlikely since the stent is gone
• Prolonged antiplatelet therapy is not necessary
Bioabsorbable Stents

- Suitable for complex anatomy
  - Where stents impede on vessel geometry and morphology
  - Areas prone to crushing and fractures

- Could be used as a delivery vehicles for drugs and genes

- Compatible with MRI and MSCT imaging.

Gene Therapy

- MSCs can act as mural cells to support endothelium by direct physical contact & paracrine secretion.
- Both MSCs and iPSCs can be differentiated into endothelial cells & aid vascular repair.
- MMPs may be differentiated into vascular cells to reverse ischemic tissue.
- iPSCs can act as progenitor cells to regenerate existing vasculature through the release of paracrine factors.
- iPSCs contribute to neovascularization by homing to ischemic areas & directly incorporating into vessels.
Conclusions

References

- Waksman R. Biodegradable Stents: They Do Their Job and Disappear, J Invasive Cardiol. 2006;18:70-74