Outline: Combat Vascular Injury

- Physiologic consequences of extremity vascular injury
- Efficient assessment and triage of vascular injuries
- Surgical principles and temporizing interventions in vascular injuries
Wartime Vascular Injuries: Vietnam Vascular Registry*

Extremity injuries predominate (> 90%)
- Superficial femoral and popliteal artery injuries most common
- Popliteal injuries associated with the highest amputation rate (29.5%)

Associated injuries common
- Nerves (42.4%), Veins (37.7%), Bone (28.5%)

*Rich et al. J Trauma, 1970
Ischemia from Vascular Injury

• Irreversible injury after 6 to 8 hours.
  – Local effect = limb threat
  – Systemic effects
    • Shock
    • Myoglobinuria
    • Disseminated intravascular coagulopathy
• Reperfusion can lead to same metabolic effects.
Life Over Limb

- Danger from active hemorrhage
- Danger from ischemia and reperfusion
- Impact of limb-salvage procedure on patient and resources
Extremity Vascular Trauma Diagnosis

• **History**
  – Pulsatile bleeding
  – Amount of blood loss at the scene

• **Physical Exam**
  – Findings extremely variable
    • Hard signs, soft signs, ABI
    • Distal pulses intact in **20%** of arterial injuries
Diagnosis: “Hard Signs”

- Pulsatile bleeding
- Expanding hematoma
- Palpable thrill
- Audible bruit
- Evidence of ischemia (6 P’s)
  - Pain, pallor, parasthesias
  - Pulseless, paralysis, poikilothermia
Diagnosis: “Soft Signs”

- History of moderate hemorrhage
- Injury in proximity (fracture, dislocation, or penetration)
- Diminished but present pulse
- Associated peripheral neurological deficit
- ABI < 0.9
  - Reduce fracture in affected limb before ABI
Extremity Vascular Trauma
Diagnosis: Ankle Brachial Index

Systolic pressure in injured extremity

Systolic pressure in uninvolved arm
Diagnosis: ABI

Measured with Doppler

- ABI > .90 Normal
- ABI < .90 Abnormal
Diagnosis: Arteriography

• “Gold Standard” for diagnosis when available

• Useful with:
  – Hard signs involving multiple levels
  – Soft signs/abnormal ABI <0.9

• Not indicated for hard signs and single level penetrating injury
Technique of Arteriography

- 19 gauge butterfly
- 3 way stop-cock
- 20-30cc Syringe
- Full strength contrast for field use
- Inflow occlusion if possible
- Timing toward end of injection
On-table Angiogram
Angiogram Interpretation
Shotgun Wound to Distal Thigh

Need 2 views when fragments overlie the vessel to rule out injury
Management Options

- Mandatory exploration
- Selective exploration
- Non-operative management
Mandatory Exploration

- “Hard” signs of arterial injury
- Significant arteriographic finding (may not require immediate exploration):
  - Occlusion/extravasation
  - A-V fistula
  - Pseudoaneurysm
Selective Exploration

- Soft signs of vascular injury
  - Arteriogram results
- Ankle-Brachial Index (ABI) < .9 with pulse
- Need close observation for nonsurgical management
Non-Operative Management

- Palpable pulses and ABI >0.9
- Life over limb
Surgical Principles

Be prepared!
Surgical Principles

- Prep and drape contralateral leg
- Use longitudinal incisions
- Obtain proximal and distal control
  - BP cuff may be useful proximally
Proximal and Distal Control: Right Common Carotid
Surgical Principles

- Debride injured vessels to normal wall
- Pass embolectomy catheters
- Heparinized saline in proximal and distal vessel
- Intraluminal shunting (artery or vein)
  - Argyle vs Sundt shunts
  - Restore flow while dealing with other injuries
Shunts

• Rapidly placed, technically simple
  – Maintains flow while more immediate injuries are addressed
  – Reduces ischemic injury

• Can be used during transport
  – Documentation key

• Complications
  – Shunt thrombosis
  – Compartment syndrome
Sundt Shunt
Argyle Shunt: Left SFA
• Use 6-0 suture
• Tension-free anastomosis
• Repairs
  – Primary repair – if lumen not compromised > 25%
  – Patch angioplasty
  – End-to-end anastomosis
    • <2cm defect
End-to-end Anastomosis
Extremity Vascular Trauma Surgical Principles

• Repairs (continued)
  – **Interposition graft**
    • Preferred: contralateral reversed saphenous vein
      – Flush with heparinized saline (10,000 U/Liter, 10U/cc)
    • Not preferred: prosthetic PTFE
  – **Extra-anatomic bypass**

• **Graft coverage**
  – Full thickness musculocutaneous coverage
Left SFA Repair with GSV
Arteriotomy
Surgical Principles

• **Technique**
  - Tissue handling
    • Gerald forceps
    • Minimal manipulation of intima
  - Fine, monofilament suture (6-0 prolene)
  - Magnification

• **Low-threshold for fasciotomy**
Fasciotomy: Artery and Venous Injury
Surgical Principles

- Selective use of heparin 50-100U/kg
- Selective use of mannitol 12.5 g IV
- Lytics: 2-5 mg t-PA
- Objective assessment of result – ABI
- Venous injuries
**Injuries to Right Leg**

- Open, comminuted proximal tibia fracture
- Open knee joint
- Transected peroneal nerve
- Injury to popliteal artery at level of tibial plateau
Arteriogram
Case Presentation

- R popliteal artery resection
- Reversed interposition saphenous vein graft
- Intraoperative power failure
Intraoperative Power Failure

- 4 compartment fasciotomy
- Await return of power
Completion Arteriogram
Case

- Thrombectomy utilizing PA catheter
- Streptokinase
- Palpable DP and PT
- Debridement and lavage
- Right leg immobilization
Priority is life, then limb

Diagnosis depends on clinical exam and ABIs.

Standard vascular repair techniques apply.

Shunts are helpful for damage control.

Fasciotomy should be routinely performed.