Peripheral Vascular Injuries
Every trauma needs ABCD first.

An injured peripheral vessel is typically ONLY one component of a multi-organ trauma.

Consequences of Peripheral Vascular Injury:

- Hemorrhage
  - Life / Death
- Limb Ischemia
  - Threat to limb viability
Patterns of Vascular Injury

Peripheral Vascular Trauma

Penetrating
- Laceration
  - Bleeding
- Complete Transection
  - Thrombosis
  - Intimal Flap

Blunt
- Disruption of Arterial Wall
  - Transmural Damage
Vascular injury: anatomy

Artery

Tunica intima: endothelium that lines the lumen of all vessels

Tunica media: smooth muscle cells and elastic fibers

Tunica adventitia: collagen fibers

ADAM
Vascular injury: anatomy
Vascular injury: anatomy

Figure 1. Major Arteries of the Upper Extremity

Figure 2. Major Arteries of the Lower Extremity
Initial Assessment

1. Control External Hemorrhage
2. Assess for limb ischemia

Non Invasive Vascular Diagnosis

Accuracy rate of 98% in detecting clinically significant injuries
Absence of Doppler signal – Grave Sign
Physical Findings Suggestive of Extremity Vascular Injury

Hard Signs
1. Pulsatile Hemorrhage
2. Expanding Hematoma
3. Thrill / Bruit
4. Acute Ischemia

Soft Signs
1. Moderate Hemorrhage
2. Small Hematoma
3. Proximity in the limb

Hard Signs = Operative Exploration
Soft Signs  = Compare systolic pressure with the non-injured Side.
For Difference > 10%, Angiogram is mandatory
Operative Principles

1) Control Bleeding
   - **Initial control** – Direct pressure by using digital or manual compression
   - **Definitive Control**-
     - Hemostatic Suture
     - Ligation
     - Temporary Shunt
     - Balloon Catheter Tamponade
   - **Proximal and Distal Control** before entering the surrounding hematoma
Operative Principles...(Continued)

Arteries for which repair should always be attempted (diameter >3mm)
Carotid          Brachial          SMA
Innominate       Proper hepatic
Renal            Iliac            Femoral
Popliteal        Aorta

Veins for which repair should always be attempted (diameter >10mm)
SVC
Supra renal IVC
Portal Vein
2) **Exposure**
3) **Repair**
   1. **Simple Repair:** Rapid, Best suited under adverse physiologic circumstances.
      - Ligation
      - Lateral Repair
      - Shunt Insertion
Temporary Intraluminal Shunts

- A mean of maintaining distal perfusion through an injured artery.
- Conduits:
  - Carotid Shunts
  - ET suction catheters
  - IV tubing !!!

*Problems:*
1. Blood flow (less than half, when compared to an artery of same diameter)
2. Last < 24 hours
The Use of Temporary Vascular Shunts as a Damage Control Adjunct in the Management of Wartime Vascular Injury


**Background:** While the use of vascular shunts as a damage control adjunct has been described in series from civilian institutions no contemporary military experience has been reported. The objective of this study is to examine patterns of use and effectiveness of temporary vascular shunts in the contemporary management of wartime vascular injury.

**Materials:** From September 1, 2004 to August 31, 2005, 2,473 combat injuries were treated at the central echelon III surgical facility in Iraq. Vascular injuries were entered into a registry and reviewed. Location of shunts was divided into proximal and distal, and shunt patency, complications and limb viability were examined.

**Results:** There were 126 extremity vascular injuries treated. Fifty-three (42%) had been operated on at forward locations and 30 of 53 (57%) had temporary shunts in place upon arrival to our facility. The patency for shunts in proximal vascular injuries was 86% (n = 22) compared with 12% (n = 8) for distal shunts (p < 0.05). All shunts placed in proximal venous injuries were patent (n = 4). Systemic heparin was not used and there were no shunt complications. All shunted injuries were reconstructed with vein in theater and early viability for extremities in which shunts were used was 92%.

**Conclusions:** Temporary vascular shunts are common in the management of wartime vascular injury. Shunts in proximal injuries including veins have high patency rates compared with those placed in distal injuries. This vascular adjunct represents a safe and effective damage control technique and is preferable to attempted reconstruction in austere conditions.

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Fig. 6. Shunt patency rates and early limb viability in cases with shunts placed in proximal vascular injuries versus distal vascular injuries.
2. **Complex Repair:** Time Consuming.
   Patch Angioplasty
   End-to-end anastomosis
   Graft Interposition

   - Before repair, Forgarty catheter thrombectomy should be performed on both ends of the injured vessel.
   - Both vessel ends should be irrigated with heparinized saline.
Sephanous vein Vs PTFE graft
PTFE graft preferred because of:
1. Clinical data shows no difference in wound infection rate
2. Expedites the operative procedure
3. Resistant to dissolution by bacterial collagenase
4. Better outcome if soft tissue cover is lost
Operative Principles… (Continued)

Combined Ortho + Vascular Injuries:

- Bone alignment first, then vascular repair
- If limb is grossly ischemic, temporary intraluminal shunt is placed first, then bone alignment followed by vascular repair.
Vein Injuries

- Repair if patient is hemodynamically stable
- Poor long term patency rates
- Post op thrombosis occurs gradually within 1-2 weeks
- Reasonable to use PTFE graft to buy time for collateral circulation development.
Compartment Syndrome

Factors contributing to compartment syndrome:
1. Direct Muscular trauma
2. Hypotension
3. Reperfusion Injury
4. Ligation of injured veins

Controversy over performing routine fasciotomies for these patients.
Iatrogenic Trauma

- Most common site: Femoral vessels
- Most common cause: Cardiac Catheterization.

**Results**

1. Hematoma: May need operative exploration and repair of defect.
3. Retroperitoneal Hematomas
4. Arteriovenous fistulas
Conventional Angiogram VS CT Angiogram

Multi-slice CT Angiography for Arterial Evaluation in the Injured Lower Extremity

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**Background:** With the evolution of multi-slice helical computed tomographic angiography (MCTA), the optimal imaging modality for arterial injury in the traumatized lower extremity has been challenged. The objective of this study was to evaluate the ability of MCTA to detect arterial injury in the traumatized lower extremity. Our hypothesis was that MCTA is a sensitive and specific test for the non-invasive evaluation of lower extremity arterial injury.

**Methods:** After Institutional Review Board approval, we reviewed all patients at our Level I trauma center who sustained lower extremity trauma and underwent initial evaluation by MCTA over a 3-year period ending in February 2005. MCTA accuracy was tested against a gold standard of operative intervention, duplex ultrasonography, catheter-based angiography, or clinical follow-up.

**Results:** Sixty-three MCTAs were performed in 59 patients. MCTA was diagnostic in 62 of the 63 scans (98.4%). The mechanism was penetrating in 45.8%. Lower extremity fractures were present in 38.7% of patients studied. There were 22 positive studies. Out of this group, 19 were confirmed at operation and 3 were managed non-operatively. In the 19 injuries confirmed in the operating theater, there were 5 superficial femoral, 2 profunda, 10 popliteal, 1 posterior tibia, and 1 injury to all 3 mid-calf arteries. There were two injuries below the trifurcation managed non-operatively and there was one popliteal occlusion with distal reconstitution that was confirmed by duplex and managed non-operatively because of patient refusal of surgery. Forty studies were negative for arterial injury, with clinical follow up available in 89.5%, for a mean of 48.2 days (range, 5–287 days). No missed injuries were identified during the follow-up period. MCTA was non-diagnostic in 1 patient (1.6%), secondary to artifact from retained missile fragments. MCTA achieved 100% sensitivity and 100% specificity in detecting clinically significant arterial injury.

**Conclusion:** MCTA is a sensitive and specific non-invasive imaging modality for arterial evaluation in the injured lower extremity that may replace catheter-based angiography in most patients.

**Key Words:** Lower Limb, Arteries, Wounds, Injuries, Radiography, Diagnostic Imaging, Computed tomography.

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Management of Specific Injuries
Common / Superficial Femoral Arteries

- Proximal Control, obtained with a longitudinal groin incision, using inguinal ligament as a guide line.
- Superficial femoral artery in Hunter’s canal is exposed through a medial thigh incision.
- Preserve sephanous nerve (anterior to the artery).
Popliteal Artery

- Popliteal artery injuries result in limb loss more often than any other peripheral vascular injury (20% amputation rate).
- Poor collaterals around the knee.
- Posterior knee dislocation = 33% risk of popliteal artery injury.
- Proximal Popliteal artery exposed through an incision along the anterior border of the sartorius muscle above knee.
- Distal Popliteal artery exposed through medial incision immediately behind the posterior border of tibia.
Lower Leg Arteries

- If one of three vessels is involved: Angiographic embolization / operative ligation.
- Either anterior tibial or posterior tibial artery should be patent to keep limb viable. (Peroneal artery alone is not sufficient)
Subclavian / Axillary Arteries

- Treated as one entity
- 3rd or 4th intercostal space anterolateral thoracotomy (proximal control) and supraclavicular incision with resection of medial third of clavicle for distal control.
- Extending a subclavian incision into the medial aspect of the abducted upper arm exposes the axillary artery.
Penetrating Injuries to the Subclavian Vessels

- Represent less than 5% of all vascular injuries

- Difficult injuries to deal with due to limited surgical exposure
  Poor patient condition/reserve with co-existent injuries

- Majority of patients have hemothorax on presentation
Penetrating Injuries to the Subclavian Vessels

- Adequate exposure and control of bleeding requires the need for
  1. Median Sternotomy
  2. Clavicular incision

- Previously done exposures with the use of ‘trap-door thoracotomy’ have become less common these days due to the severity of post op morbidity associated severe postop neuralgias and pain syndromes associated with clavicular head disarticulation
Penetrating Injuries to the Subclavian Vessels

  - 18 pts (23%) had ED thoracotomy without any survivors
  - 58 pts underwent OR exploration
  - Overall mortality ~ 34.2%
    - Mortality excluding ED thoracotomy ~ 14.8%
Penetrating Injuries to the Subclavian Vessels

- Mortality for Venous injuries was significantly higher than Arterial Injuries
  Isolated Venous mortality ~50%
  Isolated Arterial mortality ~ 20.5%
  Combined injury ~ 45%

- Clavicular Incision provided adequate exposure in 50% cases
- Median Sternotomy required in addition for remaining patients

Demetriades et al.
JACS 1999; 188: 290-295
Figure 1. Balloon tamponade of bleeding subclavian vessels. (From: Asensio JA, Demetriades D, eds. Techniques in Complex Trauma Surgery, Philadelphia, WB Saunders, in press, with permission.)
Figure 2. The medial half of the clavicle is stripped off the attached sternocleidomastoid, pectoralis major, and subclavius muscles. (From: Asensio JA, Demetriades D, eds. Techniques in Complex Trauma Surgery, Philadelphia, WB Saunders in press, with permission.)
Figure 3. Exposure of the subclavian and axillary vessels after resection of the medial half of the clavicle or division and retraction of the clavicle (inset). The pectoralis major is divided. The pectoralis minor may be divided if necessary. (From: Asensio JA, Demetriades D, eds. Techniques in Complex Trauma Surgery, Philadelphia, WB Saunders, in press, with permission.)
Brachial Artery

- The most frequently injured artery in the body. (20-30% of all peripheral vascular injuries)
- Exposure by medial arm incision in the groove between biceps and triceps muscle. Median nerve must be preserved.
Radial / Ulnar Arteries

- Most isolated ulnar OR radial injuries can be ligated.
- Radial artery exposure: Incision in lower medial arm in anticubital fossa in an S shaped configuration.
Role of Endovascular Interventions

- For Hemodynamically stable patients
- More useful for blood vessels with difficult open access