

Fractures with Associated Vascular Injury

Algorithmic Approach

UCSF Trauma 2024

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Conflict of Interest Disclosure

James R. Ficke



- I have no financial conflicts with this presentation
- Disclosures:
 - *Research Funding, NIH; U.S. Dept of Defense*
 - **Balmoral; Stryker- Transdermal COMPRESS**
 - **DT MedTech- Prospective Trial H3 Total Ankle**
 - *Board of Directors, ABOS; Team Red White Blue*
 - *Board of Trustees, Orthopaedic Research & Education Foundation*





Prevalence

- 1-3% extremity trauma
- More often penetrating trauma
 - GSW 46%
 - Blunt 19%
 - Stabbing 12%
- **HIGHER Mortality**
 - 3.3% LE
 - 6.3% UE
 - 20% pelvis





Injury Patterns

- Spasm
- Intimal flap
- External compression
 - Compartment syndrome
 - Hematoma
- Thrombus
- Laceration/transsection
 - External projectiles
 - Bone fragments





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Goals

Identify vascular injuries

Reliably & accurately evaluate injury

Coordinate treatment

ORTHOPAEDIC SURGERY



Diagnosis= Prompt Recognition

Successful diagnosis and management of extremity vascular injuries requires:

- *Thorough history and physical
- *High index of suspicion
- *Rapid administration of care





Mechanism of injury heightens the surgeon's awareness of potential vascular insult

Considerations:

- *Fracture Personality
- *Presence of dislocation
- *Blunt trauma vs penetrating trauma



High Risk Fractures



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- Penetrating trauma
- High energy pelvic fractures
- Fractures Adjacent to major vessels
 - Distal Femur
 - Proximal Tibia
- Crush injuries



Fracture Specific Vascular Injuries

- Clavicle Subclavian
- Supracondylar humerus Brachial
- Pelvic ring Gluteal, Iliac, Obturator
- Distal femur Popliteal
- Tibia plateau/ shaft Popliteal, tibial





Dislocations

- Scapulothoracic dissociation 64-100%
- Knee dislocation 16%



Blunt Trauma

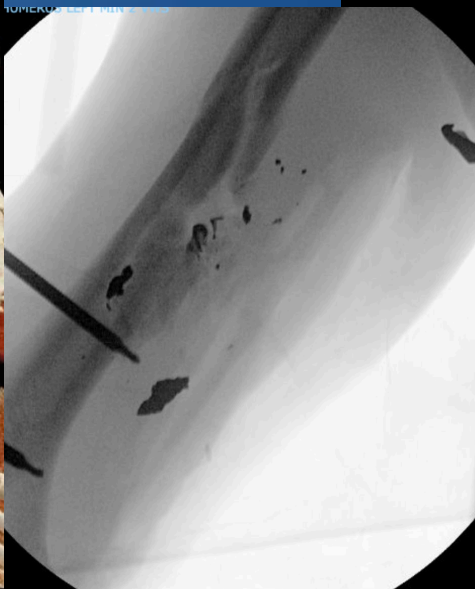
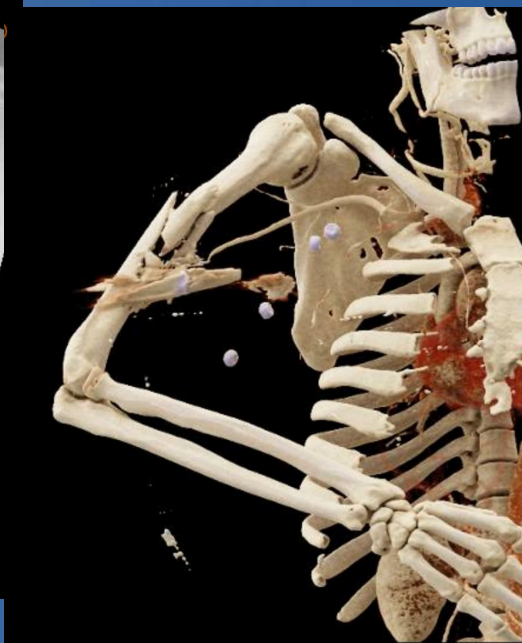
- **Stretching or shearing of vessels**
- **Intimal damage/dissection, thrombus**
- **Subtle clinical findings**
- **27% amputation rate**





Penetrating Injury

- Direct injury to vessel
 - Laceration/transection
- Exam findings- Not always obvious
- Delayed pseudo-aneurysm and AVF
- 9% amputation rate





Physical Exam

Hard Signs

- Pulsatile bleeding
- Expanding hematoma
- Thrill at injury site
- Pulseless limb

Soft Signs

- Asymmetric limb temp
- Asymmetric pulses
- Injury anatomically-related nerve
- Hx immediate bleeding p injury



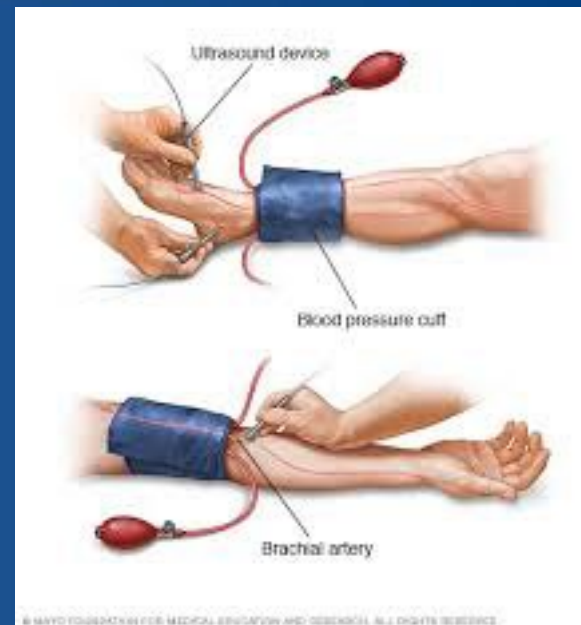
Emergency Management

- **Control Bleeding**
 - Compressive dressing
 - Judicious tourniquet
- **Fluid resuscitation**
- **Reduce & splint fractures**
- **Re-evaluate**



Ankle Brachial Index

- **Indications**
 - Asymmetric pulses
 - Soft exam findings
 - High energy tibia plateau fx
 - All knee dislocations
- **ABI < 0.9: Vascular + Advanced Imaging**
- **ABI does not define extent or level of injury**



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Ankle Brachial Index

- **Benefits**
 - Available
 - Inexpensive
 - Negative predictive value 96% - 100%
- **Limited diagnosis**
 - Venous injuries
 - False positive with arterial spasmInjuries can preclude cuff placement



Duplex Scan

- Technician dependent
- Time intensive
- Steep learning curve
- Limited indication in acute trauma patients



Angiography

- **Historical Gold Standard**
- **Localizes the lesion**
- **Defines type and extent of lesion**
 - Active hemorrhage vs occlusion
- **Allows treatment planning**
embolization vs bypass



Angiography Disadvantages

- **Patient risks**
 - Renal insult**
 - Anaphylaxis**
 - **Iatrogenic vessel injury**
- **Expensive**
- **Difficult to resuscitate patients**
- **Delays operative intervention**



Multi-Detector CT Angiography (MDCTA)

- Replaced angiography as standard
- 95% sensitivity and 87% specificity
- Decreased contrast load
- Fast
- Cost-effective



CTA Disadvantages

- **Cannot exclude all arterial dissections**
- **May still require angiography**
- **Limited resolution in presence of**
 - **Foreign bodies**
 - **Vascular calcifications**

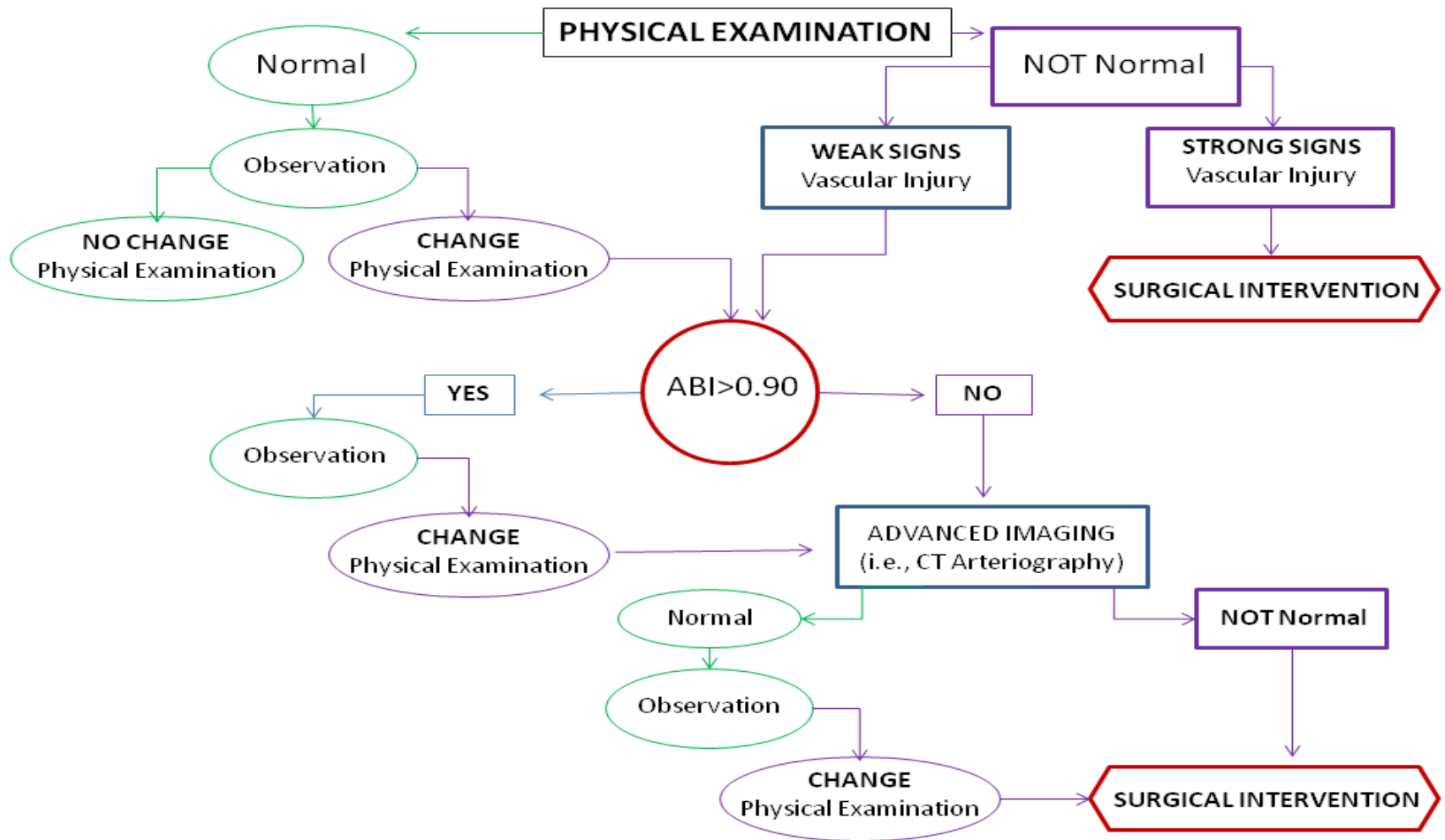


Surgical Exploration

- **Indications:**
 - **Frank vascular injury**
 - **Vascular injury not amenable to endovascular repair**
 - **Expanding/pulsatile hematoma**
 - **Thrill at injury site**
 - **Pulseless limb**



Evaluation Algorithm





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Sequence of Surgical Treatment

Who goes first? Vascular or Orthopaedics



ORTHOPAEDIC SURGERY



Treatment Decisions

Vascular Surgeon

- Non-operative
- Ligation
- Temporary Shunt
- Direct Repair
- Bypass





Restoration of Blood Flow

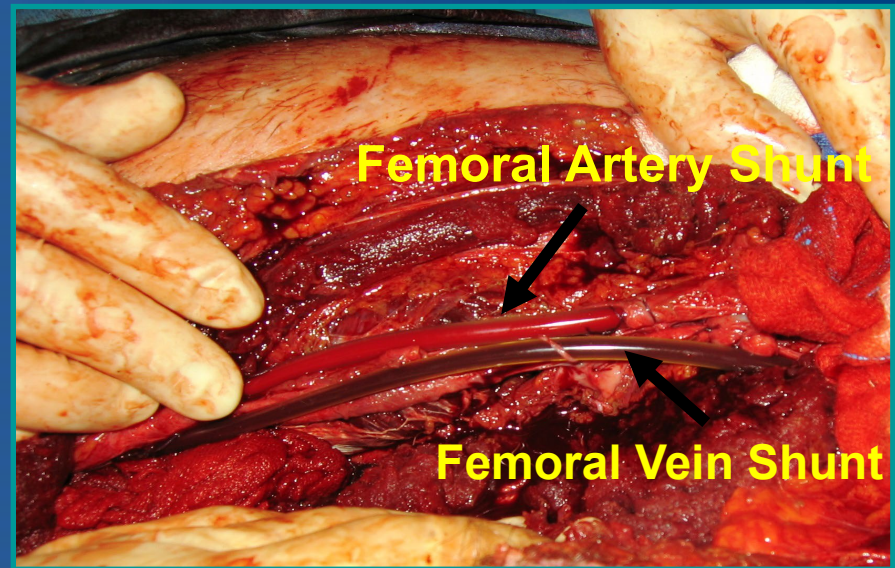
- Revascularization of ischemic tissue
 - *Fracture reduction*
 - *Joint relocation*
 - *Compartment syndrome release*
 - *Vascular repair*

Reduce and stabilize fractures
decrease pain and protect until
definitive fixation



Restoration of Blood Flow- Temporary Vascular Shunting

- Damage control for injured blood vessels
- Placement of silicone tube to bypass injured segment of vessel(s)
- Effectively controls hemorrhage
- Rapidly restores blood flow to limb
- Less physiologic stress to patient



Sets stage for definitive grafting





Who Goes First?

- **Meta-analysis: sequence (vascular vs ortho) does not affect amputation rate**
- **Traction upon vascular repair is not shown to lead to vascular compromise**



Treatment

- **Have a protocol in place**
- **Consider each patient individually**
- **Restore blood flow**
- **Debride devitalized tissue**
- **Stabilize fractures**



Fasciotomy

- **Diagnosis of acute compartment syndrome**
- **Arterial injury requiring repair**
- **Combined arterial venous injury**
- **Warm ischemia > 6hr**
- **Cold ischemia > 12hr**





Prognostic Factors

- **Soft tissue injury (crush)**
- **Level of vascular injury**
- **Collateral circulation**
- **Ischemia time**
- **Patient factors**



Complications

- **Compartment syndrome**
- **Tissue necrosis**
- **Infection**
- **Amputation**
- **Death**





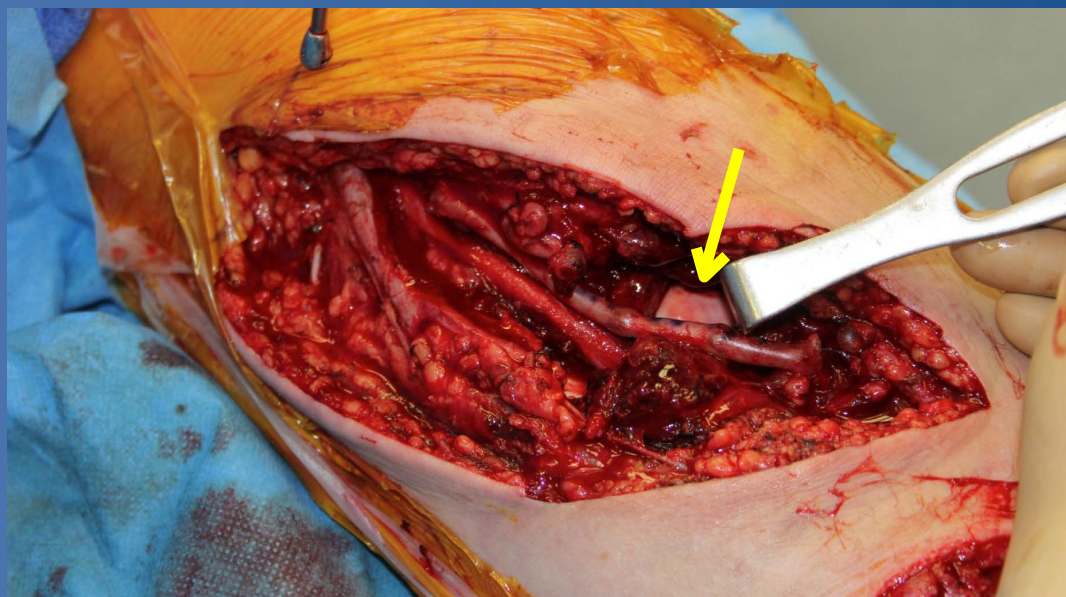
Case Example

- 30 yr old
- Open elbow dislocation
- Arterial bleeding observed in ED
- Vascular is consulted
- OR < 3 hours from injury





Direct repair brachial artery Ligament repair of elbow



Vascular Injuries: Summary

Maintain high index of suspicion

- *Recognize common injury patterns**
- *Thorough, repeated examination**

Rapid recognition and treatment is paramount

Have a protocol for evaluation and treatment



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