



Open Fractures with Vascular Compromise A Management Protocol

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◆ Disclosure

◆ Nothing too Declare



High Energy Injury Grade 3 C Fxs



Gustillo Classification

Type I <1cm

Type II >1 cm but without
extensive soft tissue flaps,
avulsion, or crush

Type III - A, B, C



VASCULAR INJURY INCIDENCE

- ◆ **VASCULAR DAMAGE** requiring repair: 0.3 to 3% of all long-bone fractures and dislocations.

Major Vascular Lesions Associated With Orthopaedic Injuries

Dionissios Karavias, *Panagiotis Korovessis, †Kriton S. Filos, ‡Dimitrios Siampelis, John Petrocheilos, and John Androulakis

Journal of Orthopaedic Trauma
Vol. 6, No. 2, pp. 180-185
© 1992 Raven Press, Ltd., New York

- ◆ **Vascular injuries of the Upper Extremity** represent approximately 30-50% of all peripheral vascular injuries.

Southern Med J. 2000;93(5):466-8

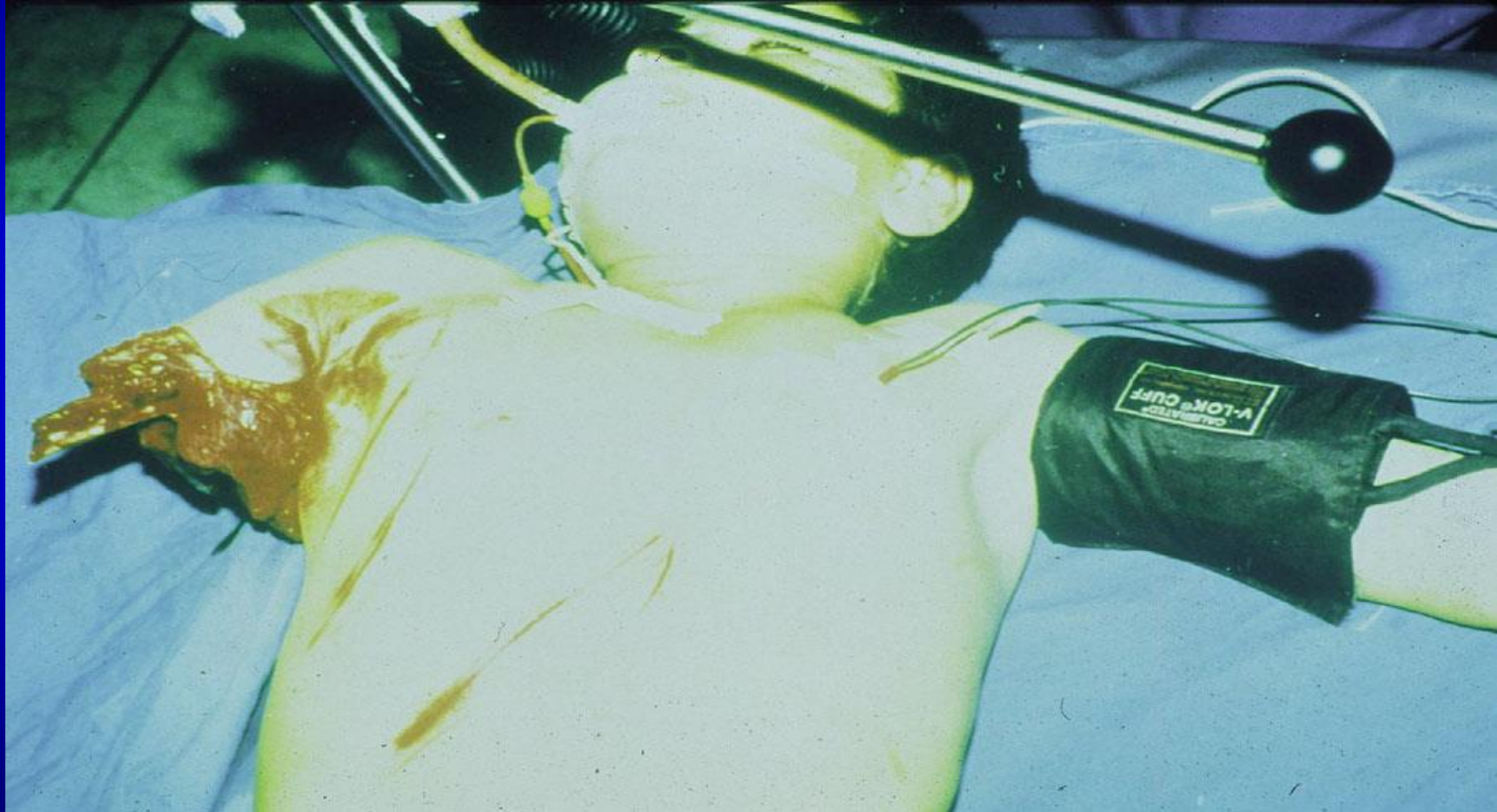
Emergency Care

- ◆ **Advanced Trauma Life Support (ATLS)**
- ◆ **Resuscitation (ABCDE)**
- ◆ **Vascular Assessment:**
 - pulses, cap refill > 2 sec, Doppler
 - Hemorrhage control- tourniquet**

Emergency Care

- ◆ **Antibiotics**
- ◆ **Simple irrigation of open wound**
- ◆ **Splinting of fracture**
- ◆ **Then to OR ASAP if vascular compromise**
- ◆ **Muscle has 3-4 hours warm ischemia**
- ◆ **Then irreversible muscle necrosis**

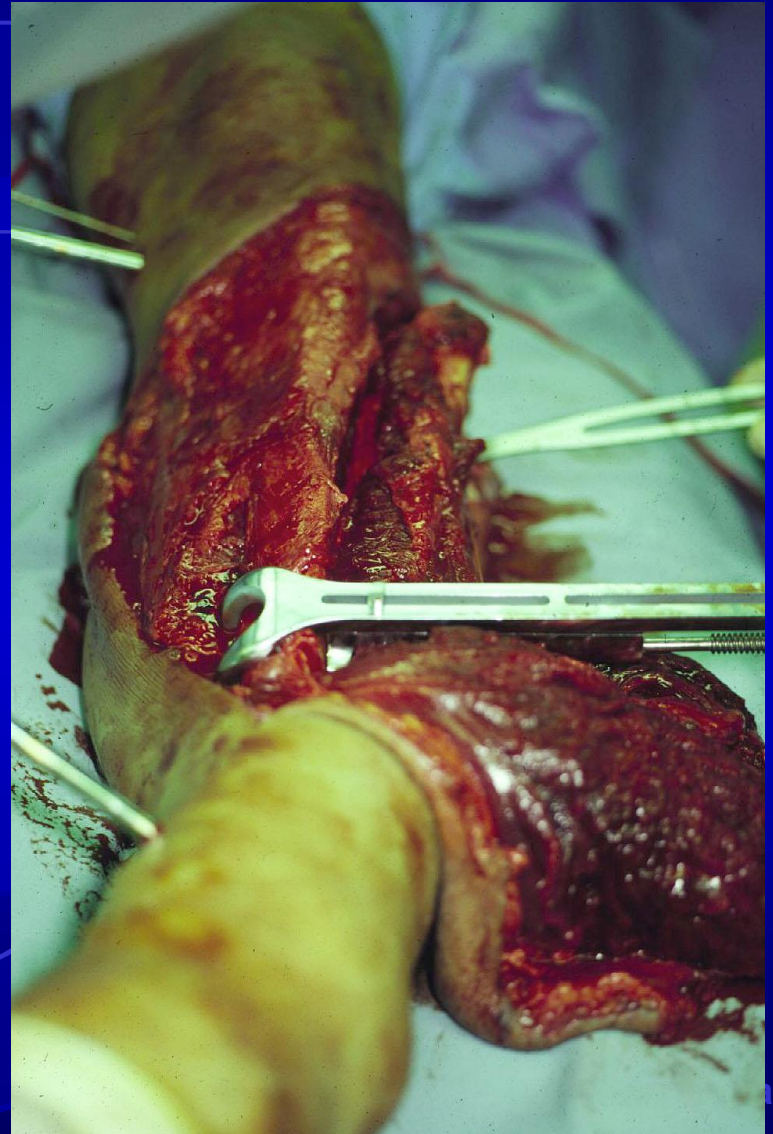
Try to keep Muscle Ischemia < 3 hours



O.R.

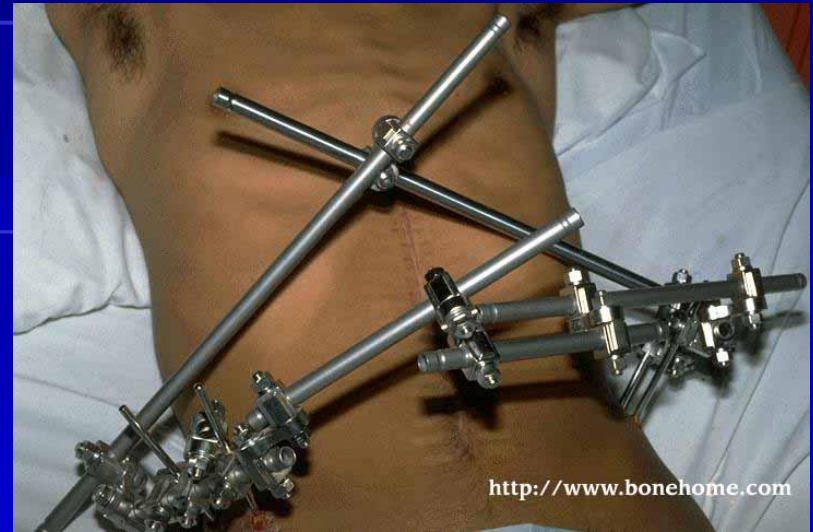
- ◆ **Aggressive debridement of all devitalized tissue**
- ◆ **Lavage with Betadine Saline**
- ◆ **Pressurized lavage worse than low pressure syringe**
- ◆ **External Fixation to span fracture**
- ◆ **Fasciotomy for post revascularization prevent compartment syndrome**

- ◆ **This Grade 3 C injury open tibia**
- ◆ **Pulseless foot**
- ◆ **No improvement post realignment and ext fix**
- ◆ **Immediate vasc shunt**



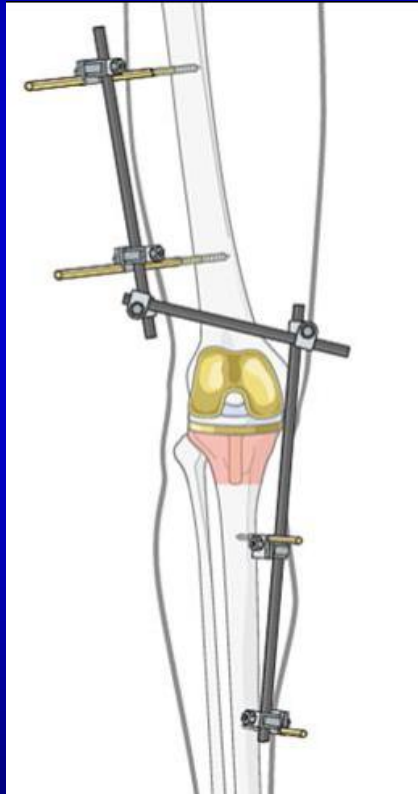
Open Fracture with vascular injury

- ◆ **External fixation**
 - Stabilize the skeleton and soft tissues
- ◆ **Angiography**
 - Must not wait for study in lieu of early exploration for ischemic limb



External Fixation

- Applied quickly
- Protects vascular repair

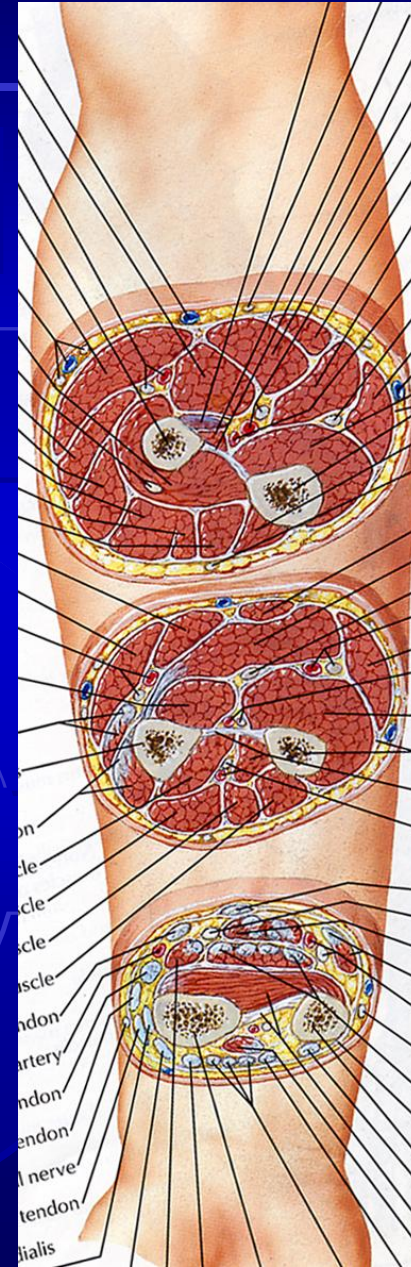
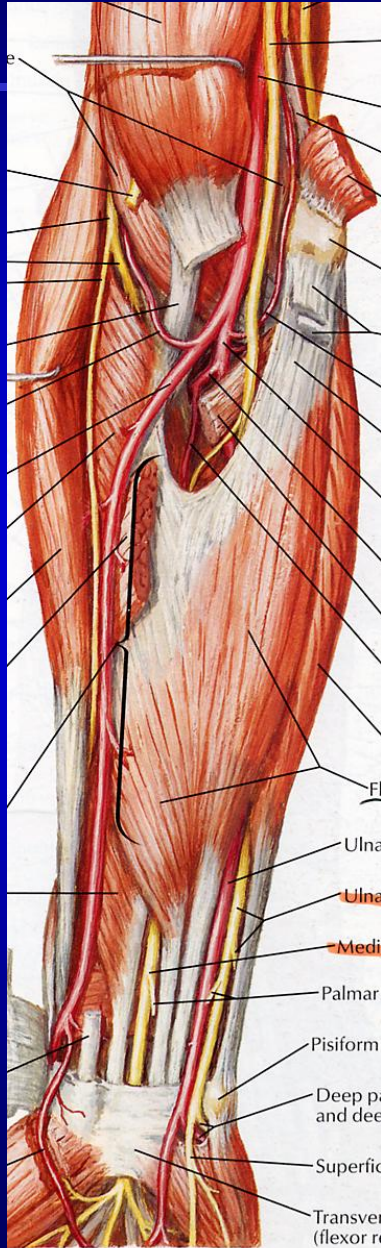


Higher energy injury

Fx displacement- Inc vasc injury



Vessels vulnerability



Vascular Injury

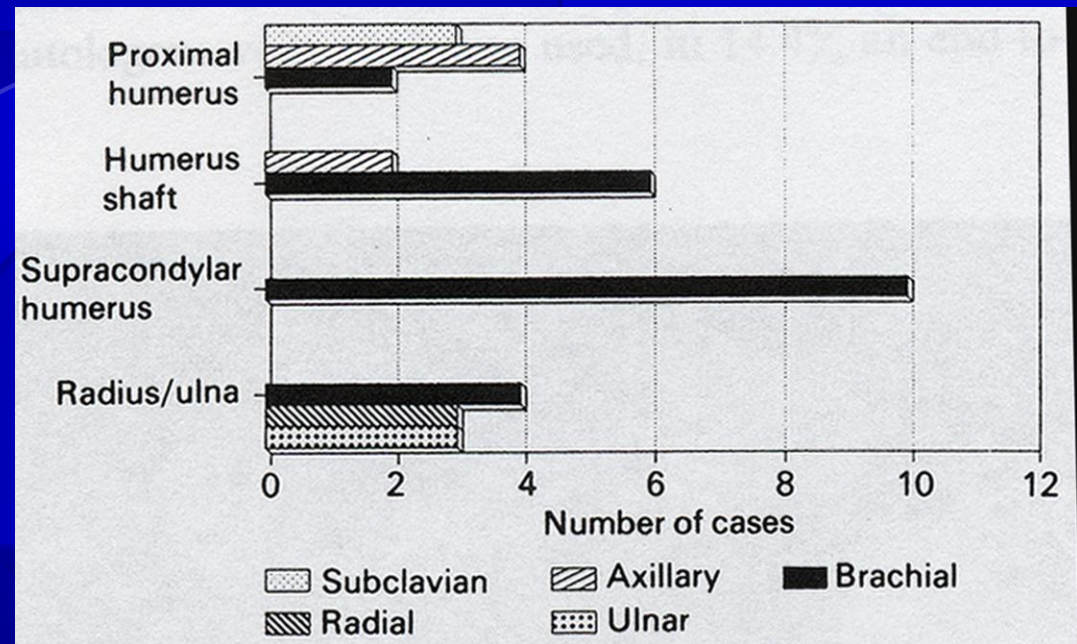
UPPER AND LOWER LIMB FRACTURES WITH CONCOMITANT ARTERIAL INJURY

W. SCHLICKWEI, E. H. KUNER, A. B. MULLAJI, B. GÖTZE

From the University of Freiburg

JBJS, 74B, 1992

- ◆ 113 Cases over a period of 18 years
 - 38 upper extremity
 - 75 lower extremity
- ◆ Vessel injured can be remote to Fx site



Early Management of Extremity Injuries

- ◆ Trauma Protocols (ABCDE)
- ◆ Immobilize with Splints and/or Traction
- ◆ Restore Limb Alignment
- ◆ Perform Wound Care



If Vascular Injury Is Suspected...

- ◆ **Assure adequate temporary immobilization**
- ◆ **Assess fracture alignment**
- ◆ **Re-assess distal perfusion**
- ◆ **Check tight dressings, casts, or splints**
- ◆ **Pulse oxymeter, Doppler monitor**

Vascular Injury: Evaluation

- ◆ **Partial Tear:**

- Persistent Bleeding

- ◆ **Complete Tear:**

- Vasoconstriction and Thrombus Formation

- ◆ **Look for: (The 5 P's of Acute Ischemia)**

- Pain
- Pallor
- Pulselessness
- Paralysis
- Paresthesia

Vascular Injury: Evaluation

◆ Unequivocal Signs

- Brisk, external bleeding
- Expanding hematoma

◆ Suggestive Signs

- Bruit/thrill
- Abnormal Pulses
- Pallor
- Empty Veins
- Decreased cap refill
- Relative coolness
- Close proximity of wounds to course of major artery
- Decreased Sensation
- Motor Weakness
- Progressively increasing pain after immobilization

Correlation of Physical Exam and Vascular Injury found at surgery

A Comprehensive Approach to Extremity Vascular Trauma

James O. Menzoian, MD; Jeanne E. Doyle, RN; Nancy L. Cantelmo, MD; Frank W. LoGerfo, MD; Erwin Hirsch, MD

Archives of
Surgery, 1985(120)

Table 1.—Correlation Between Physical Examination and Surgical Exploration

Indication	No. Explored	No. (%) Positive
Bruit-thrill	5	5 (100)
Ischemia	16	16 (100)
Absent pulse	68	62 (91)
Shock	37	33 (89)
Hemorrhage	97	79 (81)
Neurologic deficit	130	102 (78)
Hematoma	74	41 (55)
Proximity	70	14 (20)

Management Algorithm

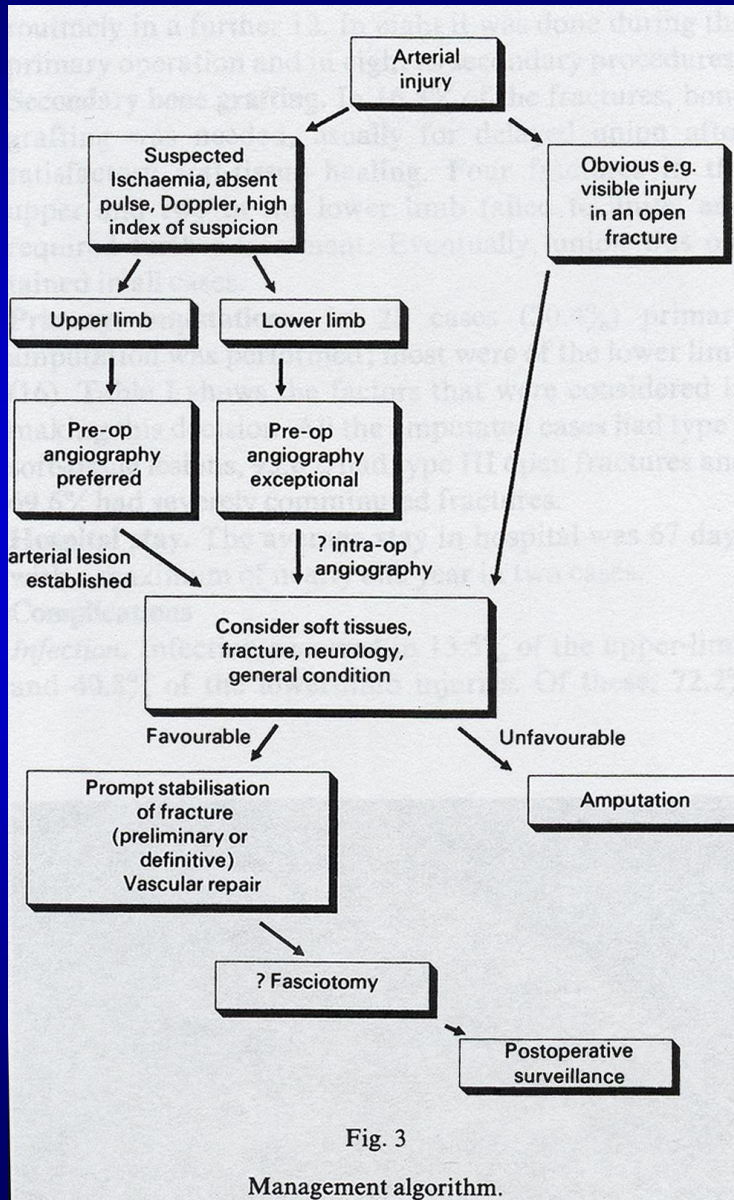


Fig. 3

Management algorithm.

UPPER AND LOWER LIMB FRACTURES WITH CONCOMITANT ARTERIAL INJURY

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JBJS, 74B #2, 1992

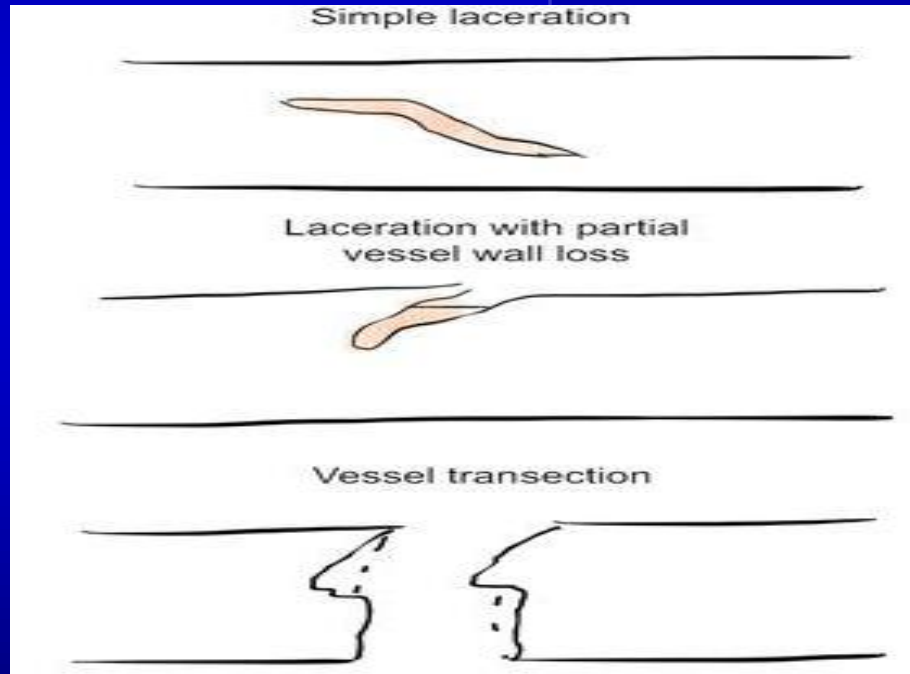
Vascular Injury Management

- ◆ **Angiography helpful if can be obtained promptly**
- ◆ **Otherwise direct to OR**
- ◆ **UE vasc injury tolerated a bit better because of rich collateral flow versus LE**
- ◆ **More time to get angiography**



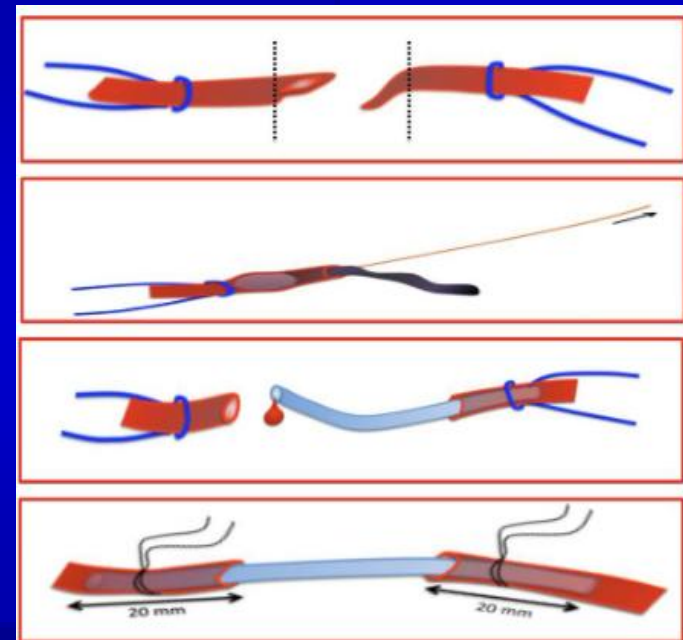
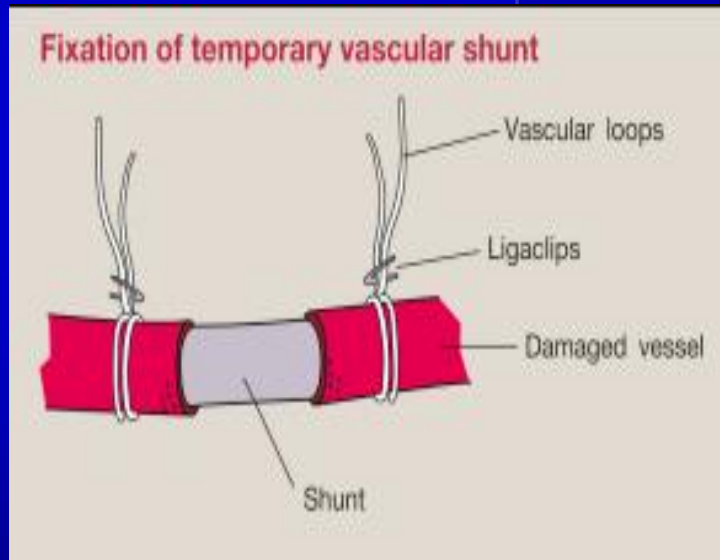
Types of Vascular Injury

- Laceration
- Transection

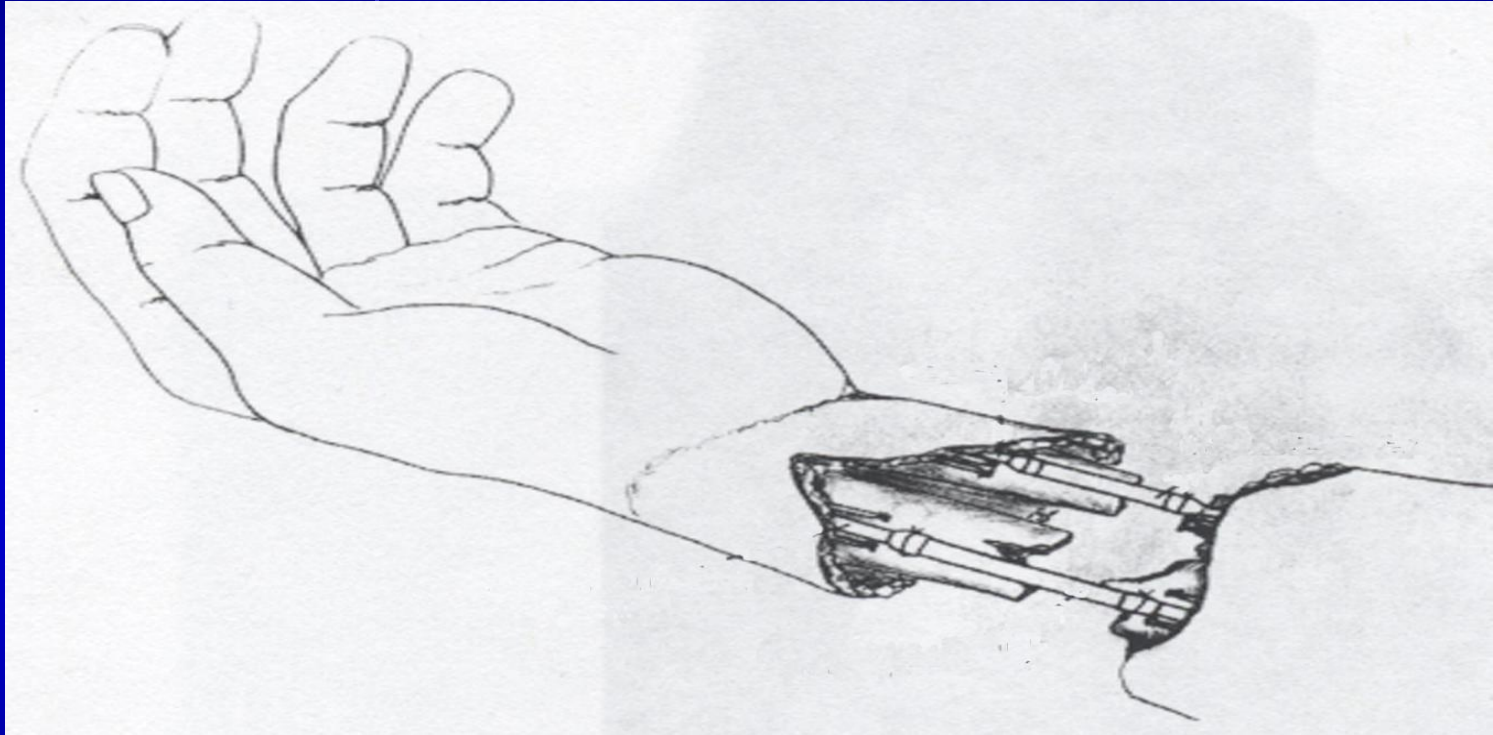


Temporary Shunt

- Re-establish blood flow promptly
- Ischemia time critical

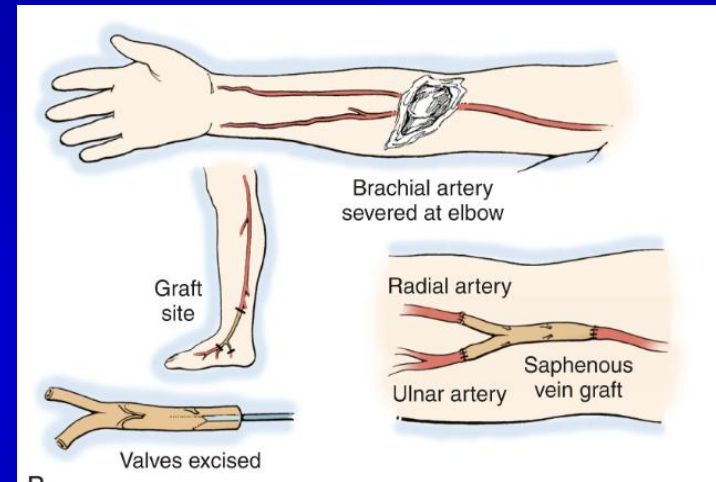


Arterial and Venous Shunting



Temporary arterial and venous shunting of the devascularized forearm

Vein Graft Reconstruction if adequate time



Vascular Injury Management

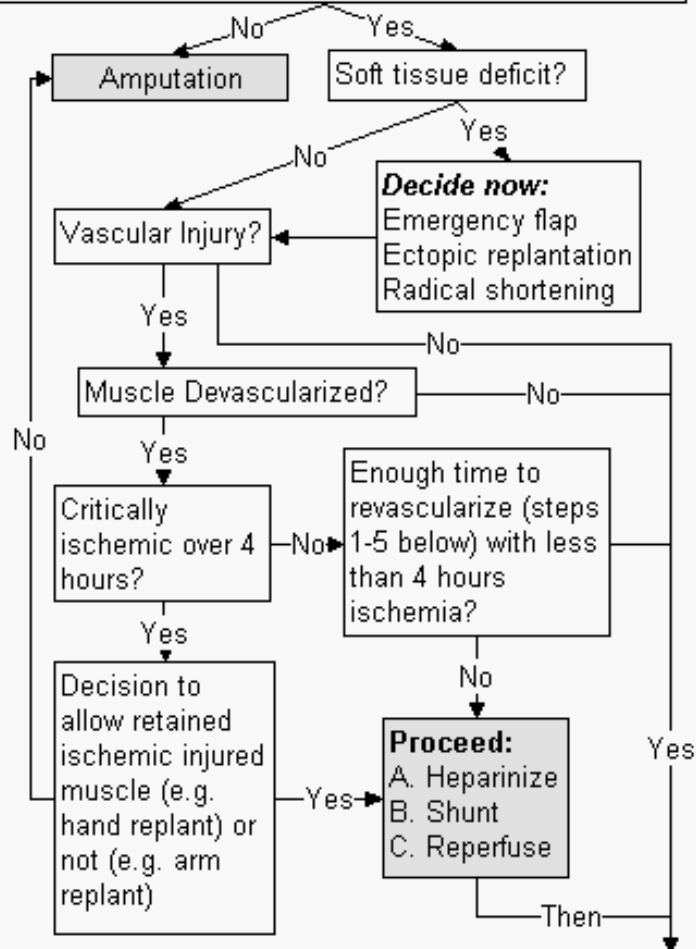
- ◆ SURGEON MUST INSURE ADEQUATE BLOOD SUPPLY WITH:

- *Debridement*
- *Revascularization*
- *Or Both!*

Although revascularization may be the most important step of the operation, it should not be the first step taken!

Severe Trauma: Order of Procedures

Anticipated final outcome justifies attempted salvage?



Order of Procedures

Proceed as applicable, in this order:

1. Debride under tourniquet control, extensile incisions
2. Wound irrigation / lavage
3. Skeletal realignment and stabilization
4. Fasciotomies if muscle ischemia time over 2 hours
5. Musculotendinous repairs adjacent to vascular injuries
6. Definitive vascular repairs
7. Confirm final plan for wound closure
8. Remaining deep soft tissue repairs
9. Wound closure

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Debridement

- ◆ Debridement is **CRITICAL**
- ◆ Post-Op infection is evidence of inadequate debridement
- ◆ Must include tissues that are devascularized and those that cannot be revascularized
- ◆ Should be approached in same manner as *tumor surgery*
 - Removal, not rinsing
 - Surgical excision, not scrubbing
- ◆ Best done under tourniquet control, before vascular repairs
 - Reduces blood loss and allows most accurate evaluation of injury.

Muscle Ischemia Time

- ◆ **Should be less than four hours**
 - However, defer definitive vascular repair until after debridement, skeletal fixation, and repair of musculo-tendinous structures adjacent to site of vascular repair.
 - May involve provisional revascularization with a shunt.

Common Error

→ *Definitive vascular repair before other repairs*

- *Vein graft can become redundant, kink and may need to be replaced.*

Controversy: Surgical Sequence

Fractures with Major Vascular Injuries from Gunshot Wounds: Implications of Surgical Sequence

MAJ Timothy P. McHenry, LTC John B. Holcomb, Noriaki Aoki, MD, and Ronald W. Lindsey, MD

J. Trauma, 2002; 53:717-721

Conclusion: For patients with combined injuries, priority should be given to revascularization before orthopedic fixation because of shorter hospitalization and a trend toward lower fasciotomy rates. Revascularization before fracture fixation did not result in iatrogenic disruption of the vascular repair.

- ◆ **Grade 3 C wounds**

- ◆ **Need temporary coverage: VAC**



Brachial Artery Vein Graft

Grade 3 C Distal humeral fracture

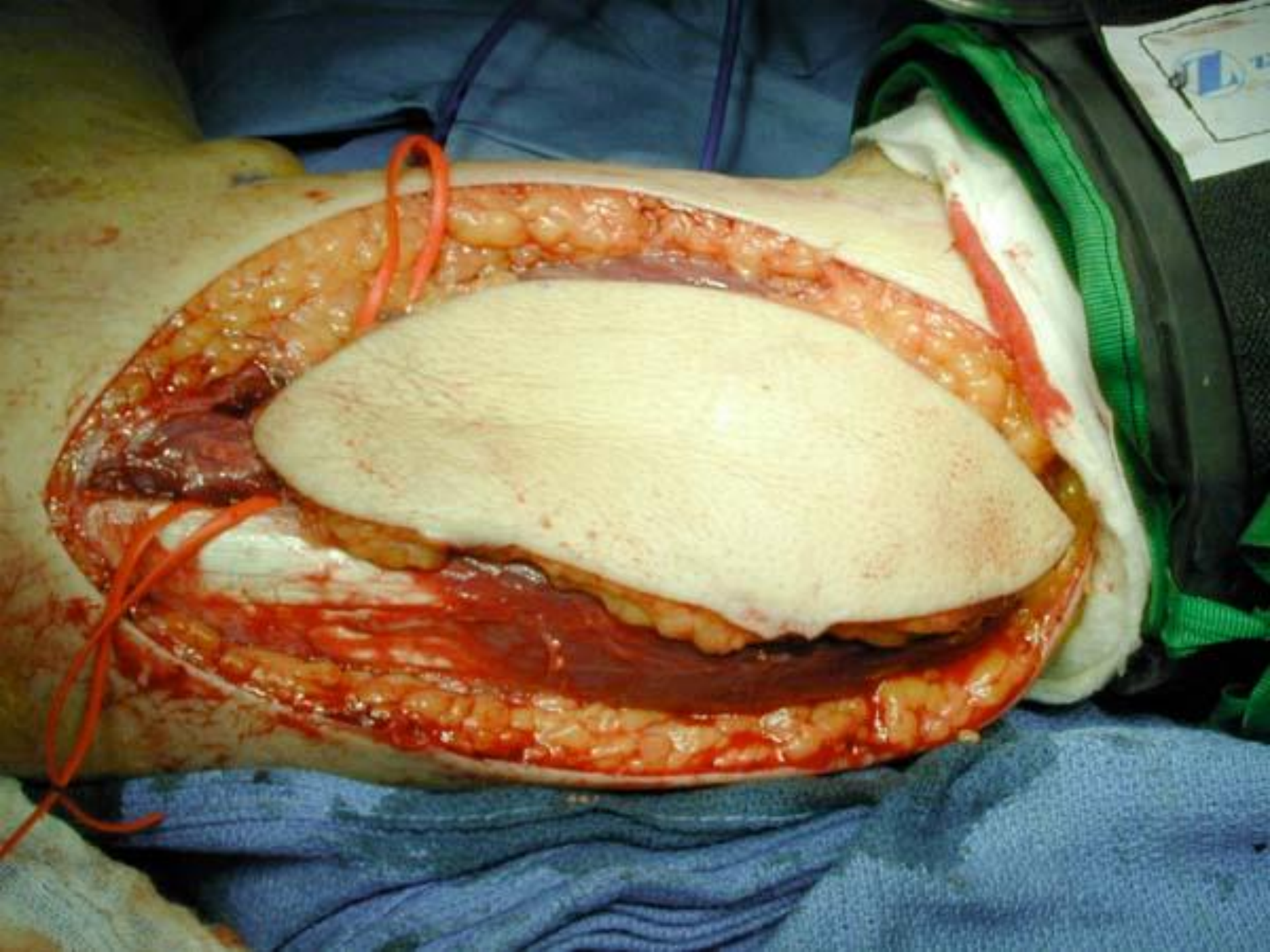
Elbow was flexed during repair

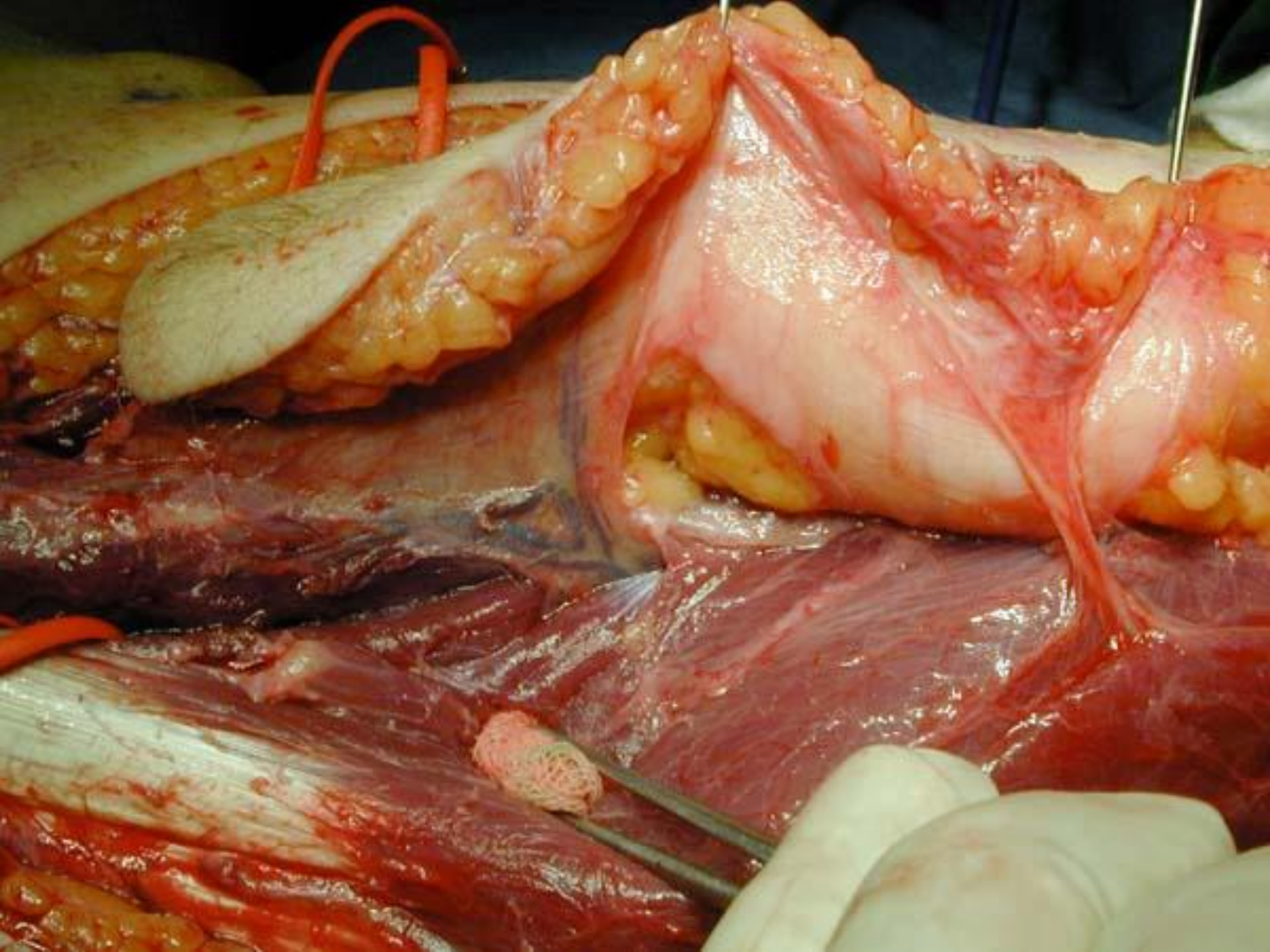
Now arm cannot be extended

Lateral Arm Flap required to do elbow release and arterial repair redone











Controversy: Repair or Ligate?

Radial or Ulnar Artery Laceration: Repair or Ligate?

Johnson M, Ford M, Johansen K.

Arch Surg. 1993;128:971-4.

- ◆ Patency following repair of radial or ulnar artery laceration does not exceed 50%
- ◆ Adverse hand symptoms relate to nerve or tendon damage, not to arterial damage.
- ◆ In the absence of acute hand ischemia, simple ligation of a lacerated radial or ulnar artery is safe and cost effective.

Ligate!

Management of Isolated Radial or Ulnar Arteries at the Forearm

Aftabuddin M, Islam N, Jafar M, Haque E,
Alimuzzaman M.

J. Trauma:1995(1):149-51

- ◆ **More support for ligation:**
 - Overall patency rate after repair of radial or ulnar arteries was 52%
 - Conclusion: Ligation of a radial or ulnar artery is safe and cost effective.

Repair?

- ◆ Literature also supports repair over ligation!?

Acute Penetrating Arterial Injuries of the Forearm: Ligation or Repair

Lee R, Obeid F, Horst H, Bivins B.

Am. Surg. 1985;51:318-24

- ◆ Reports an 85.7% patency rate after vessel repair!
- ◆ **Conclusion: Arterial ligation is recommended only when repair is not readily accomplished...**

For the Skeptics...

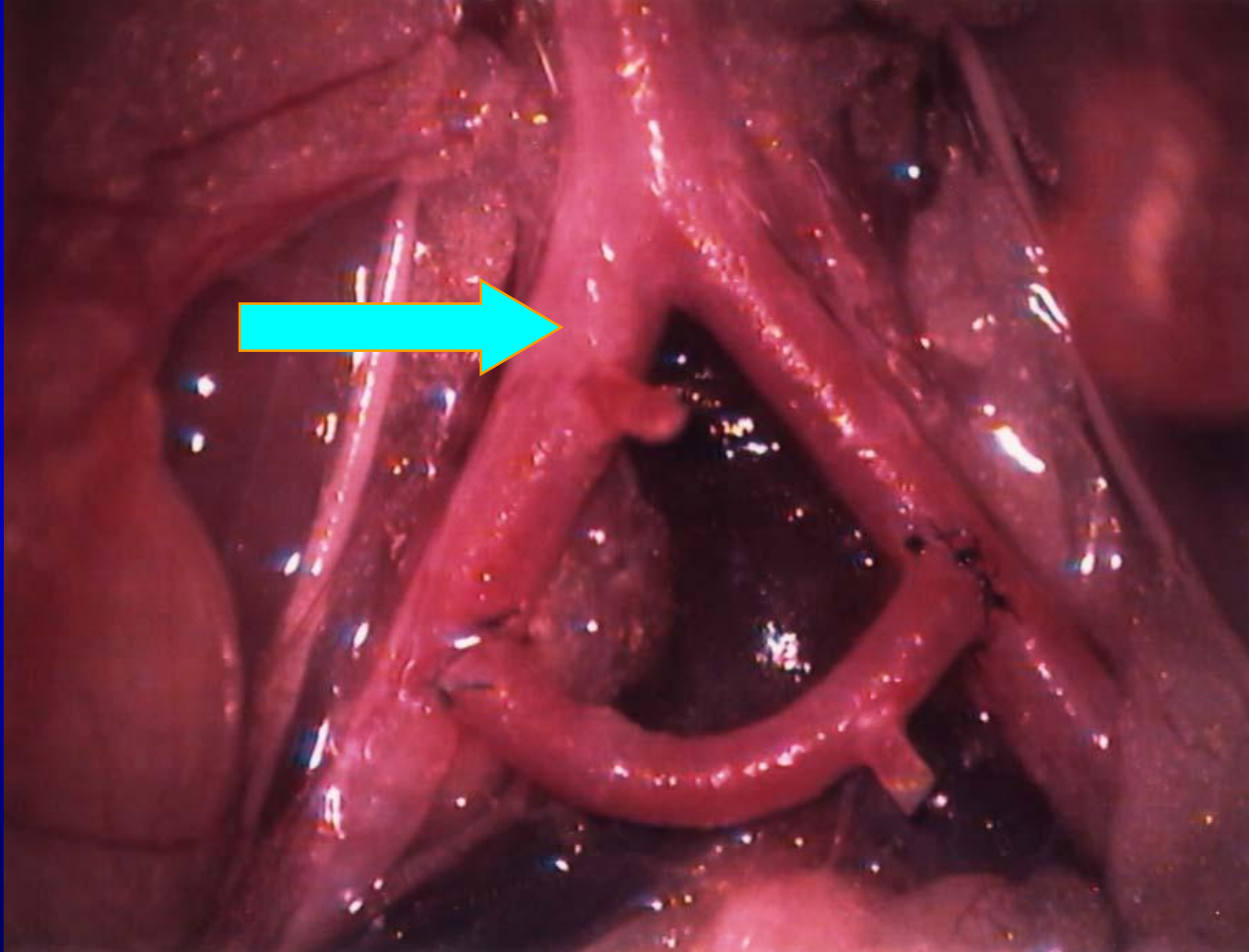
Radial Artery Use in Bypass Grafting Does Not Change Digital Blood Flow or Hand Function

Dumanian G, Seagalman K, Mispireta L, Walsh J, Hendrickson M, Wilgis E.

Ann Thoracic Surgery. 1998;65:1284-7

- ◆ **For properly selected patients, there are minimal changes in hand function after radial artery removal**
 - The patients had an increased incidence of a small amount of forearm numbness and tingling, but no increase of pain or cold intolerance

Vein Graft Radial Artery



Other Vascular-Associated Complications of Forearm Fracture

- ◆ **Compartment Syndrome**
- ◆ **Volkmann's Ischemic Contracture**
- ◆ **Reperfusion Injury**

Compartment Syndrome

◆ Clinical signs

- Expanding circumference
- Pain on passive stretch
- 5 P's, often late:
 - **Pain**
 - Pallor**
 - Pulselessness**
 - Paralysis**
 - Paresthesia**

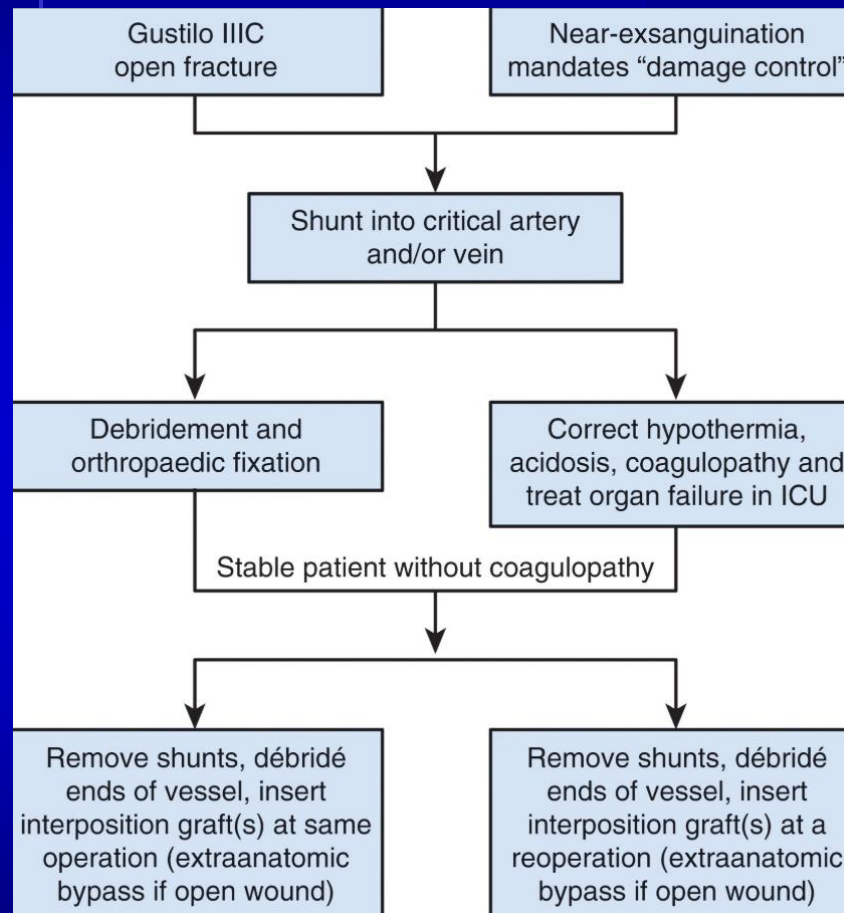
◆ Compartment pressure

- >40 mm Hg ⇒ fasciotomy

◆ Monitoring important especially in unconscious/obtunded patients



Summary-Treatment Protocol



Thank You

AMAZING
THINGS
ARE
HAPPENING
HERE

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