

Imaging of Upper and Lower Extremity Vascular Injuries

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Disclosures

I do not have any relationships to report with ACCME defined ineligible companies.

I will not be discussing unlabeled/investigational uses of medical devices or pharmaceuticals during this presentation.

Objectives

- *Discuss the importance of peripheral vascular injury in trauma.*
- *Review the role of imaging for the extremity vascular injury evaluation.*
- *Exemplify the typical imaging findings of extremity arterial trauma on MDCT*



Extremity Vascular Injury

Extremity Trauma:

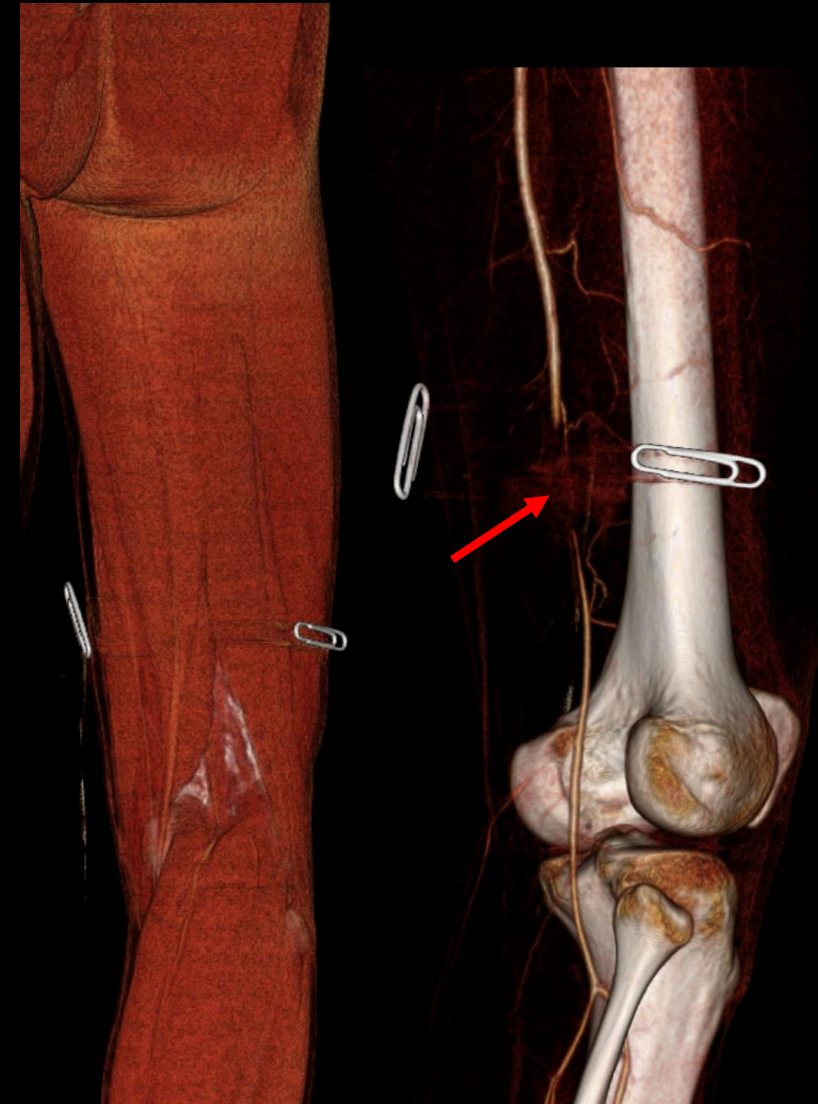
- Very common in isolation.
- As part of polytrauma: 40% LE and 32% UE

Vascular Injury Risk

- Penetrating > Blunt → GSW > SW

MSK Associations

- Closed long bone fracture → 0.1%.
- Severe tibia fractures → 9-10%.
- Knee dislocations → 16%



Pieroni S, et al. Use of 64-Row Multidetector CT Angiography in Blunt and Penetrating Trauma of the Upper and Lower Extremities. *RadioGraphics* 2009 29:3, 863-876

Miller-Thomas MM, et al. Diagnosing Traumatic Arterial Injury in the Extremities with CT Angiography: Pearls and Pitfalls. *RadioGraphics* 2005 25:suppl_1, S133-S142

Halvorson, Jason J., et al. Vascular injury associated with extremity trauma: initial diagnosis and management." *Journal of the American Academy of Orthopaedic Surgeons*, vol. 19, no. 8, 2011

Complications

- **Uncontrolled hemorrhage** → Exsanguination
- **Compartment Syndrome**
 - *70% occurs associated with fractures and half of those from tibia fractures.
- **Limb Ischemia and Amputation.**
 - *50.000 traumatic amputations/year in the US.

* **Prompt repair** of arterial injuries **improves outcome** in terms of limb function and mortality related to blood loss.

- Delays are associated with amputation rate as high as 86%

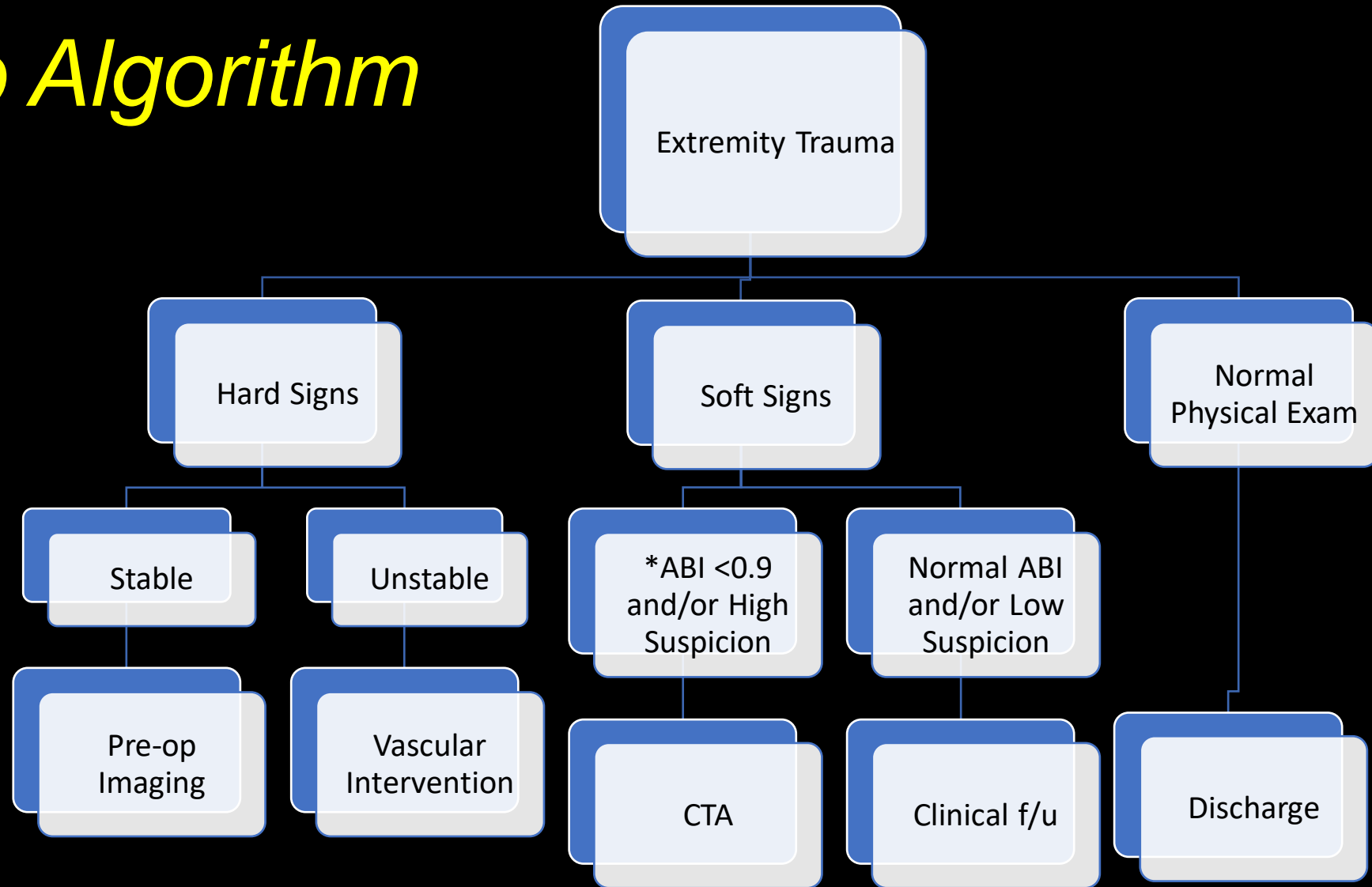


Triage of Peripheral Vascular Injury

- **Clinical Evaluation:**
 - Stable or Unstable
 - Isolated or Polytrauma
- **Hard vs Soft Signs**
 - +Pulse → “misleading”.
 - present in 5% to 15% of patients with clinically significant vascular injury.

Hard Signs of Vascular Injury	Soft Signs of Vascular Injury
<ul style="list-style-type: none">• Pulsatile or exsanguinating hemorrhage• Expanding or pulsatile hematoma• Absent distal pulse• Palpable thrill or audible bruit• Signs of occlusion (pulselessness, pallor, paresthesias, pain, paralysis, poikilothermia)	<ul style="list-style-type: none">• History or significant hemorrhage on scene• Stable, nonexpanding, non-pulsatile hematoma• Diminished distal pulse• Neurologic deficit• Proximity of wound to neurovascular bundle or nearby bony injury

Work-up Algorithm

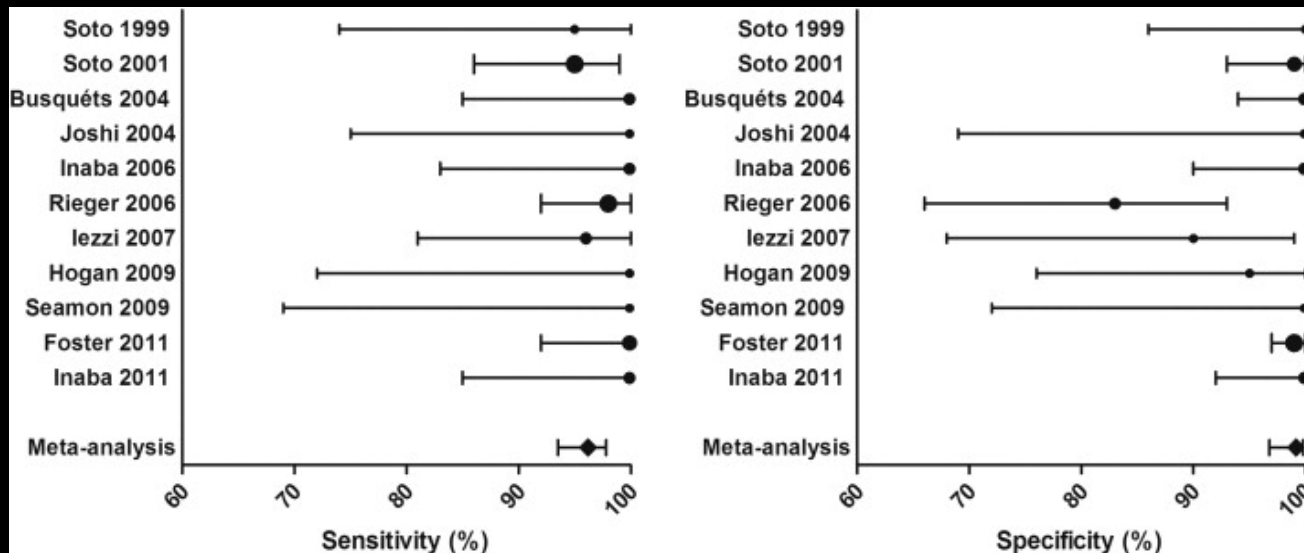


Imaging Options

- **Conventional Angiography:** 1%-2% morbidity, high cost, treatment delay.
- **Duplex sonography:** low sensitivity and specificity, operator dependent.
- **MRI:** not widely available, costly, time-consuming, not practical in most trauma cases (metal foreign bodies, etc.)
- **MDCT – Standard of care**
 - Available, fast, cost-effective, efficient, and complete screening of polytrauma patients
 - Helps determine the need and plan surgical or angiographic intervention when necessary.

CT – Role in Vascular injury

- **Outstanding accuracy** for diagnosis of upper and lower extremity vascular injury.
 - **Sensitivity** – 95-100%, **Specificity** – 87-100%, and **Accuracy** - 93%, with excellent inter-observer variability.



- Fishman, EK et al. Multidetector CT and Three-dimensional CT Angiography for Suspected Vascular Trauma of the Extremities. *RadioGraphics* 2008; 28:653–667
- Diagnostic performance of computed tomography angiography in peripheral arterial injury due to trauma: a systematic review and meta-analysis. *S Jens* 2013 Sep;46(3):329-37. doi: 10.1016/j.ejvs.2013.04.034.

MDCT Protocol

Optimization: Part of "Panscan"? Isolated CTA?

Preparation:

- 18- or 20-gauge cannula in an antecubital vein.
- 300-350 mg/ml (Omnipaque/Optiray)
- 4ml/s, followed by saline chaser

Contrast Trigger:

- **Fix delay:** 25s for upper and 50s for lower extremity
- **Bolus trigger:** ROI in the external iliac/common femoral or subclavian axillary
- Continue acquisition of LE run-off after whole-body sweep (+/- delay).



Patient Position

Torso and Lower Extremity Evaluation

- Supine with arms up (unless prevented by fracture or injury) → Decreases radiation dose and streak artifact

Additional or Isolated Upper Extremity

- Arms up or by the side, palm up.
- Injection on contralateral side (decrease streak from venous enhancement).

Penetrating Injury

- Position depending on the area of interest/extremity

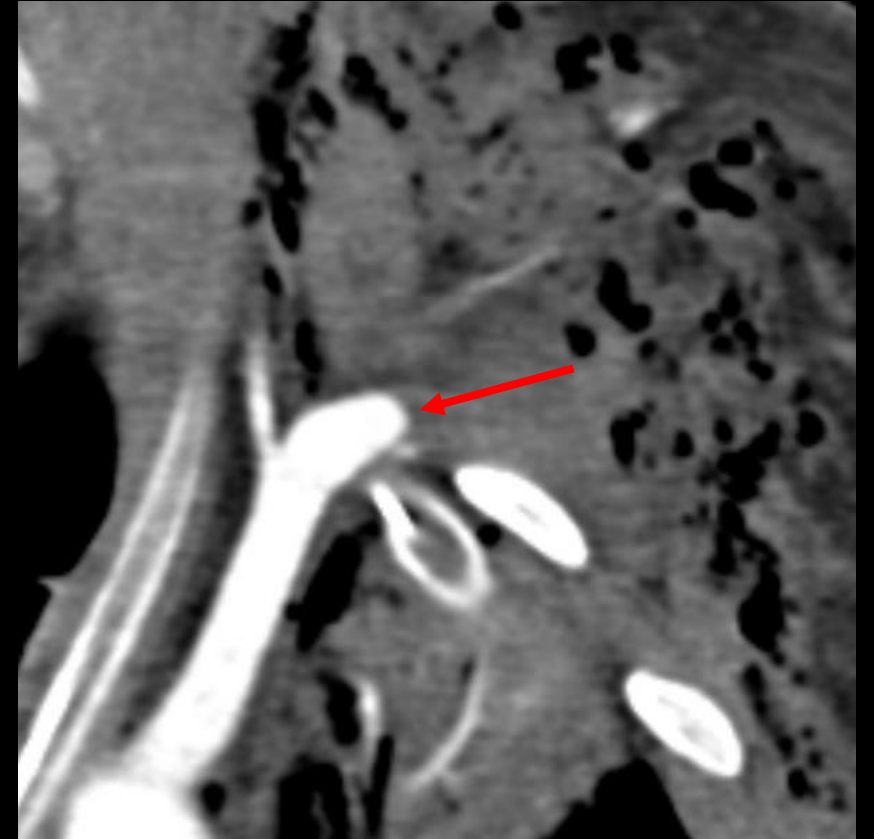
***Secure Extremity (Tape), if possible.**

****Document presence of tourniquet.**



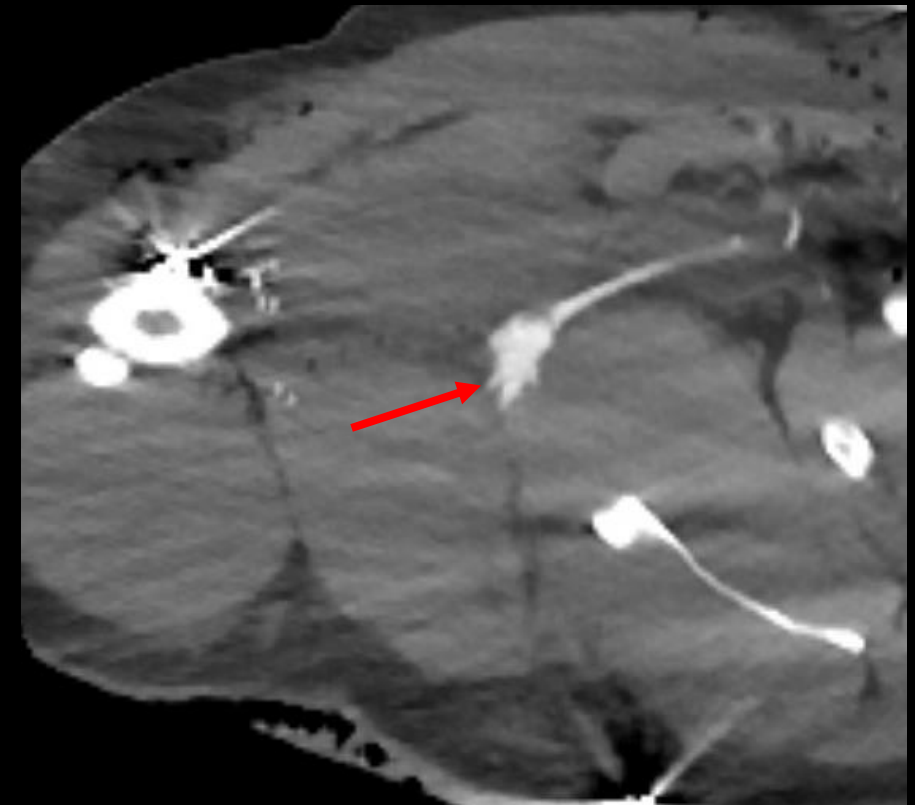
CTA Findings of Arterial Injury

- Abrupt cut off/Loss of opacification



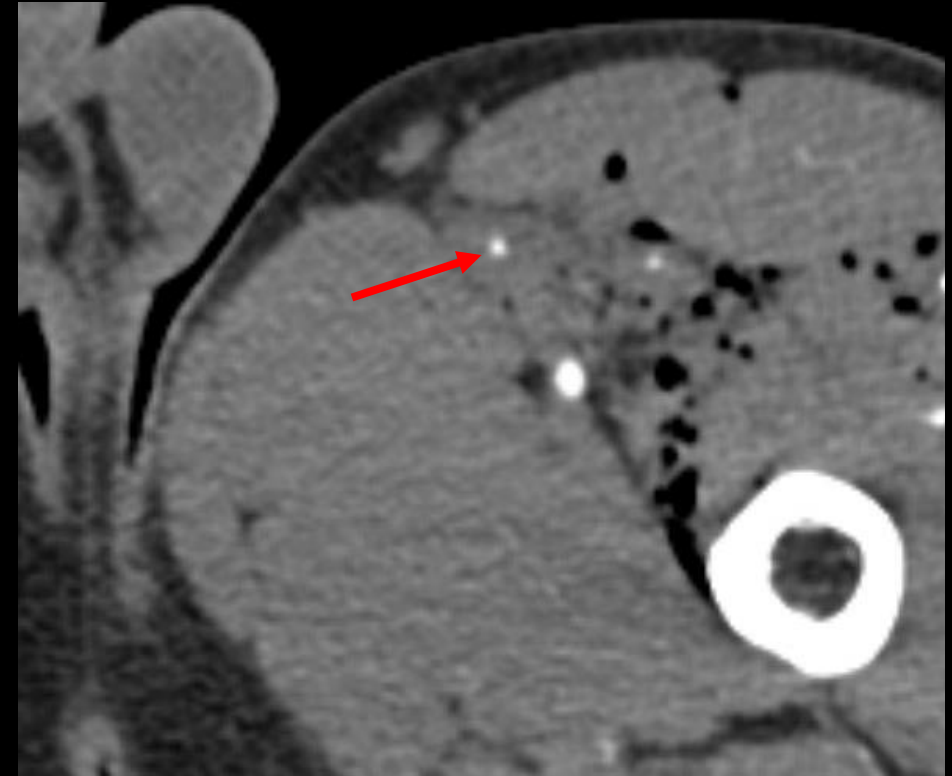
CTA Findings of Arterial Injury

- Abrupt cut off/Loss of opacification
- Active Extravasation



CTA Findings of Arterial Injury

- **Abrupt cut off/Loss of opacification**
- **Active Extravasation**
- **Contour irregularity/Narrowing**



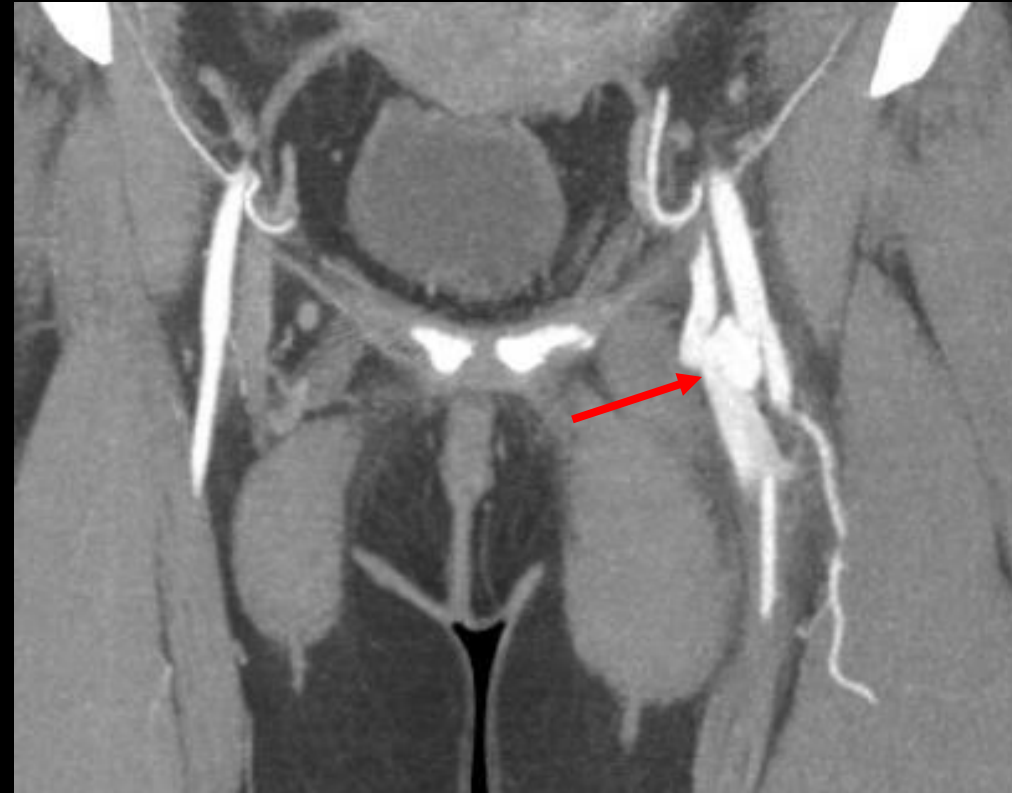
CTA Findings of Arterial Injury

- Abrupt cut off/Loss of opacification
- Active Extravasation
- Contour irregularity/Narrowing
- Pseudoaneurysm



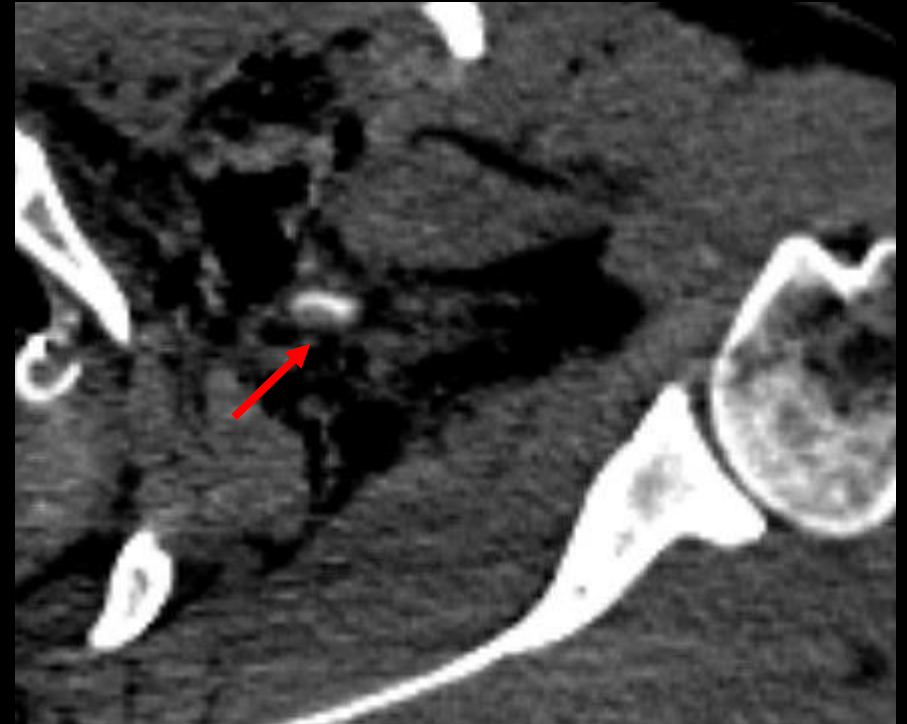
CTA Findings of Arterial Injury

- Abrupt cut off/Loss of opacification
- Active Extravasation
- Contour irregularity/Narrowing
- Pseudoaneurysm
- Arterial venous fistula



CTA Findings of Arterial Injury

- Abrupt cut off/Loss of opacification
- Active Extravasation
- Contour irregularity/Narrowing
- Pseudoaneurysm
- Arterial venous fistula
- ***Dissection Flap/Intimal Injury(Rare)**

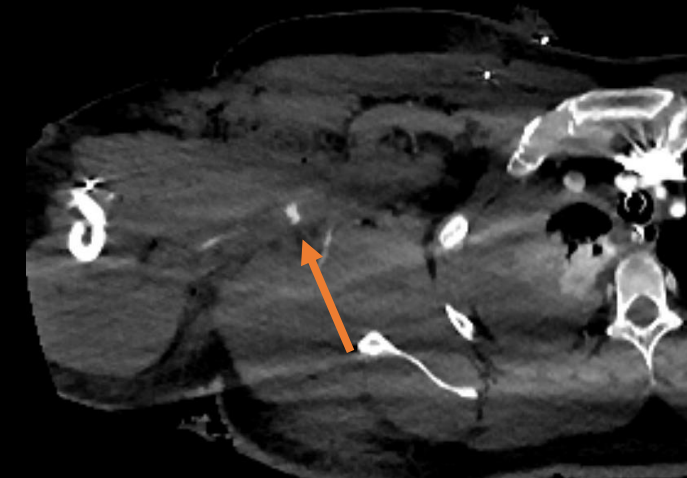
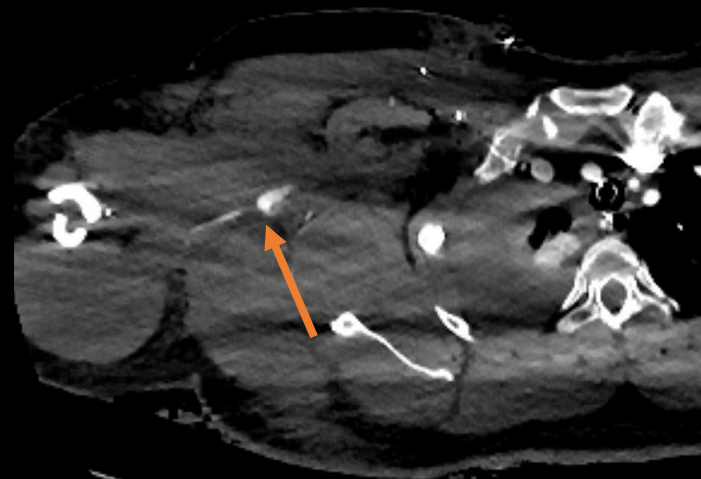
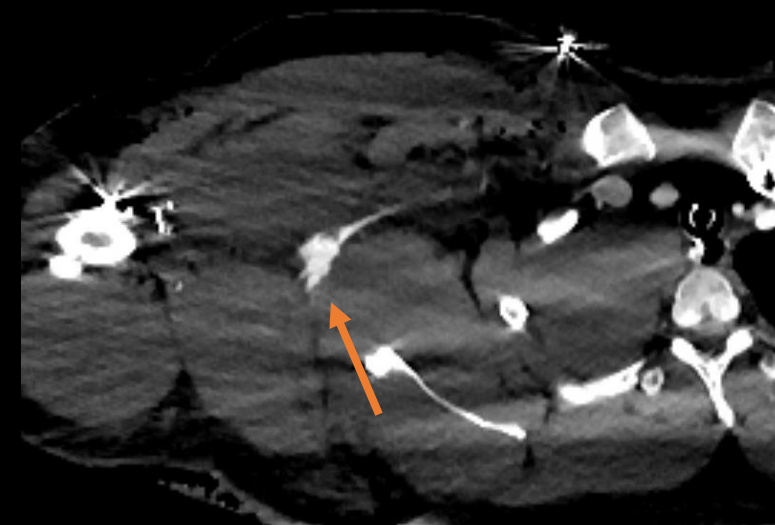
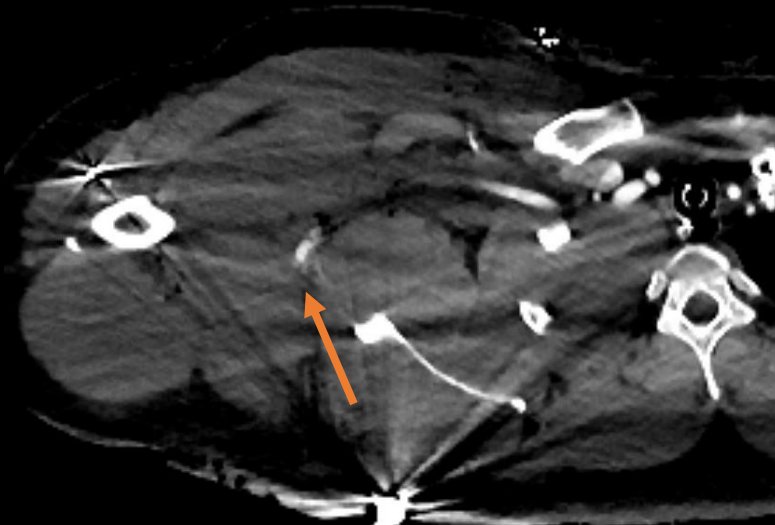
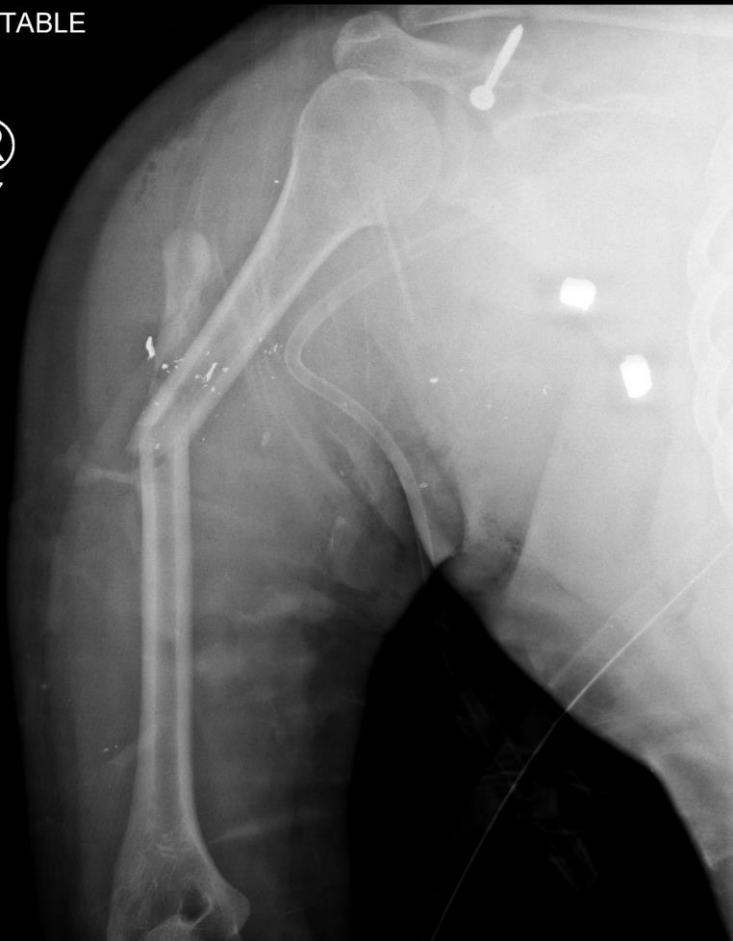


Extremity Vascular Injury Cases

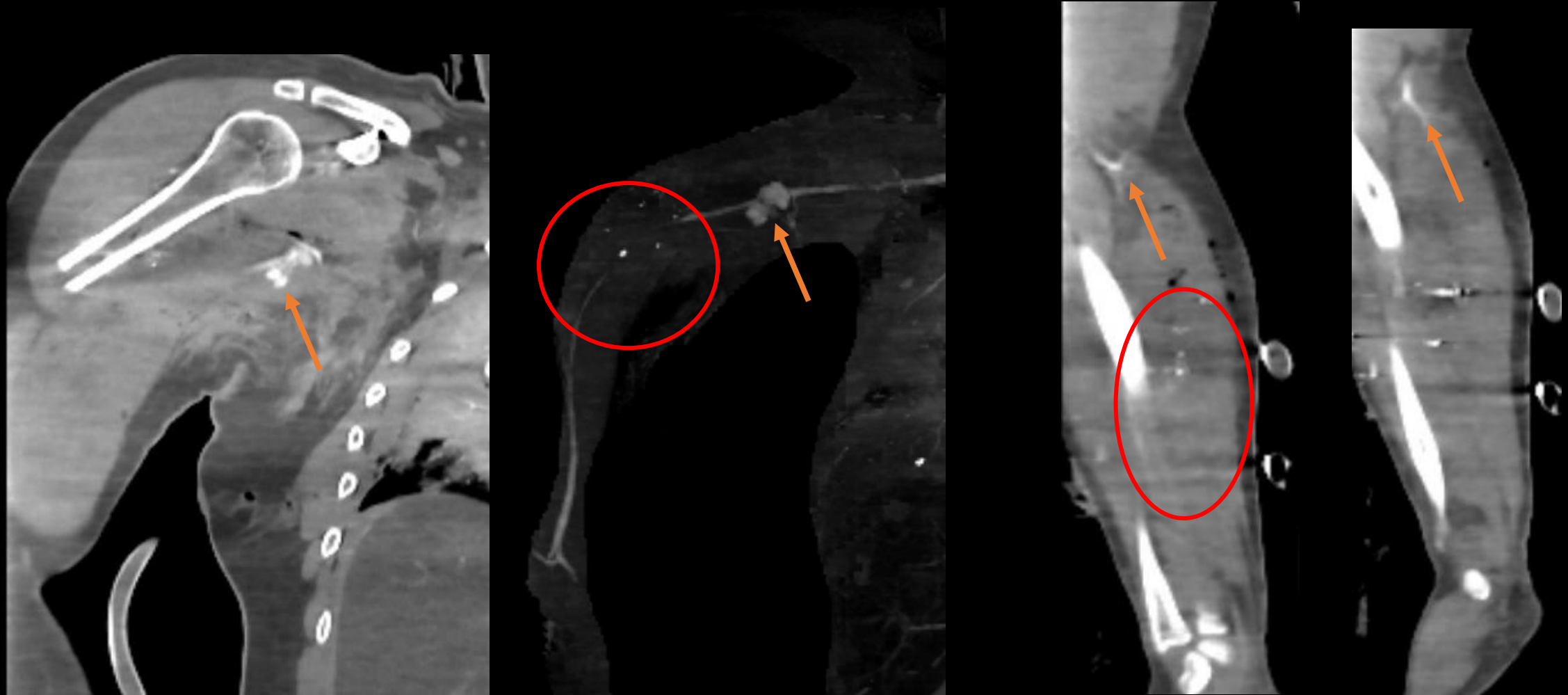
35 y/o after multiple GSW. Decreased pulse in the RUE.

PORTABLE

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77



35 y/o after multiple GSW. Decreased pulse in the RUE.

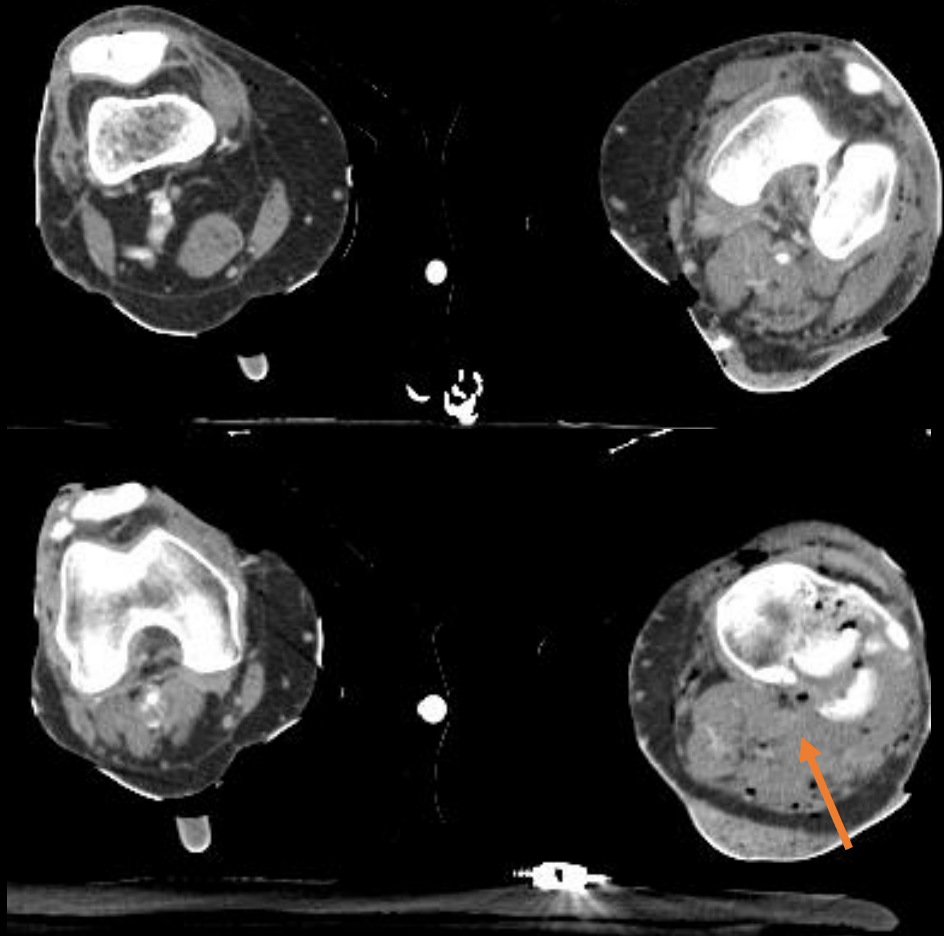


Transection/active extravasation of the R axillary artery

43 y/o male hit by a car. Multiple extremity fractures. Decreased pulses on the LLE.

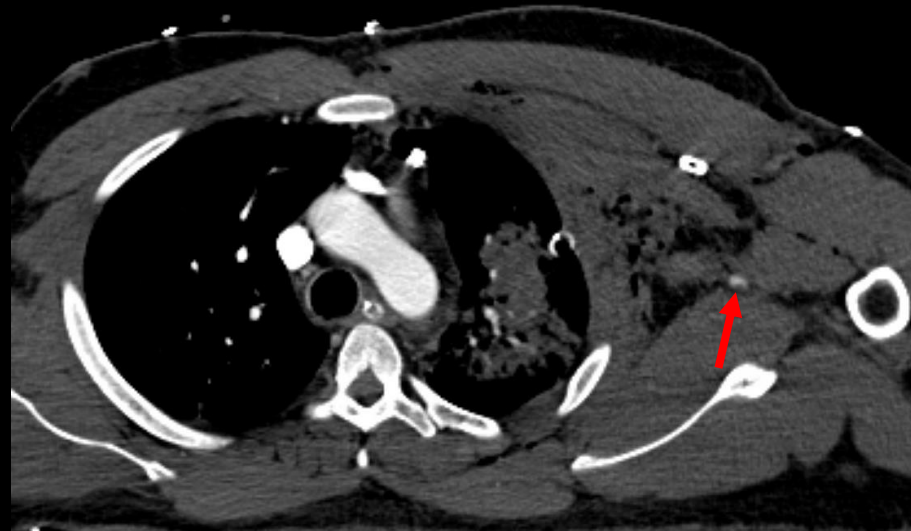
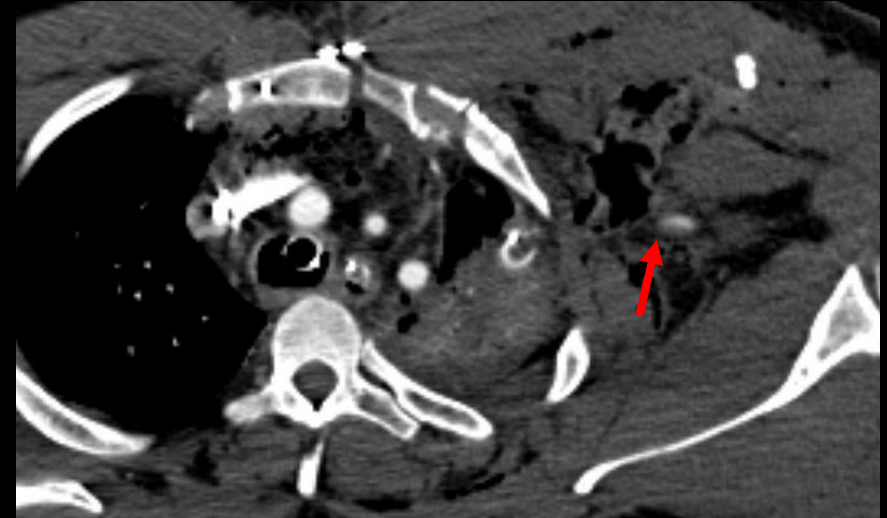


Left Leg

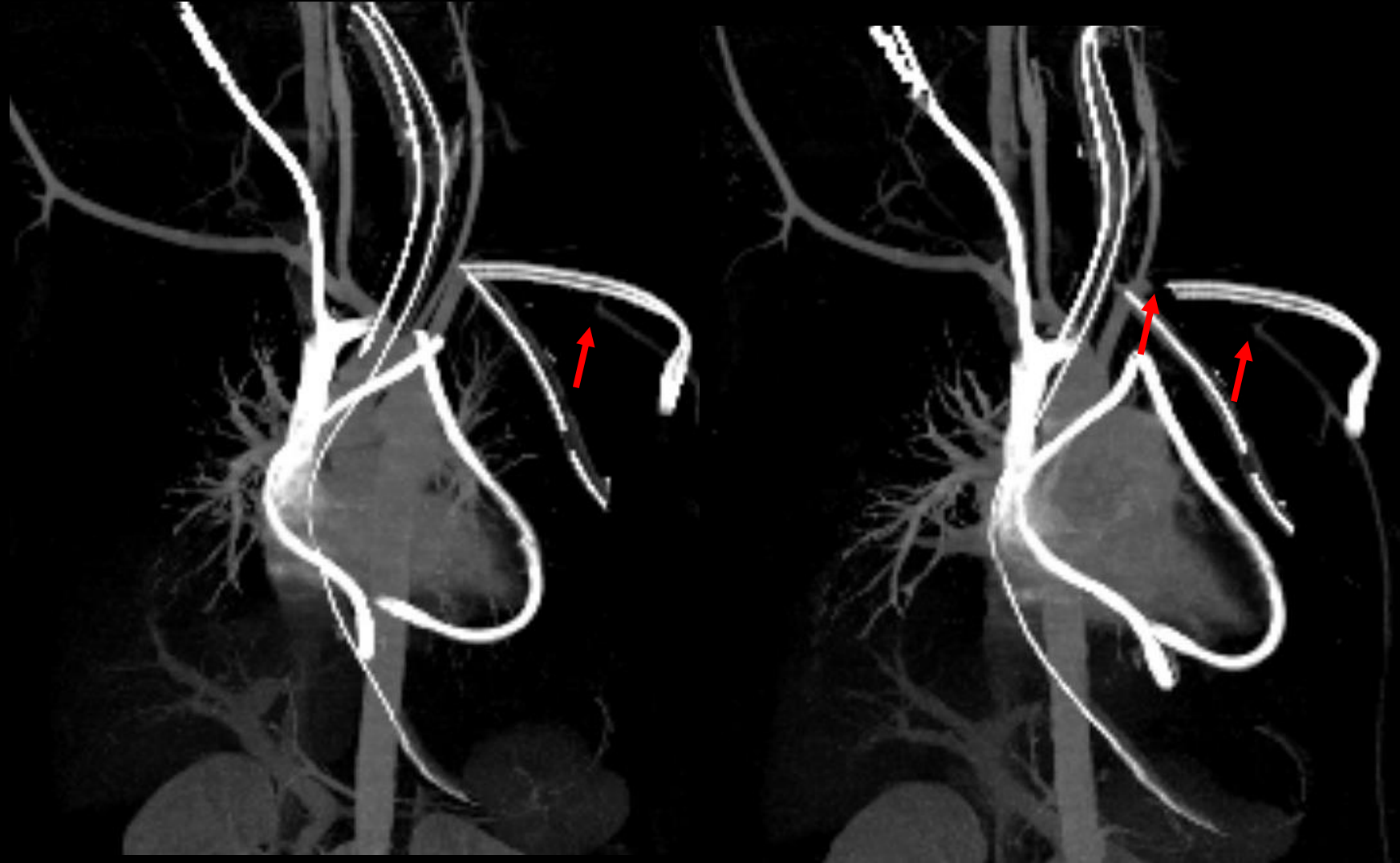


Popliteal Occlusion - Thrombosis

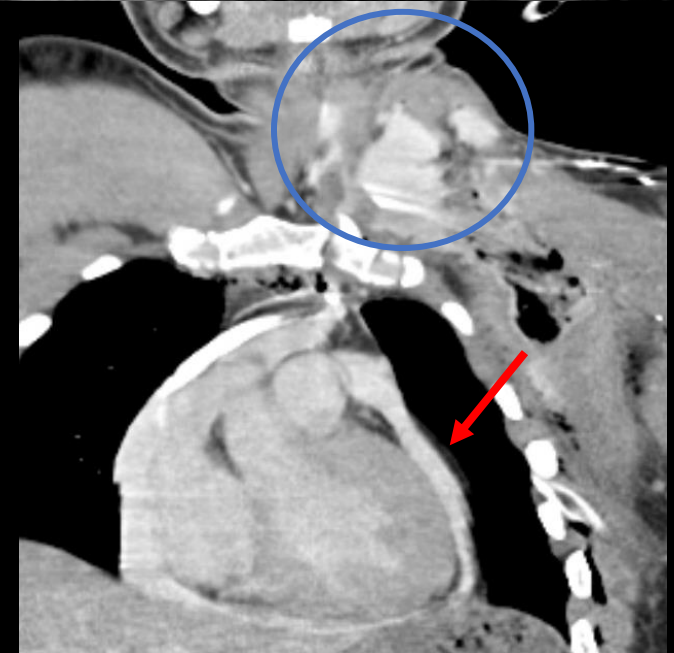
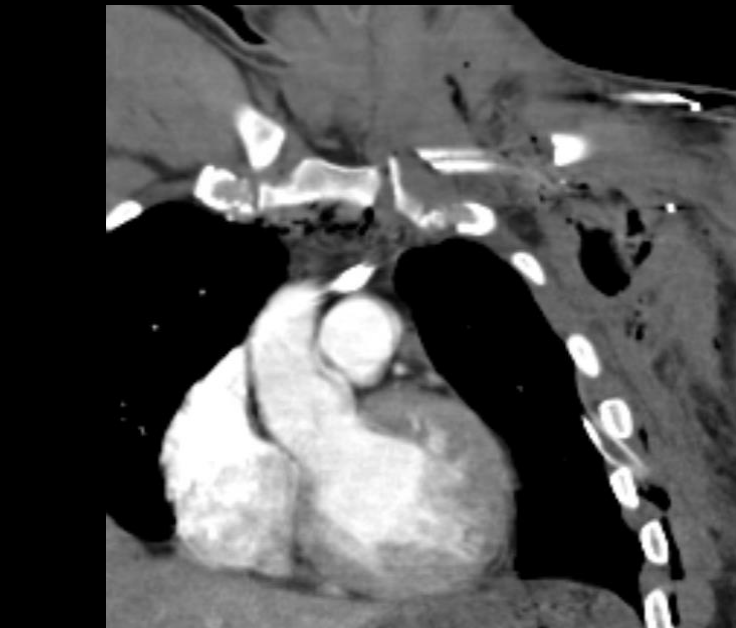
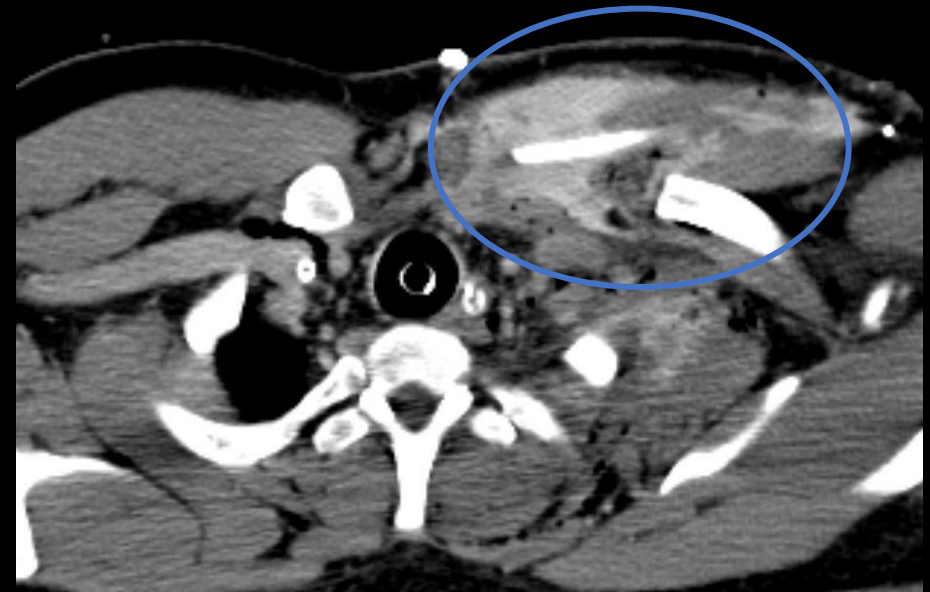
32y/o after multiple GSW, status-post left shoulder exploration for bleeding control.



*32y/o after multiple
GSW, status-post left
shoulder exploration
for bleeding control.*



Transection/occlusion of the L SCA



32y/o after multiple GSW, status-post left shoulder exploration for bleeding control.

Arterial

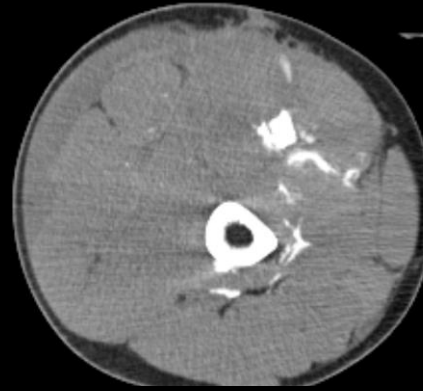
Delay

35 y/o male hit by a car. Multiple extremity fractures. Enlarging right thigh hematoma.

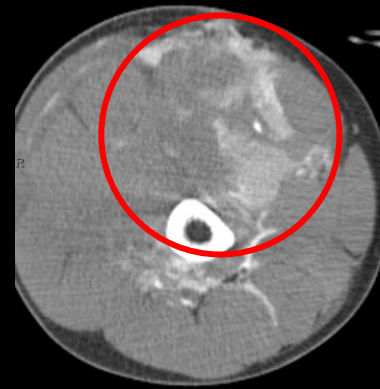




Arterial



Delay

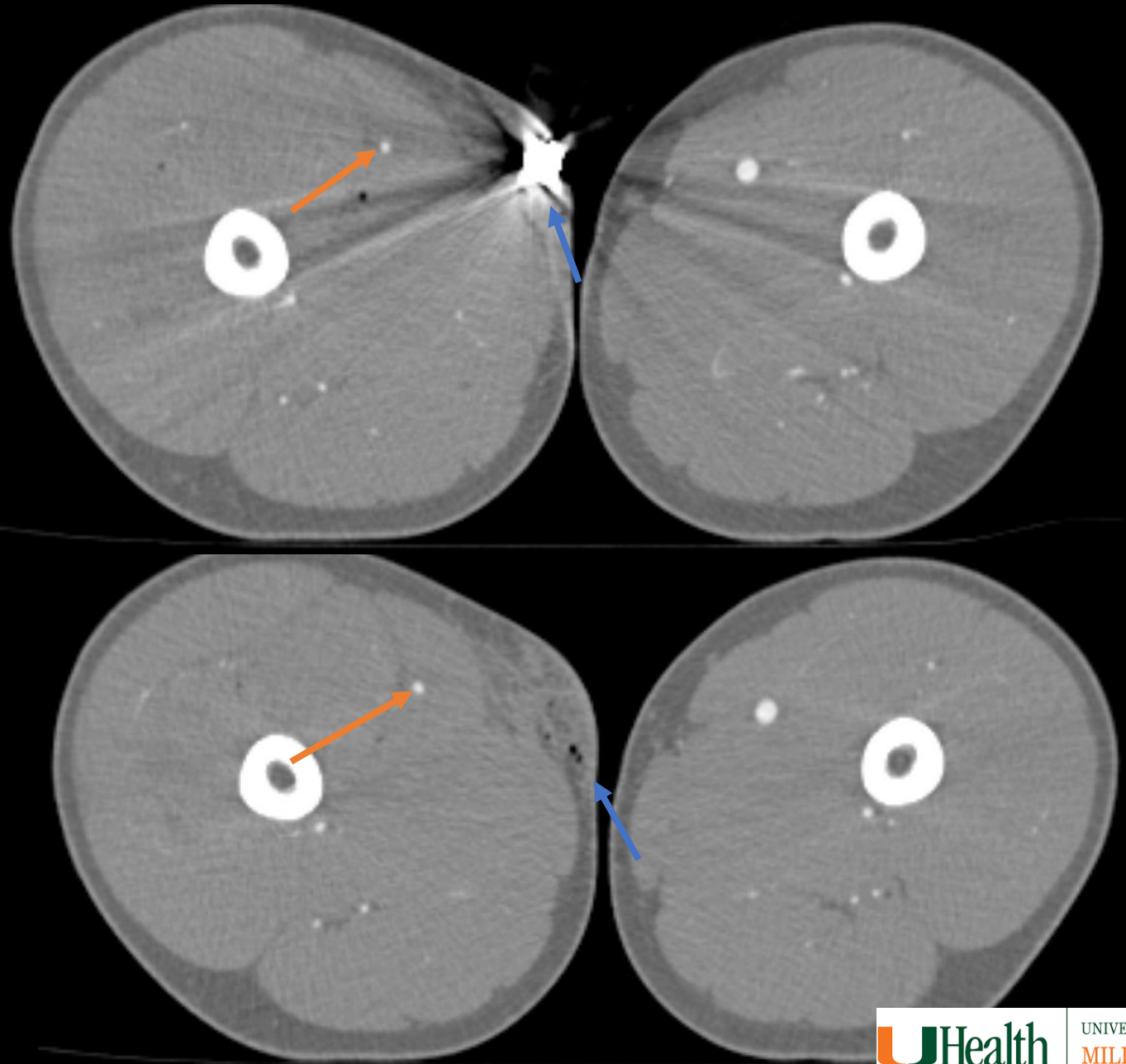


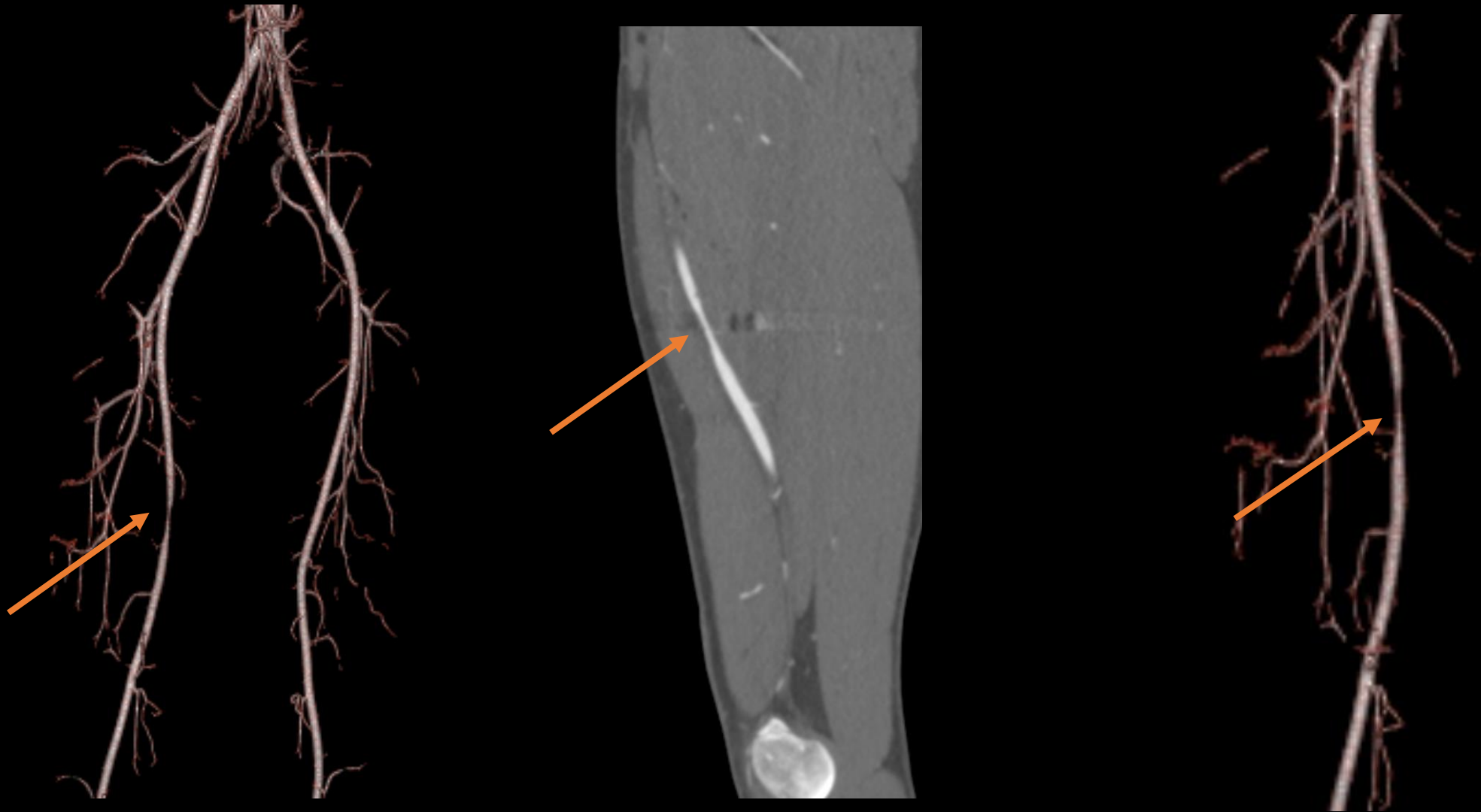
R SFA Transection – Active extravasation



Above the Knee Amputation

*21 year-old male post
GSW to the right thigh.
Decrease pulses to
RLE.*

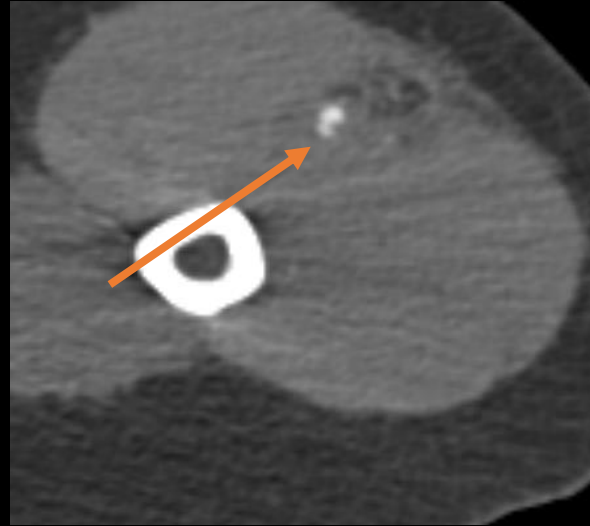




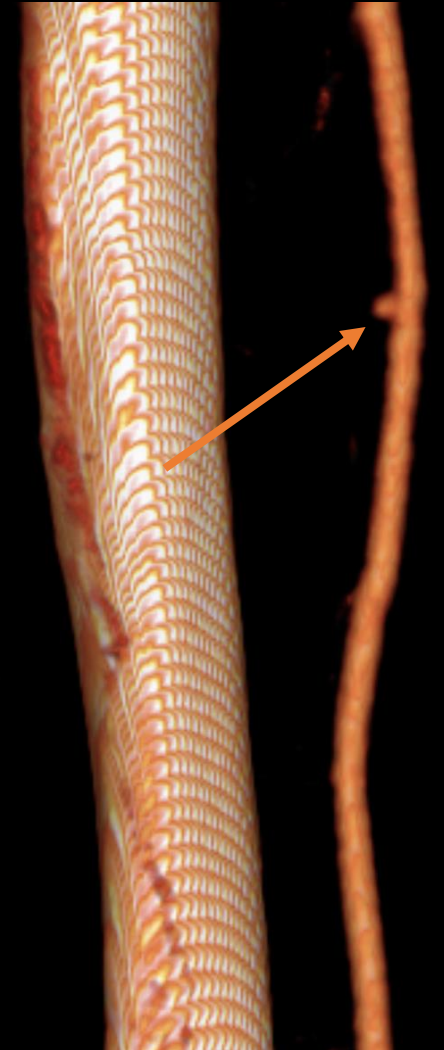
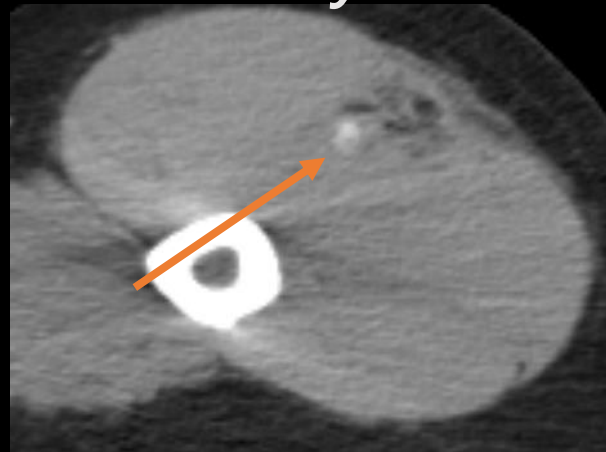
SFA segmental narrowing - Vasospasm

*28 y/o male post stab-
wound to the left arm.*

Arterial

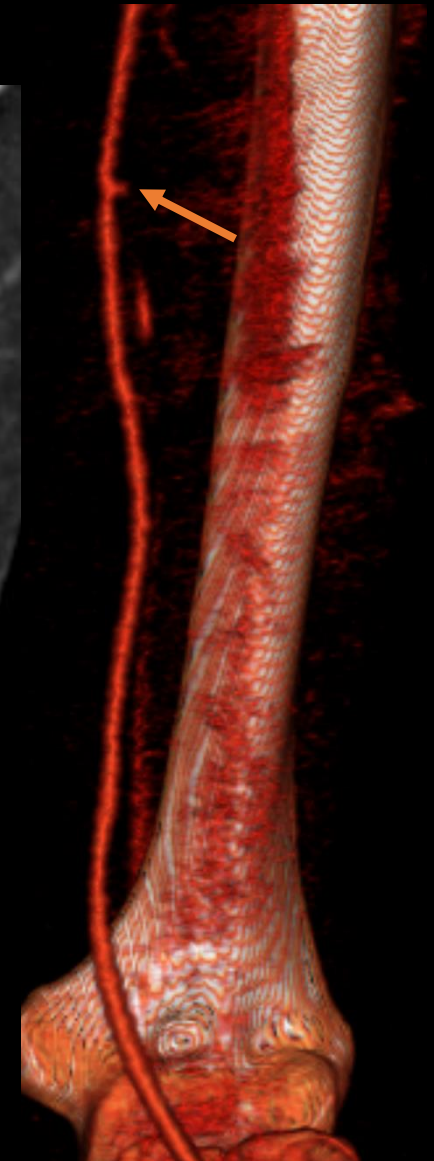
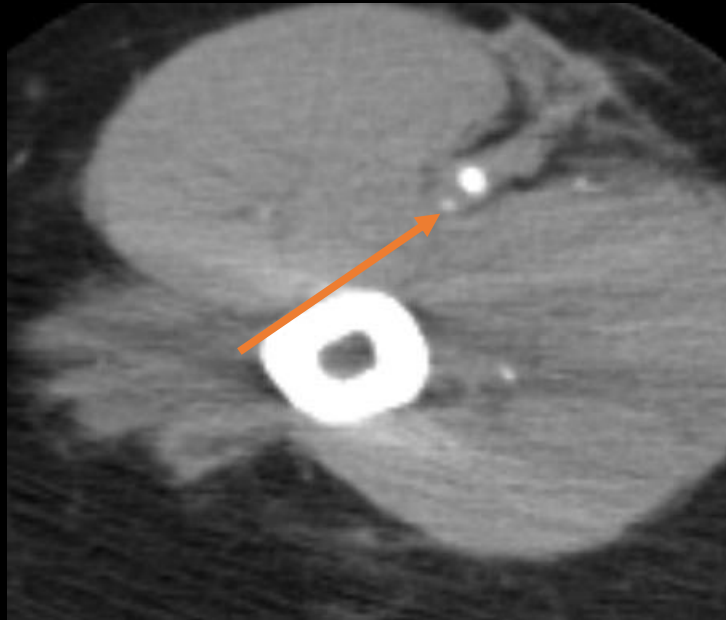


Delay



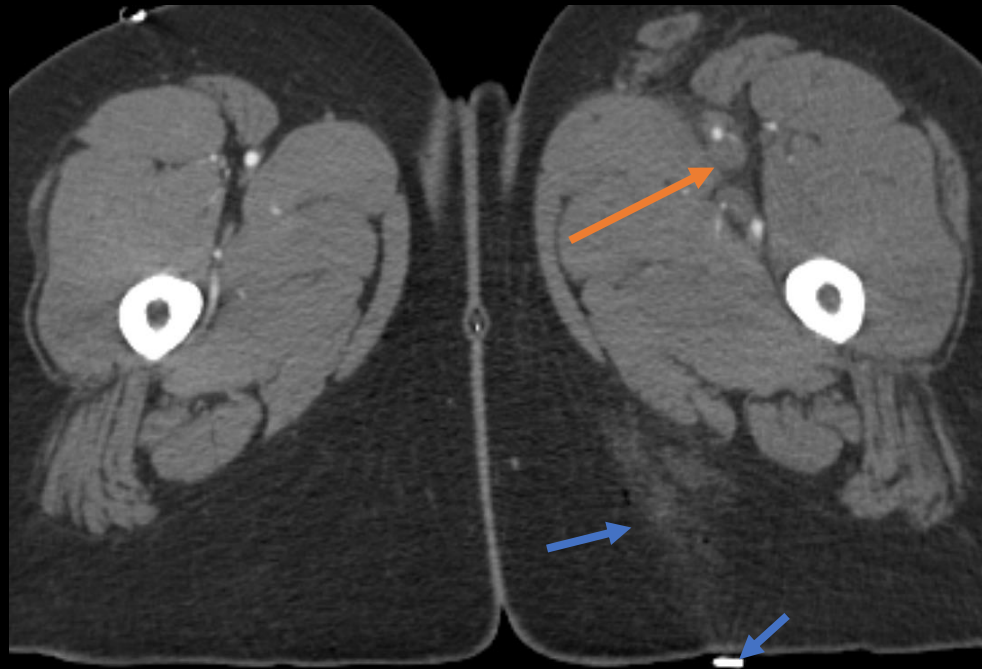
Brachial artery Pseudoaneurysm

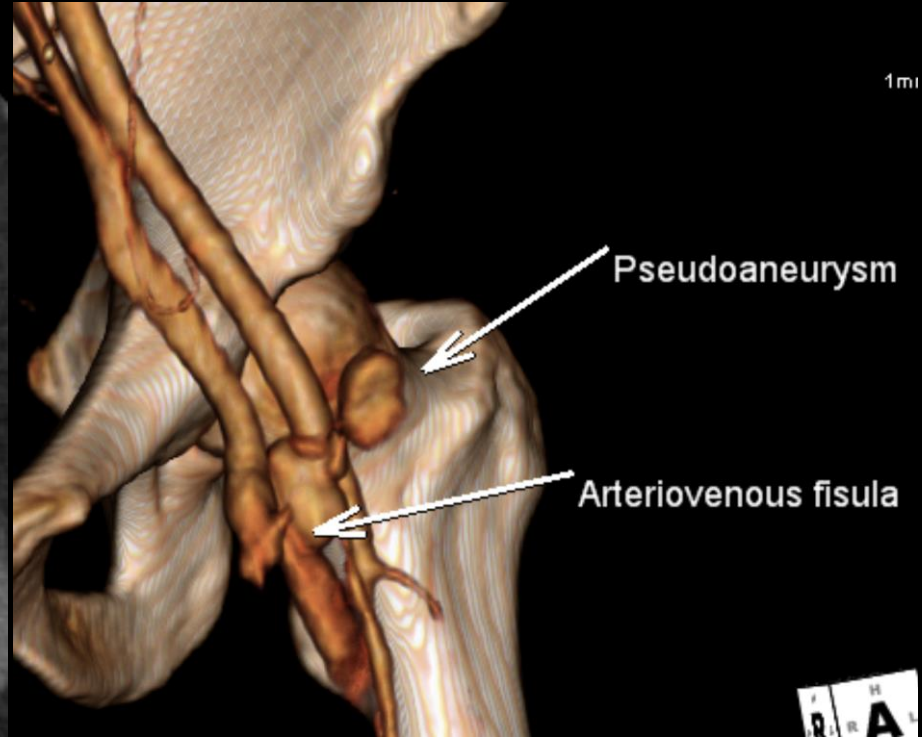
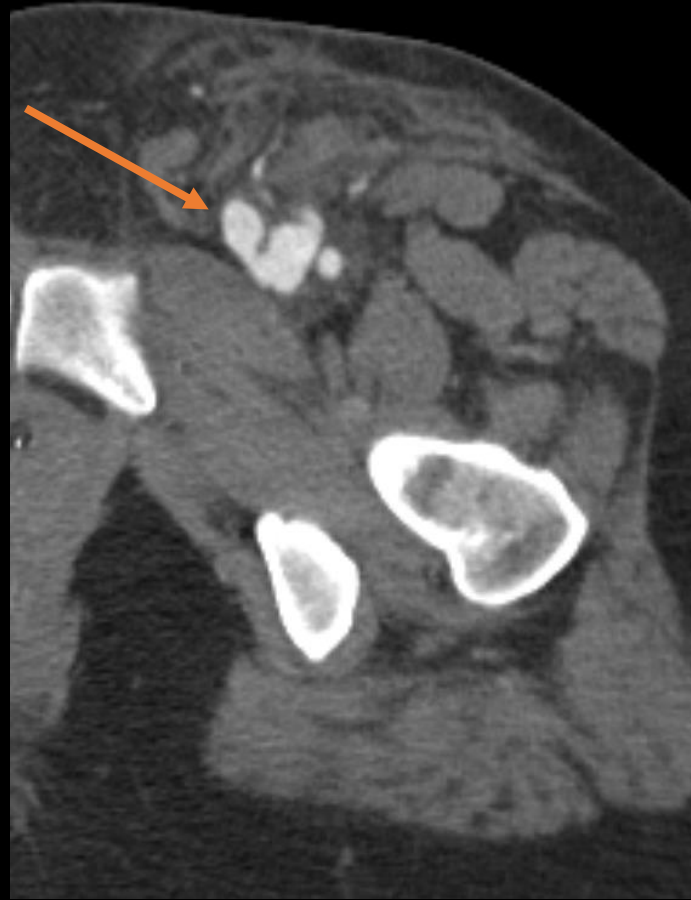
Companion – Stab wound



Brachial artery Pseudoaneurysm

*26 y/o female post
GSW to the left
buttock/upper thigh.*





L Common Femoral AV Fistula and Pseudoaneurysm

*36 y/o male post GSW to RLE.
Small pin-hole wound on the skin of the left calf.*

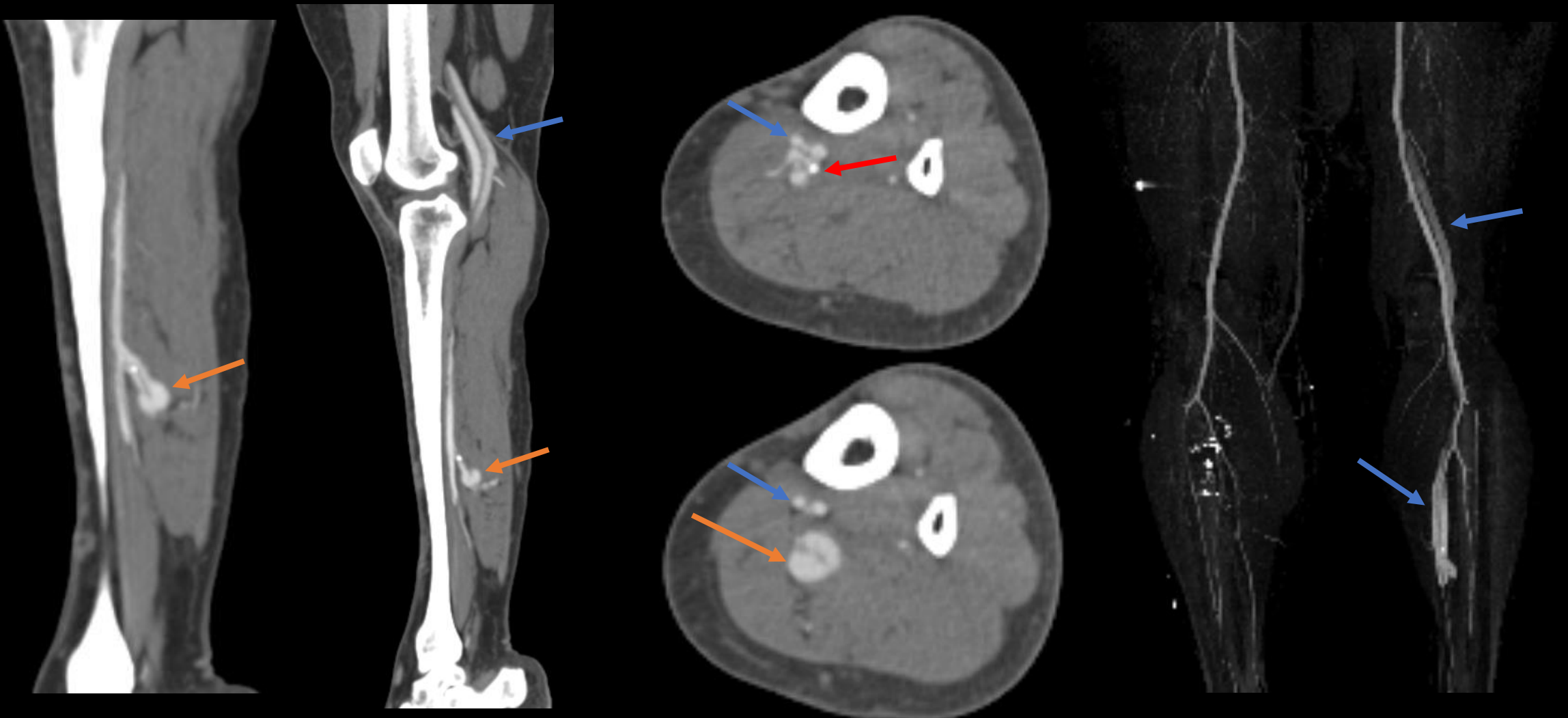


Right



Left



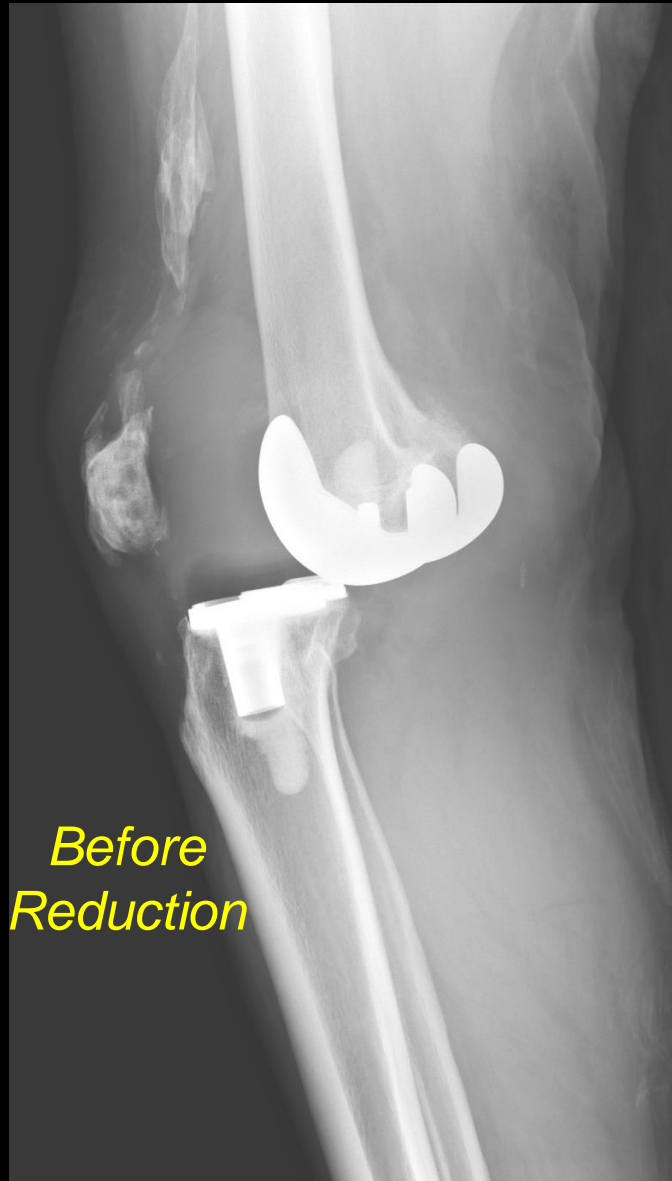


Posterior Tibial AV Fistula and Pseudoaneurysm

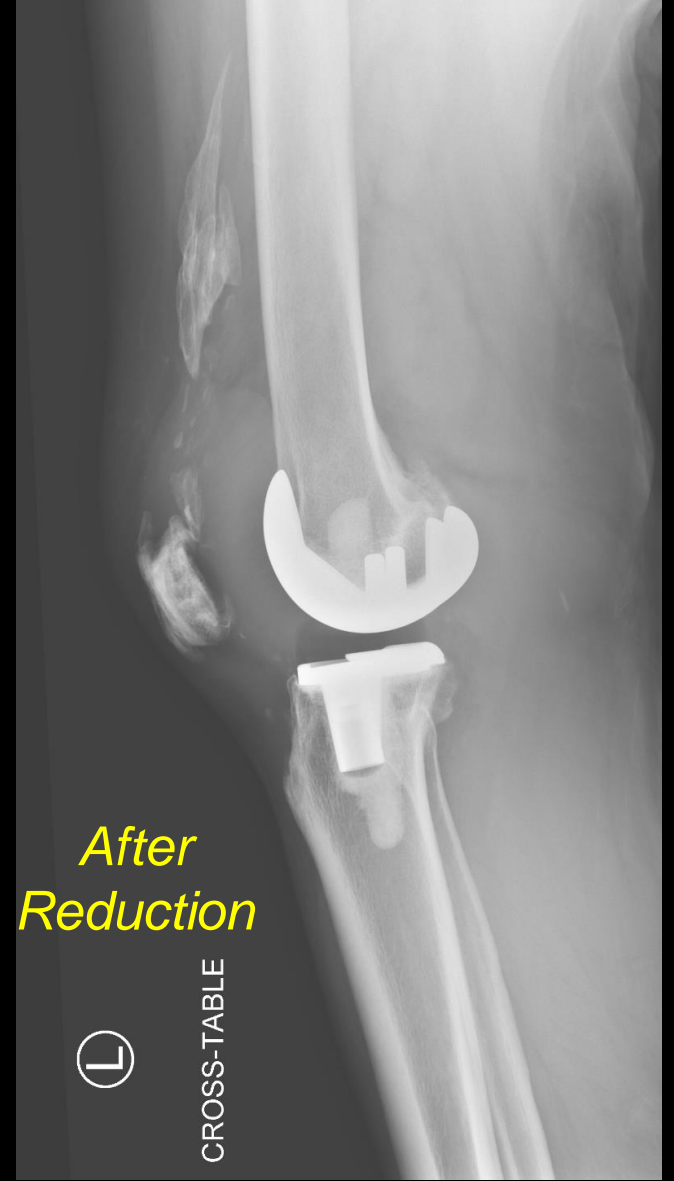
*65 y/o female
post MVC. Knee
dislocation.*



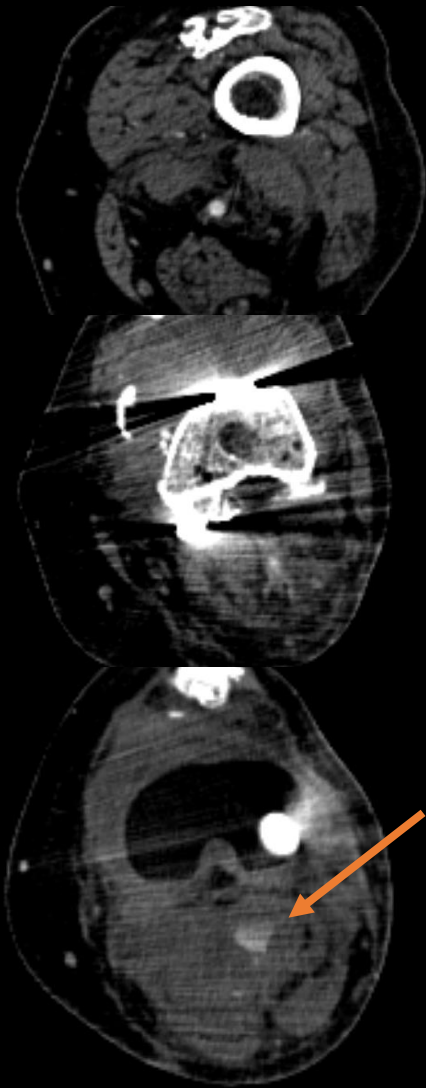
*Before
Reduction*



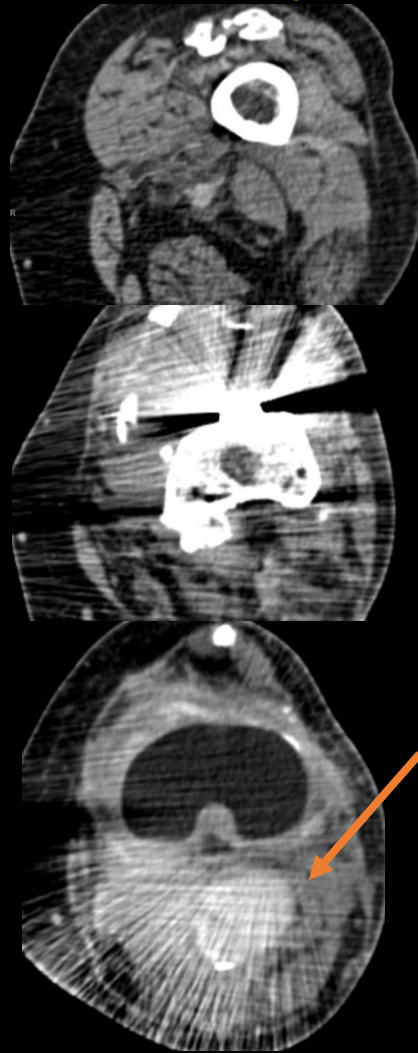
*After
Reduction*



Arterial



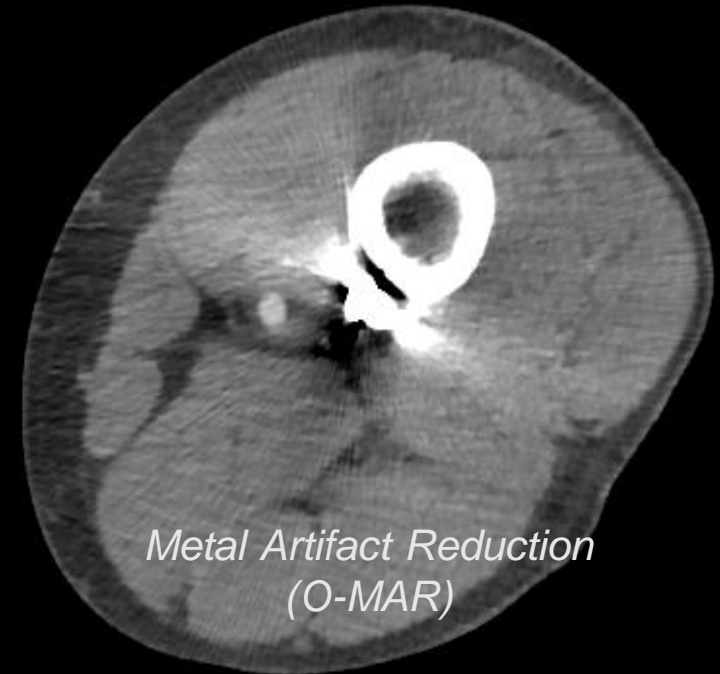
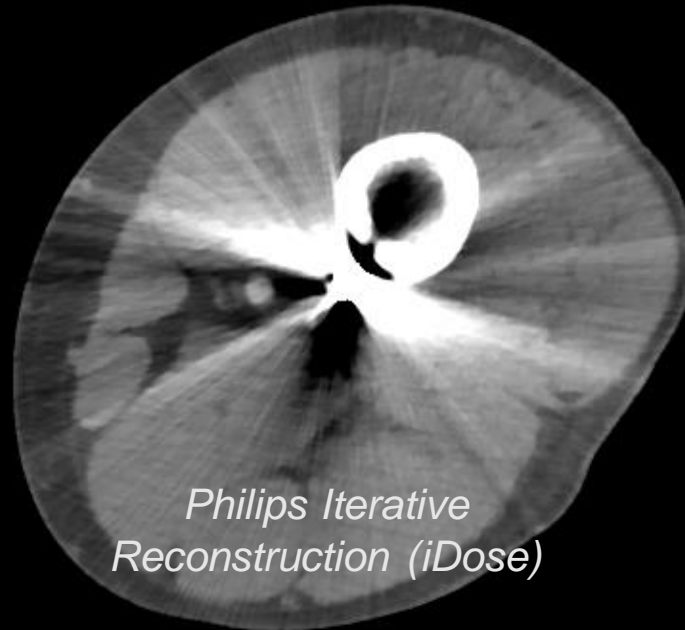
Delay



Popliteal transection and active extravasation

Challenges

- **Streak Artifact** → bullet fragment, prosthetic joints, or orthopedic hardware
- Potential to “create” pseudolesions or hide subtle lesions.
 - Metal Artifact Reduction Algorithms
 - Still diagnostic most of time.

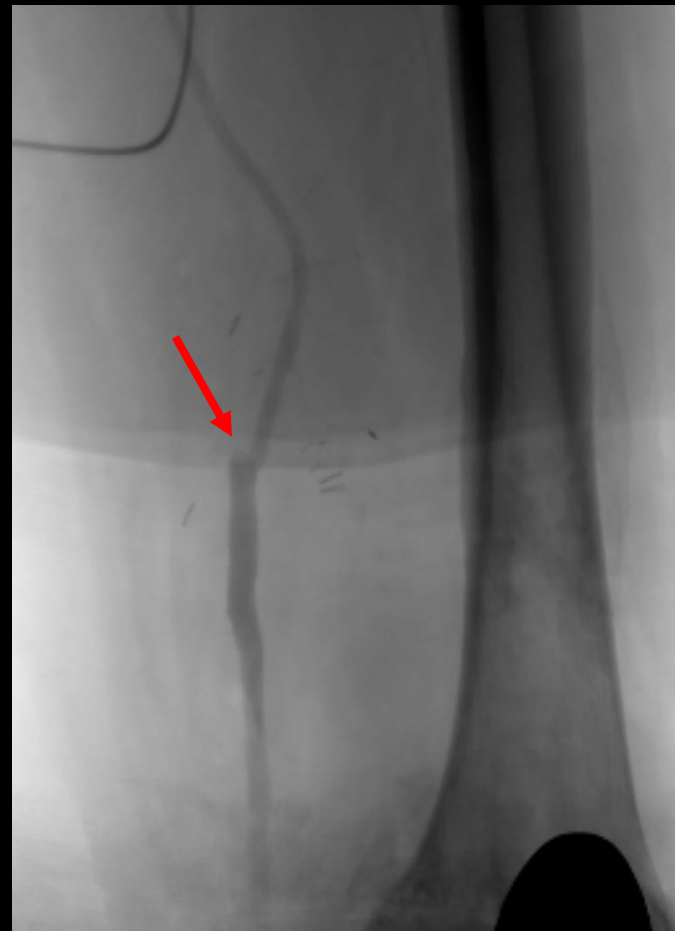


*Courtesy from Dr. Scott Steenburg
Indiana University*

Before

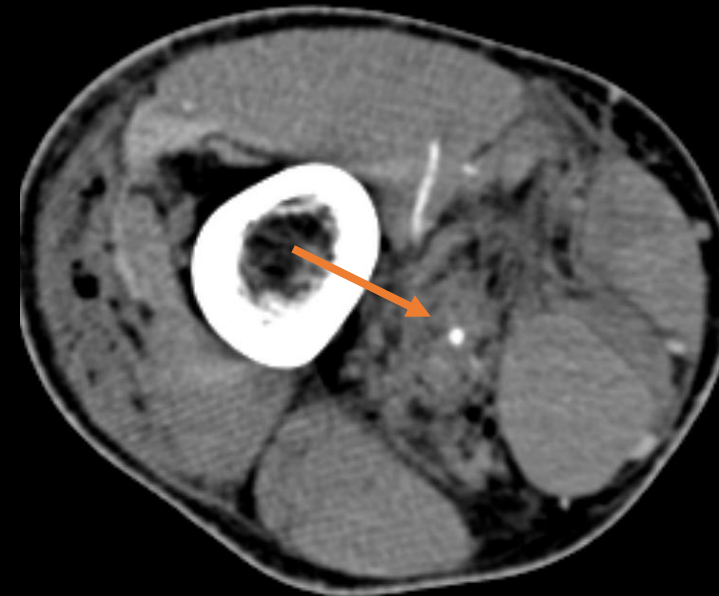
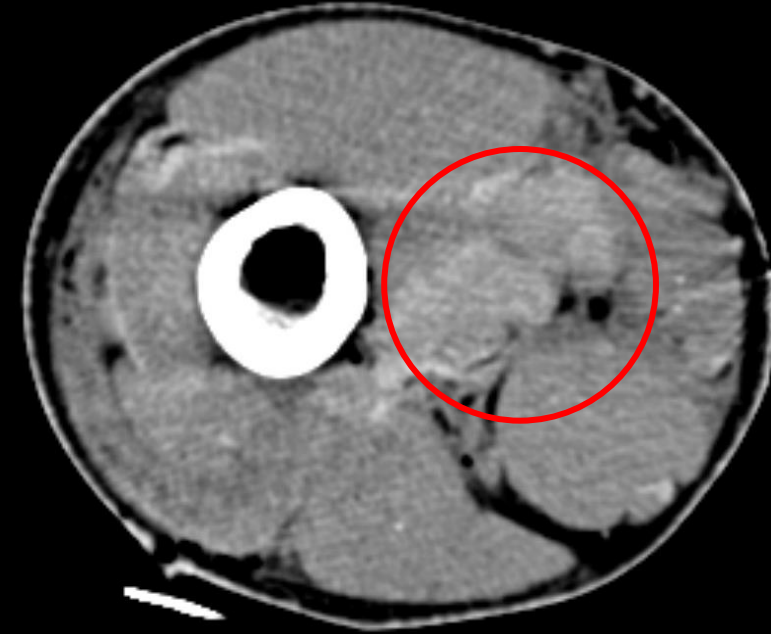
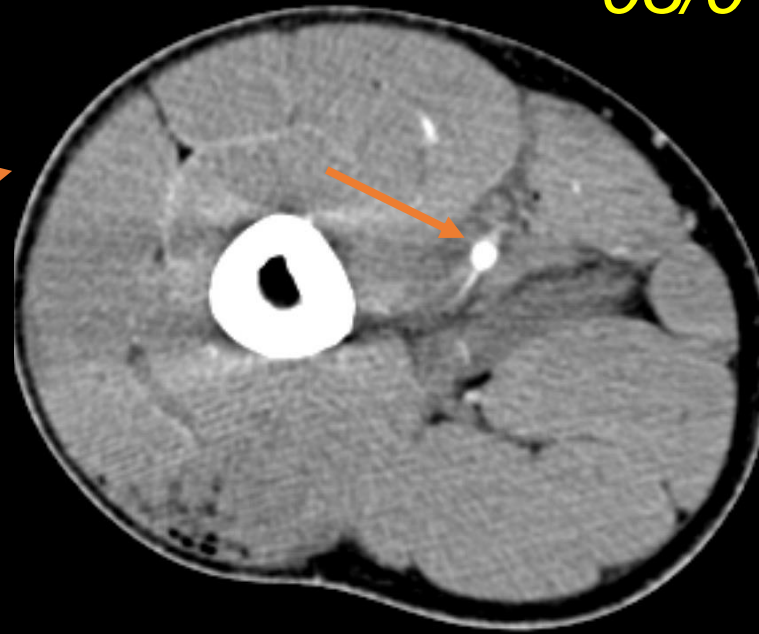
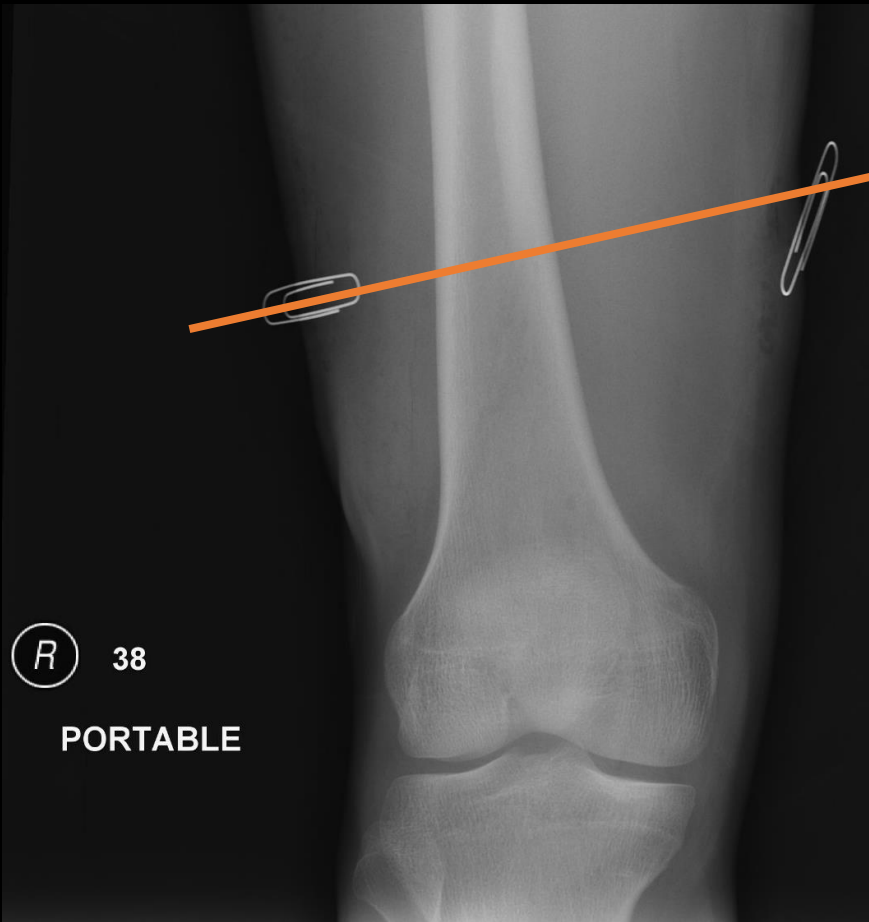


After



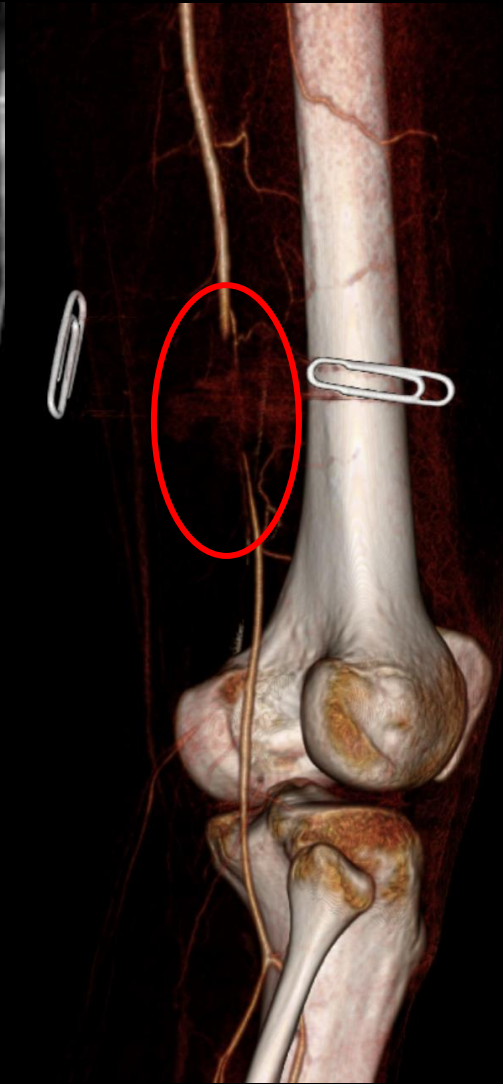
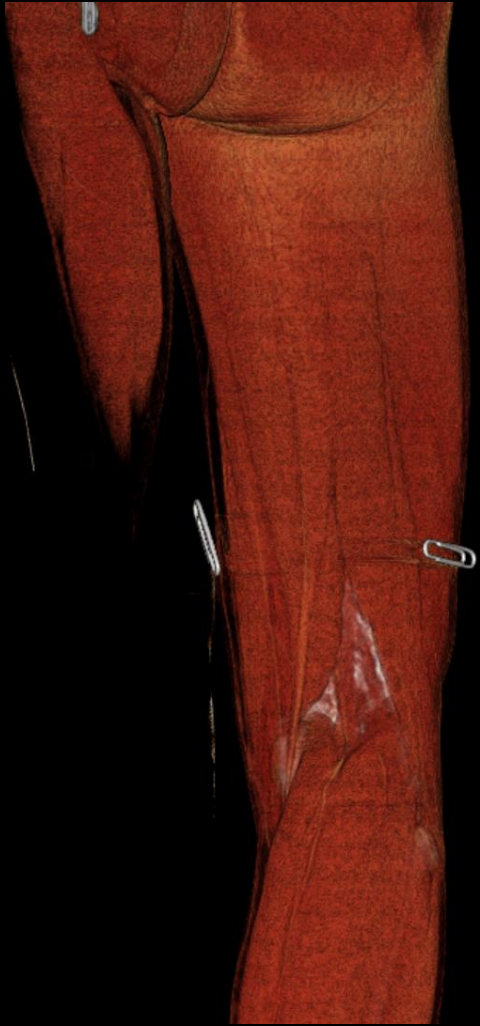
Revascularization – Inverted Saphenous graft

03/04/2018



65 y/o post GSW to R thigh. Enlarging hematoma and decreased RLE pulses

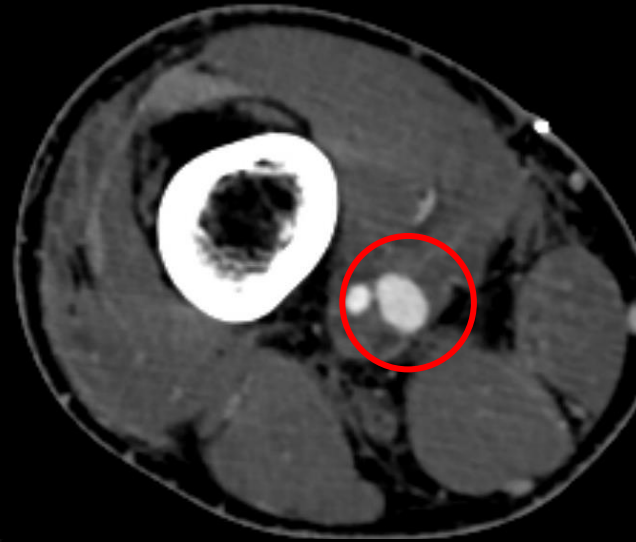
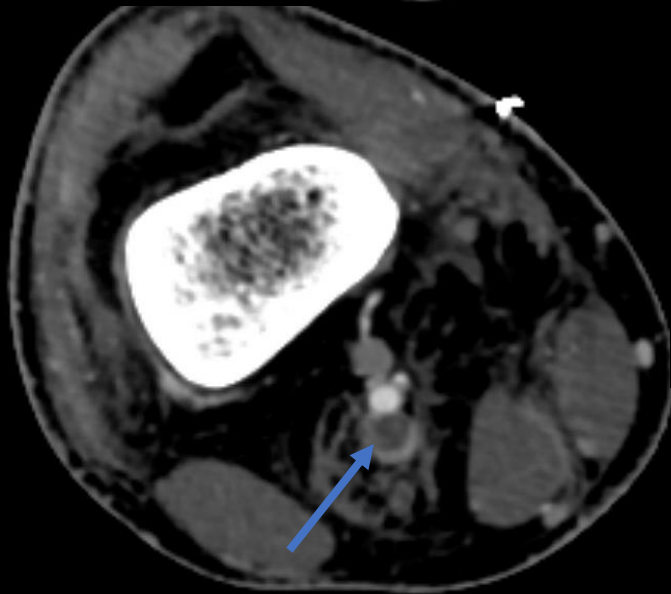
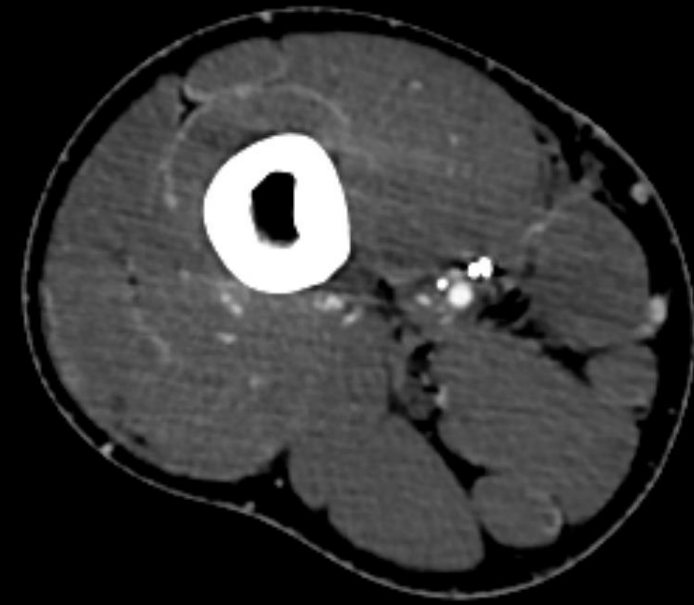
03/04/2018



L SFA transection – treated with open repair

03/13/2018

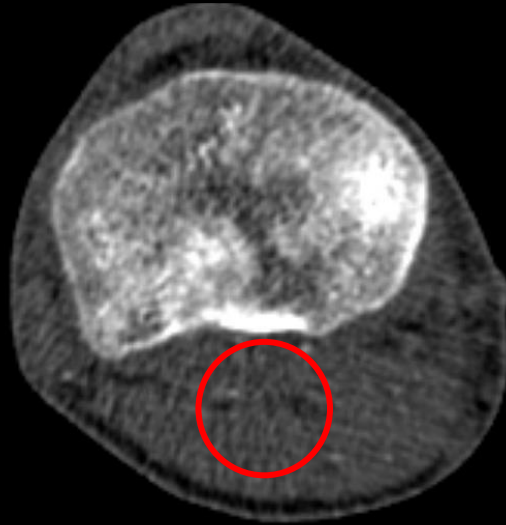
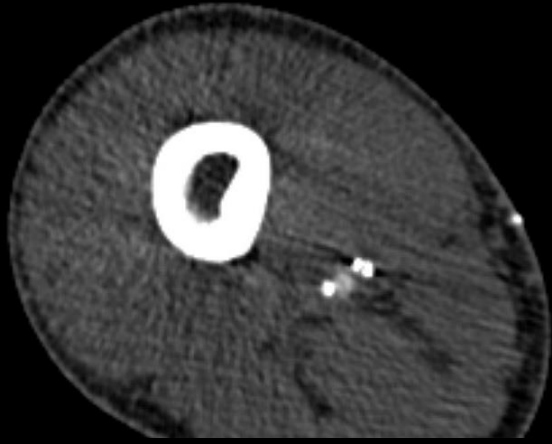
65 y/o POD#9 with pain and swelling at the surgical site.



Complication: Pseudoaneurysm and DVT

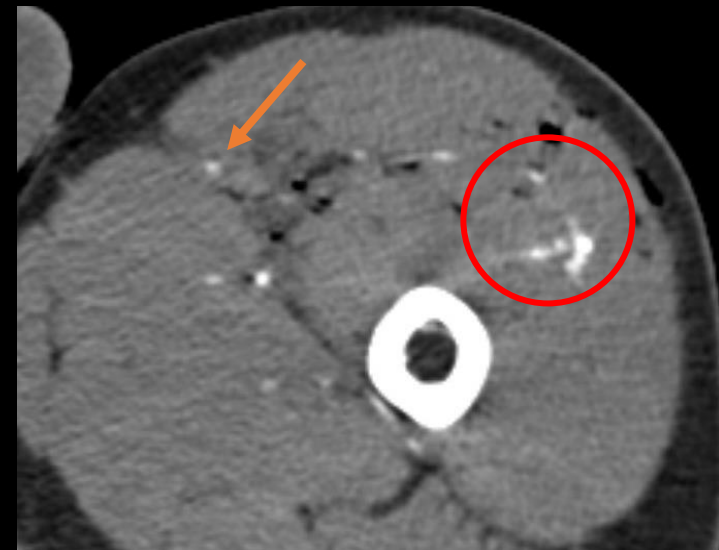
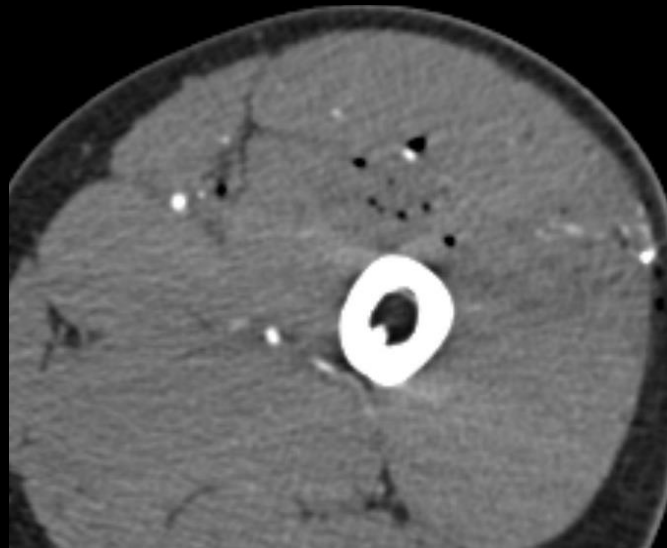
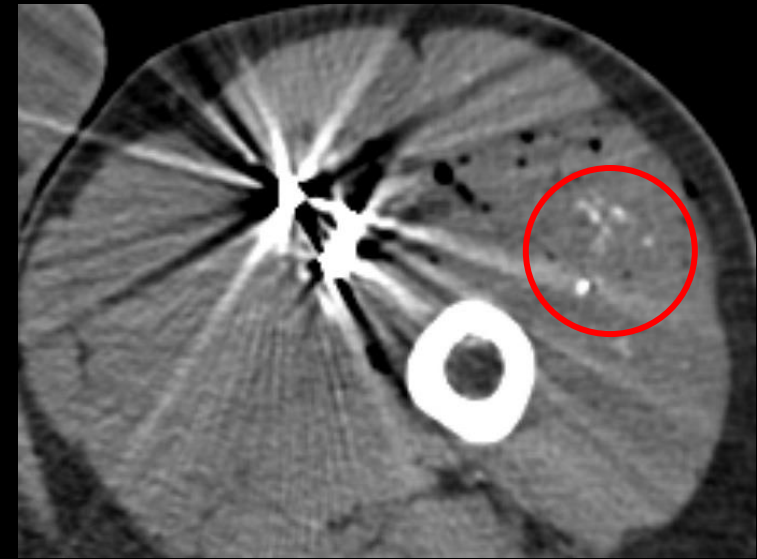
03/18/2018

65 y/o POD#14
with decreased
pulses in the LLE.

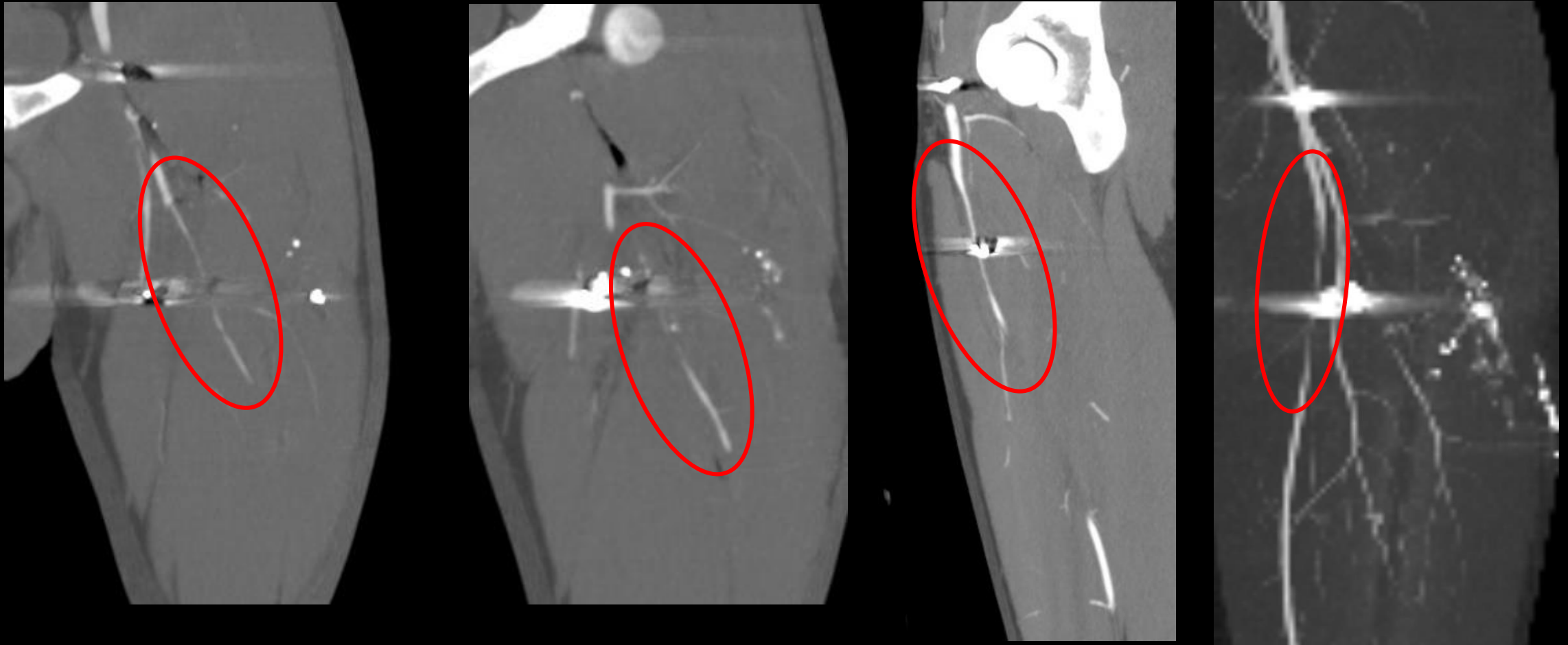


Complication: Popliteal occlusion

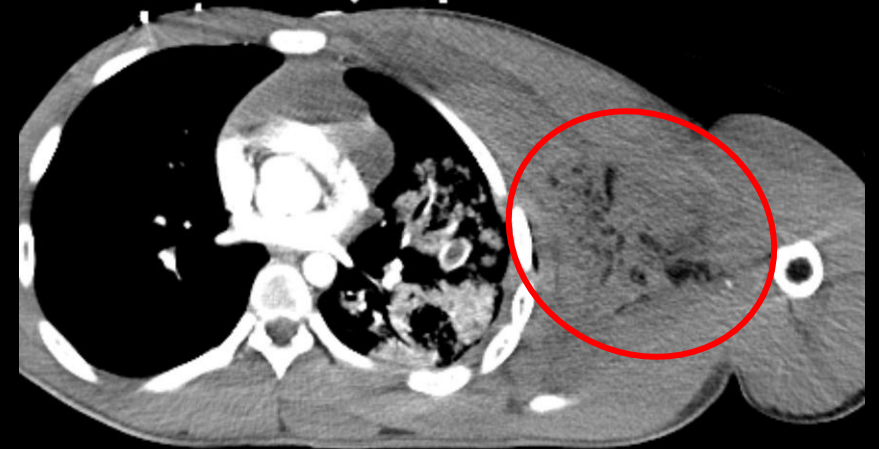
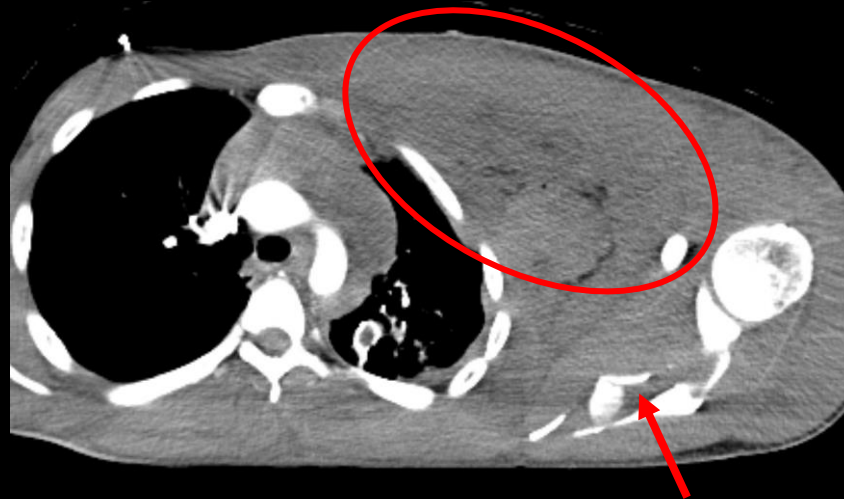
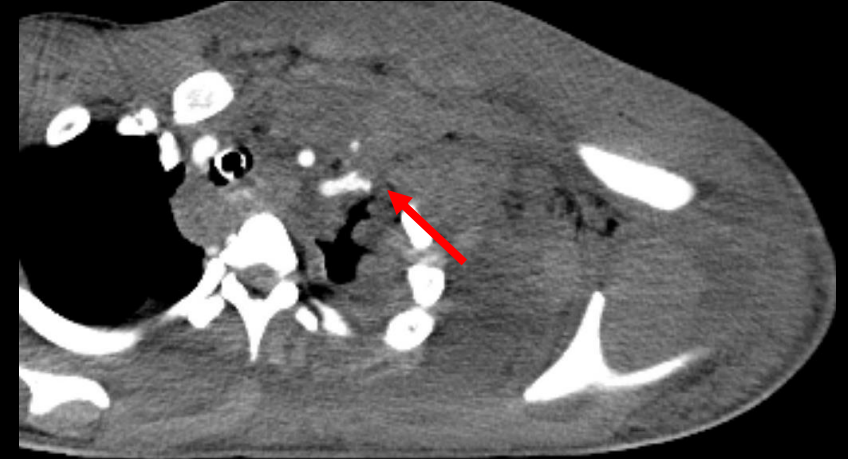
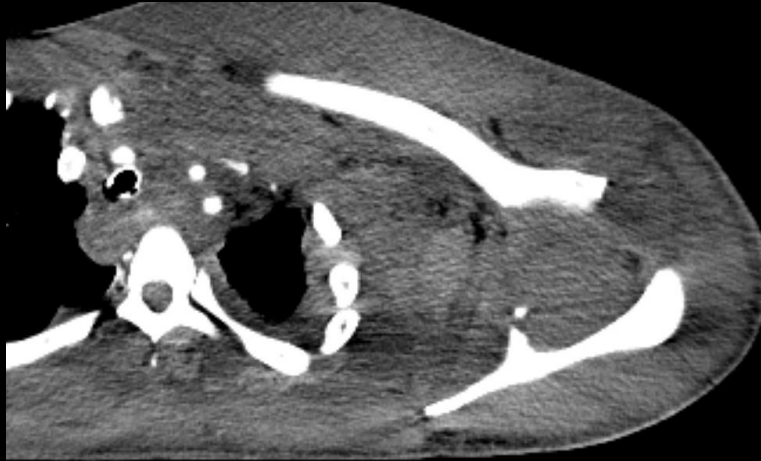
40 y/o GSW to L hip
and decreased LLE
pulses.



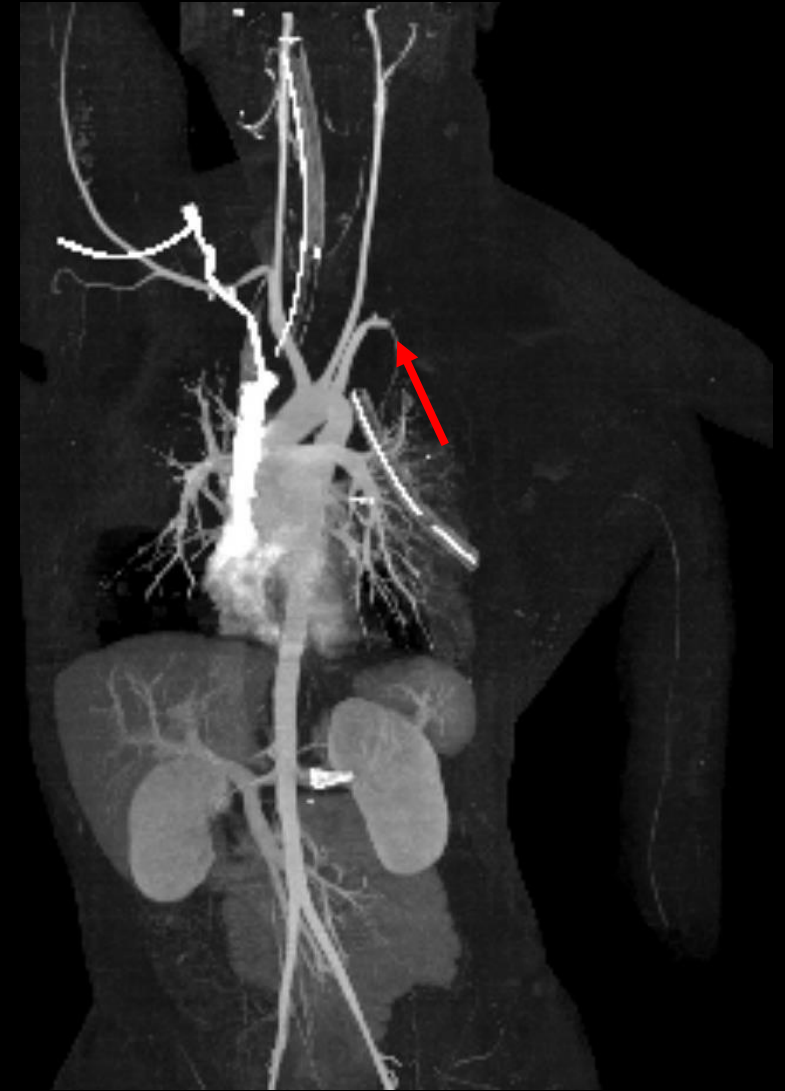
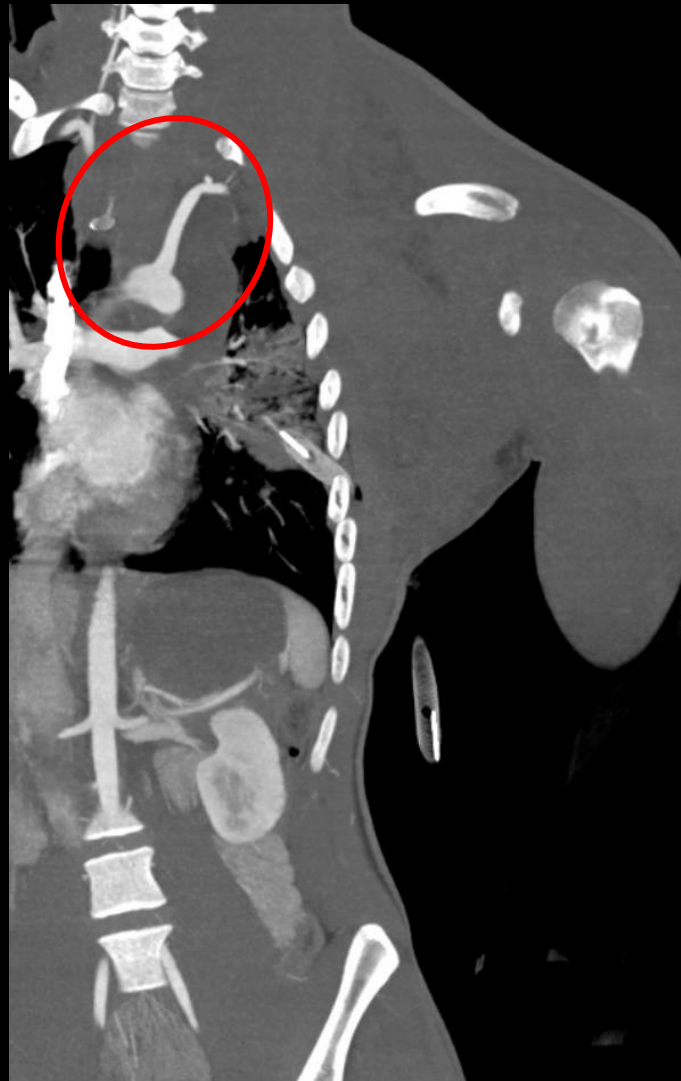
40 y/o GSW to L hip and decreased LLE pulses.



L SFA narrowing – spams and/or dissection



20 y/o after motorcycle accident, with left shoulder hematoma, deformity of the LUE, and rapidly declining



Scapulothoracic dissociation

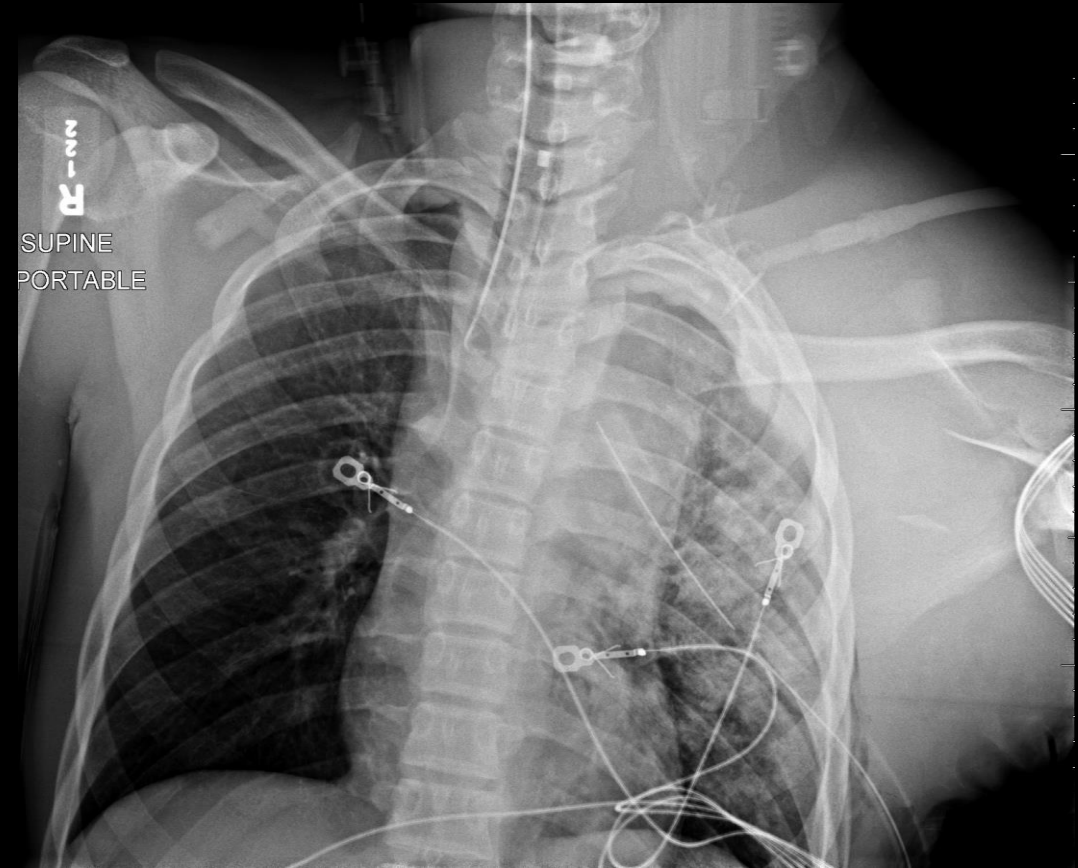
Spectrum of MSK, vascular and neurological abnormalities:

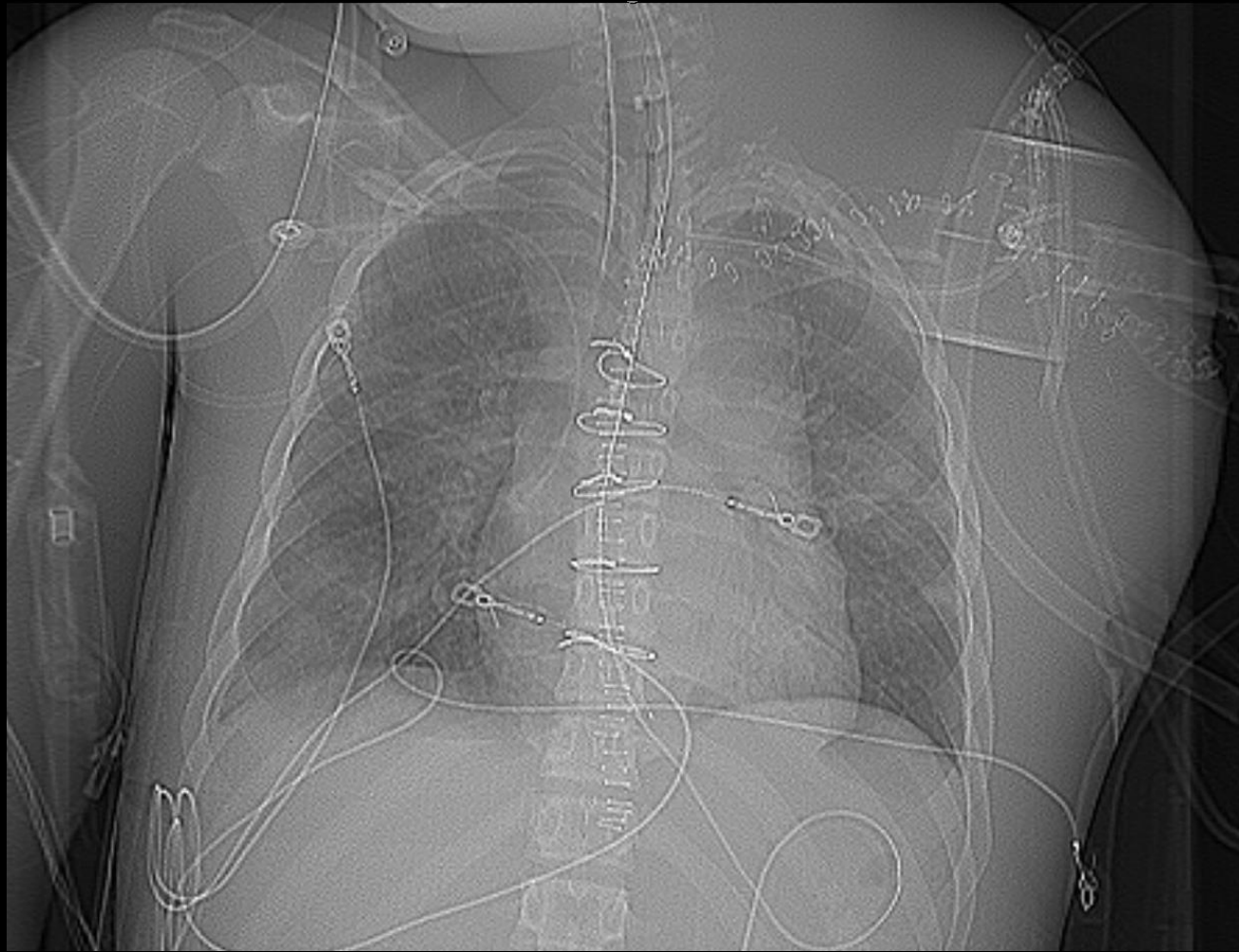
- Lateral displacement of the scapula
- Ipsilateral distracted clavicular fracture
- Acromioclavicular joint separation
- Sternoclavicular joint injury

Associations: Subclavian or axillary vascular injury and brachial plexus injury.

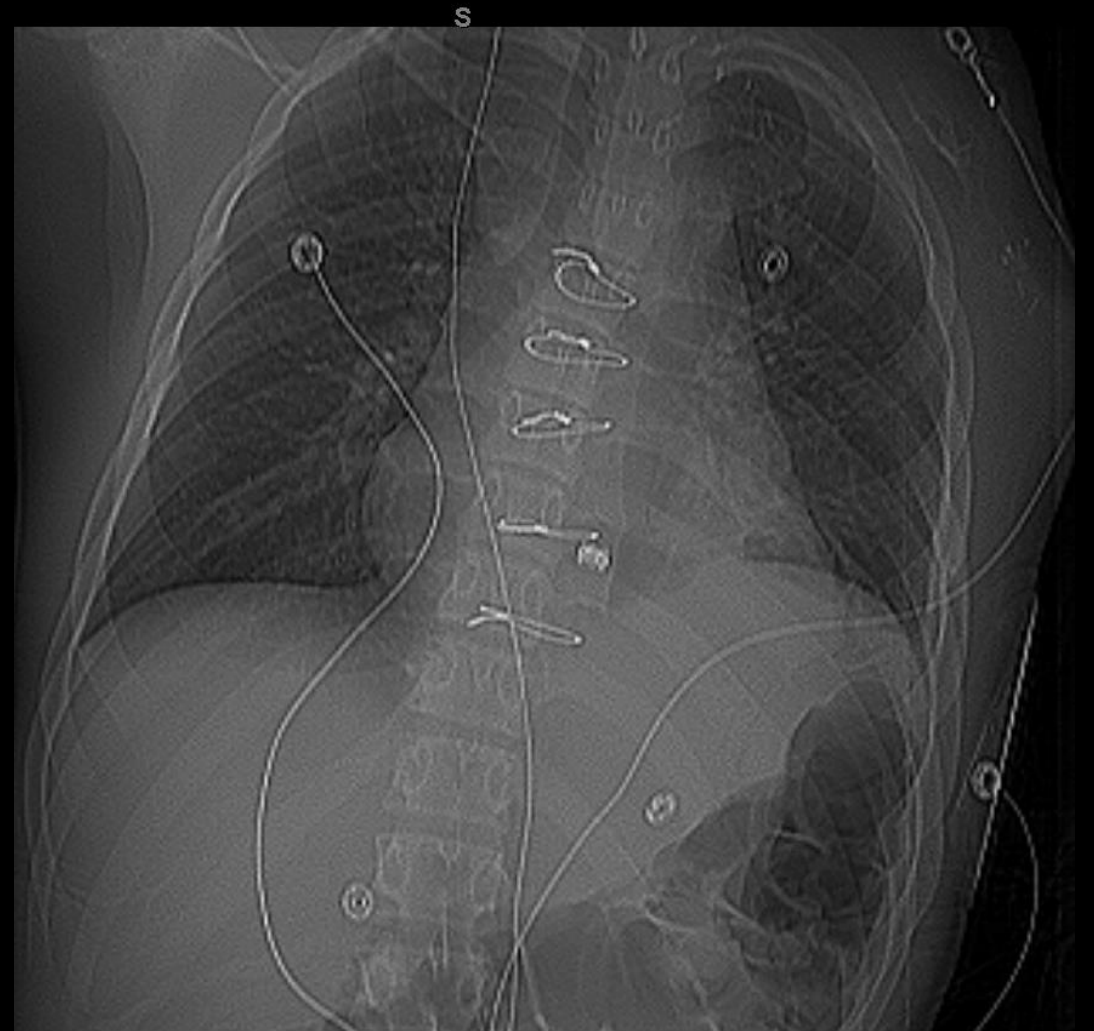
Mechanism: Massive blunt force affecting the shoulder girdle and upper extremity: MVC, falls, and industrial machine accident

High mortality rate of approximately 11%





10/2021



11/2022

Take Home Points

- Peripheral vascular trauma can lead to serious complications including exsanguination, limb ischemia and amputation. Prompt diagnosis and repair of arterial injuries is key to improve outcomes.
- CT is the most valuable imaging tool for the timely detection and characterization of clinically significant vascular injuries of the extremities.
- Knowledge of the vascular anatomy, imaging findings, trauma mechanism and trajectory are key for accurate vascular injury diagnosis.

Thank You!

