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#### **Educational objectives**

- Describe the mechanisms and management of traumatic vascular injury.
- Apply clinical reasoning to modify testing procedures and support diagnostic accuracy.
- Explain the role of the sonographer and Doppler ultrasound in diagnosing and managing traumatic vascular injuries.

Disclosure: I have no actual or potential conflict of interest in relation to this presentation

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#### Presentation overview

- Trauma overview
- Toe-to-head body parts
- Case-based ultrasound

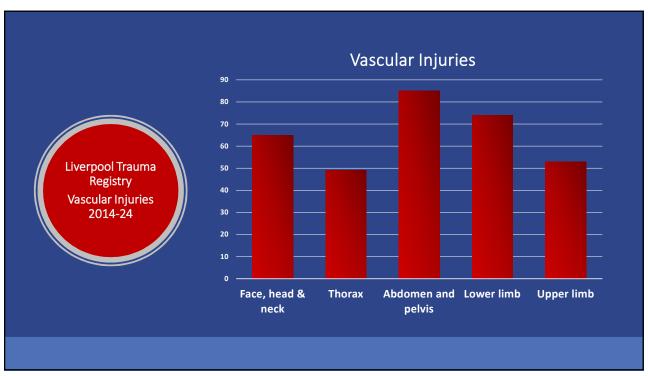
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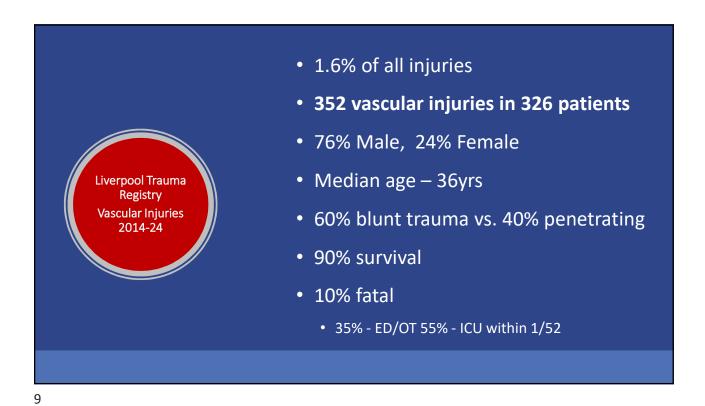
#### Trauma Epidemiology

- Young males at highest risk
- Most patients between 25 44yrs avg age of 34
- 20% between 15 and 24yrs
- 80% of all injuries sustained by people younger than 45yrs
- Penetrating mechanisms dominate
- Leading causes of injury are MVA, firearms, knives, falls

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Trauma - Military

1861-65

75% of all surgical procedures were amputations

1939-45
Advent of Mobile
Medical Units
Reduction in
fatalities compared
to previous wars
50% of vascular
injuries resulted in

Vietnam War 1959-75 CASEVAC advances reduced ischaemic time Vascular focus Vietnam Vascular Registry Battlefield tourniquets
Forward deployment of surgical
capabilities
GWOT Vascular Initiative
12% of battle related injuries
vascular

68% of injuries - penetrating

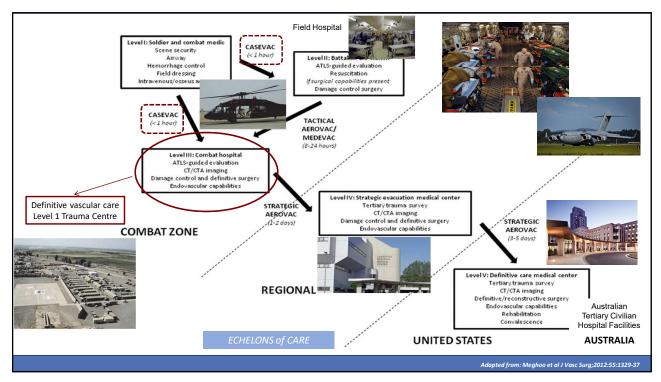
GWOT 2001 -

Post Vietna Developmer civilian trau

1914-18
First conflict where mortality from battle injuries exceeds deaths from disease

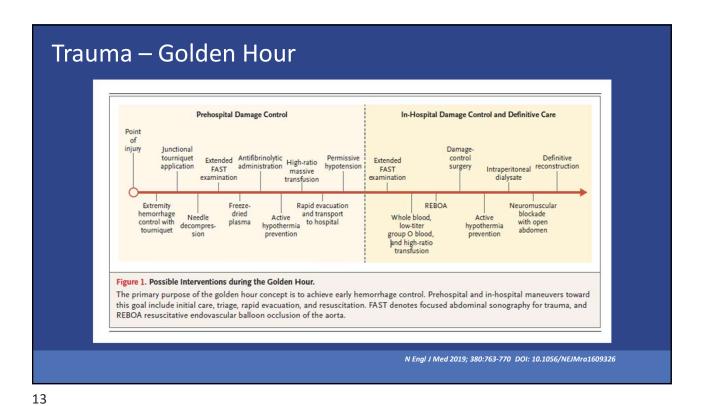
wwi

Korean War 1950-53 Arterial repair introduced Helicopters CASEVAC & MAS Amputation rate



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Mechanisms of Injury

#### Blunt trauma

- No open wound
  - · Local compression or rapid deceleration
  - Compression / shearing injuries
  - MVAs major cause
  - Fractures near joints
  - Dislocations

Forces behind abdominal injury
Blunt trauma, a force to the abdomen that doesn't leave an open wound, commonly occurs with motor vehicle crashes or falls. Compression and shearing are examples.

Compression is the result of a direct blow, such as being thrust against a steering wheel or seat, or with pressure from a seat beh.

Shearing is common during rapid deceleration in a motor vehicle crash as a portion of tissue continues to move forward while another portion remains stationary. Here, the liver has torn away from the portal vein.

Blank-Reid, Nursing2004;34:36-41

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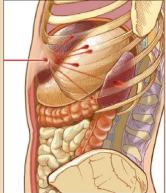
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#### Mechanisms of Injury

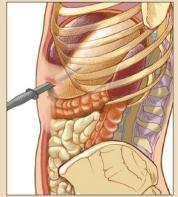
#### Penetrating trauma

- Open wound
  - Laceration
  - Gunshot wounds
  - Stabbing

Penetrating trauma causes an open wound, such as from a gunshot or stabbing. The *solid* organs—diaphragm, spleen, liver, pancreas, and kidneys—can bleed profusely when injured. The *hollow* organs—stomach, gallbladder, duodenum, large intestine, small intestine, and bladder—generally don't bleed significantly but are more likely to cause peritonitis if damaged.



A gunshot can damage multiple organs because of high bullet velocity or fragmenting. The patient needs surgery to repair the injured tissues and remove bullet fragments.



**A stab wound** is typically more localized and may be less damaging.

Blank-Reid, Nursing2004;34:36-41

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#### Mechanisms of Injury

#### Penetrating trauma

- latrogenic injury
  - Majority of penetrating vascular trauma



https://www.hmpgloballearningnetwork.com/site/cathlab/articles/back-basics-femoral-artery-access-hemostasis

# Mechanisms of Injury

#### **Gunshot** injuries

- Handguns, rifles and shotguns
- Degree of damage depends on number of factors, including;
  - Weapon and projectile type
  - Distance between weapon and victim
  - Tissue type and local anatomy

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#### Mechanisms of Injury

#### **Gunshot** injuries

• Handguns, rifles - single projectile

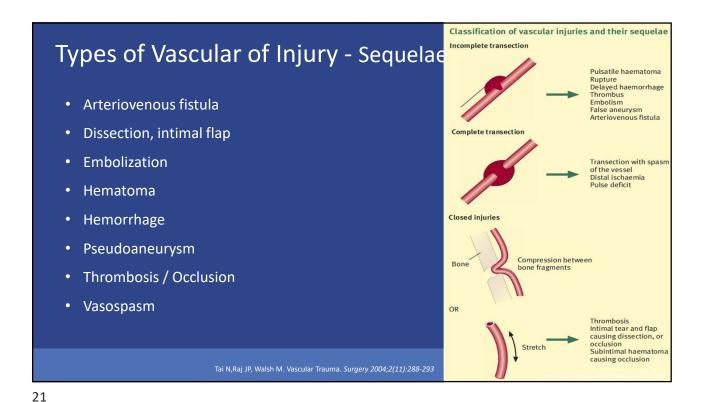




Classification of vascular injuries and their sequelae Types of Vascular of Injury Pulsatile haematoma Rupture Delayed haemorrhage Thrombus Embolism False aneurysm Arteriovenous fistula Laceration • Simple laceration Transection with spa of the vessel Distal ischaemia Pulse deficit • Partial or complete transection Stretch injury Compression between bone fragments • Disruption of one or more vessel layers • Flap / dissection Thrombosis Intimal tear and flap causing dissection, or Subintimal haemato

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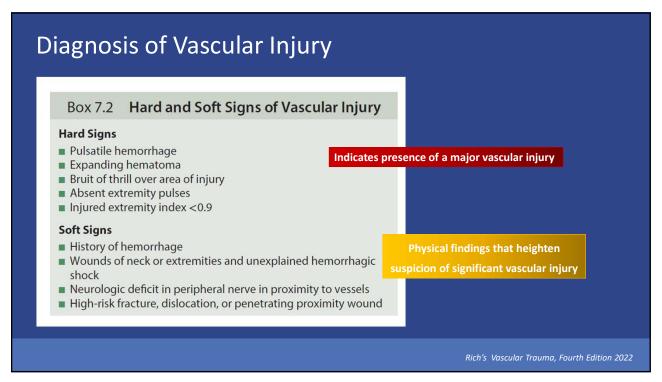
Arterial Dissection — Vessel Wall Integrity

Sub-Intimal Lumen compromise Emboli

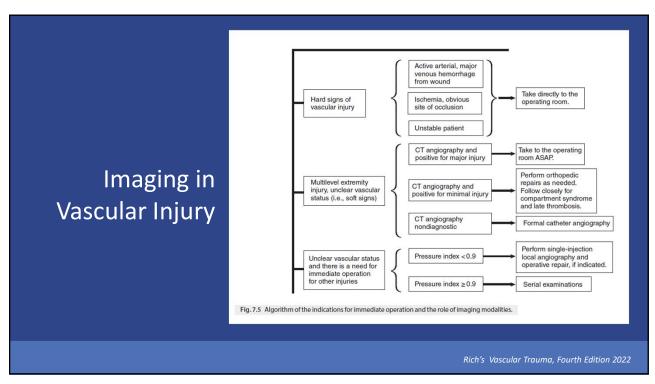
Sub-Adventitial Aneurysmal outpouching, Compressive symptoms Emboli

22

Adapted from: Chengazi HU, Bhatt AA. Pathology of the carotid space. *Insights Imaging*. 2019;10(1):21. Published 2019 Feb 15. doi:10.1186/s13244-019-0704-z



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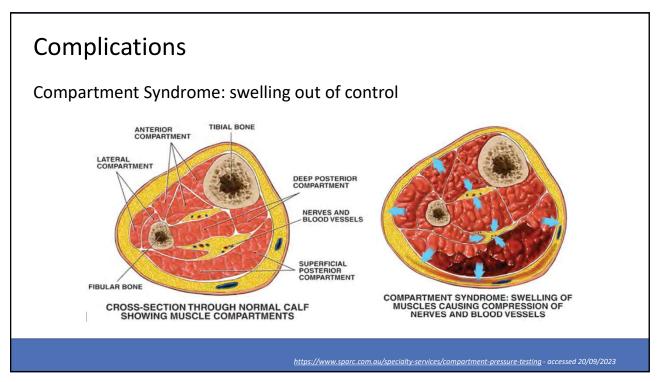
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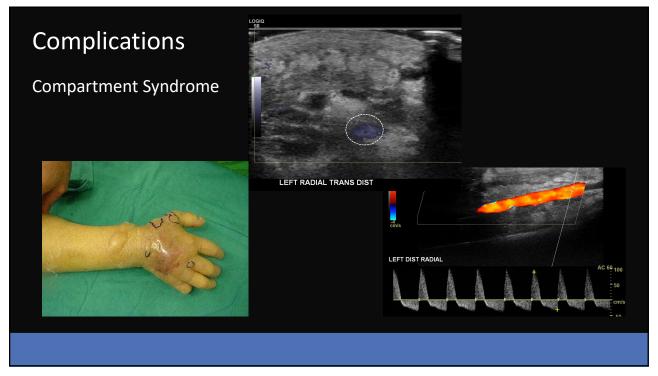
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#### **Post-Trauma Complications**

- Thromboembolic
- Stroke
- Myocardial infarction / cardiac arrest
- Infection incl. pneumonia
- Organ failure



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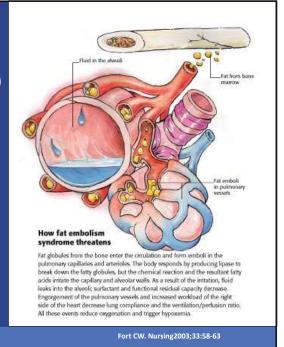




#### Complications

Fat Embolism / Fat Embolism Syndrome (FES)

- Fat globules from bone enter the bloodstream
- Long and/or pelvic bone fractures
- Usually asymptomatic
- FES Organ dysfunction lungs, brain
- Pathogenesis is unknown

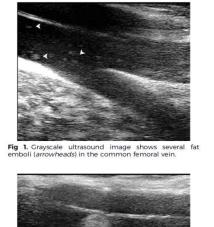


#### Complications

Fat Embolism / Fat Embolism Syndrome (FES)

Sonographic findings

- Discrete hyperechoic masses
- · Echogenicity resembling adjacent fat
- Micro large
- Mobile, intraluminal
- Spherical ovoid in shape





Naddaf Abdallah et al. "Duploy ultrasound ovidence of fa

Naddaf, Abdallah, et al. "Duplex ultrasound evidence of fat embolism syndrome." *Journal of Vascular Surgery Cases, Innovations and Techniques* 2.4 (2016): 155-157.

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#### Complications

Fat Embolism Syndrome (FES)

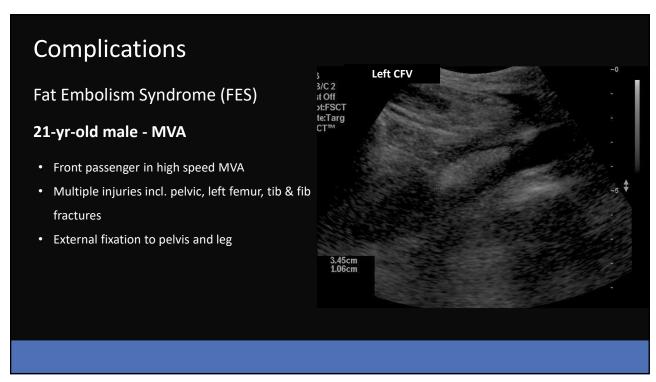
- Embolization
  - heart
  - lungs
  - brain



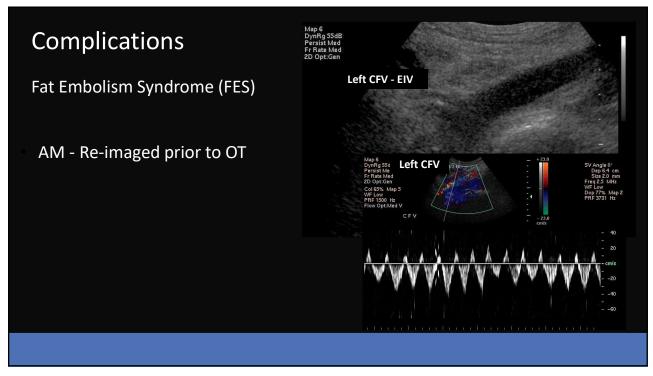
Pell, A. C., et al. "The detection of fat embolism by transoesophageal echocardiography during reamed intramedullary nailing. A study of 24 patients with femoral and tibial fractures." *The Journal of Bone & Joint Surgery British Volume* 75.6 (1993): 921-925.

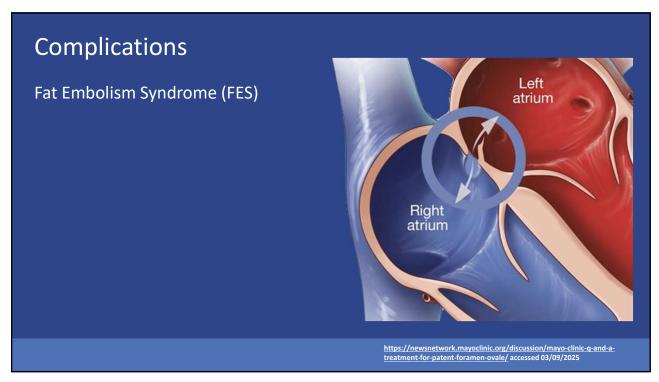
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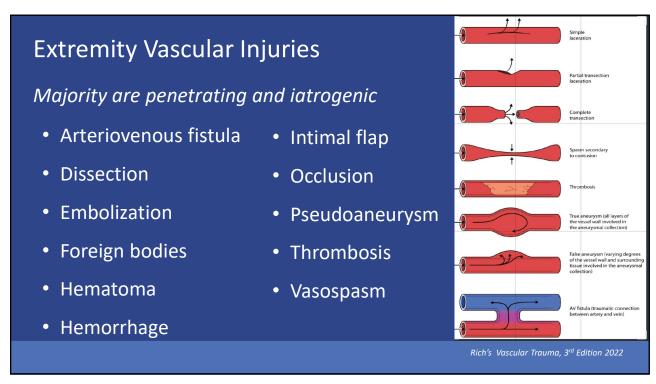


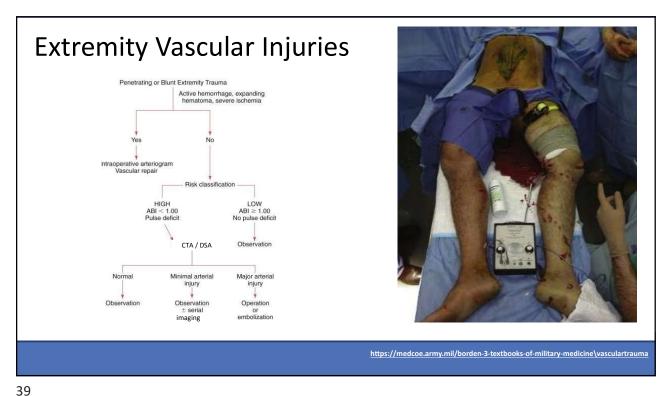
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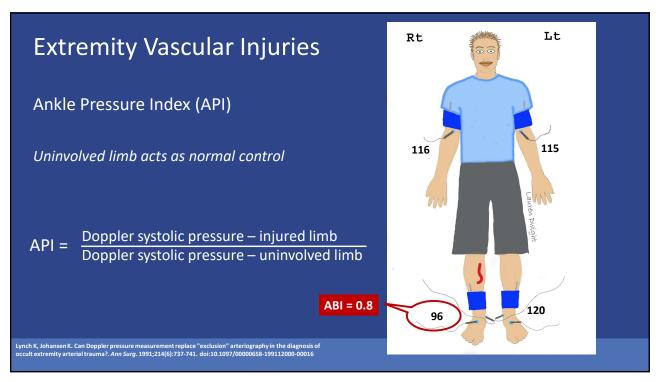
# Extremity Vascular Injuries

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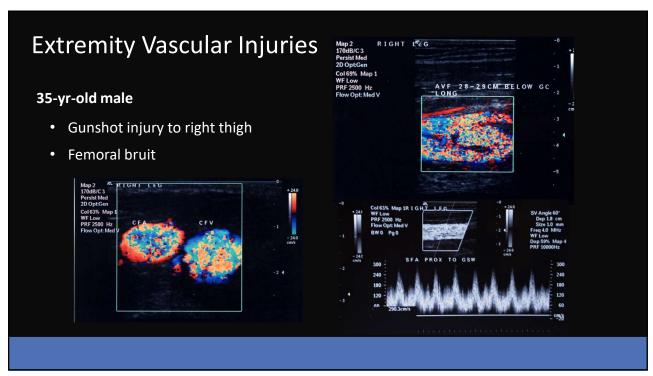


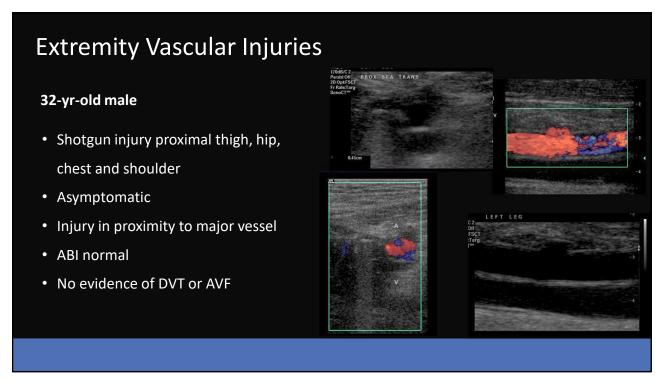


#### Lt Rt **Extremity Vascular Injuries** Ankle / Brachial Index (ABI) 116 Distal to injury Comparable sites for both limbs Index from *lowest* ankle pressure Uninvolved limb acts as normal control • Not proof of arterial injury Heightens suspicion ABI = 0.83120 96

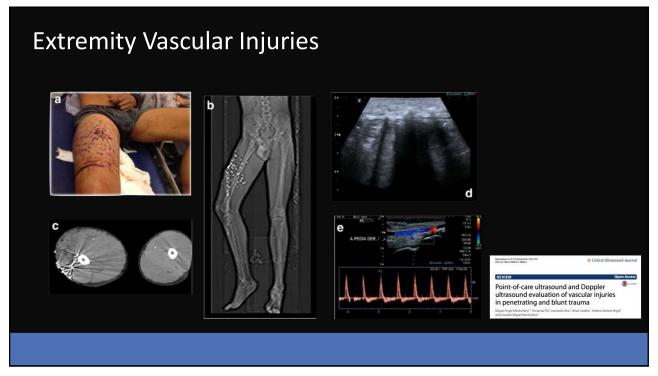


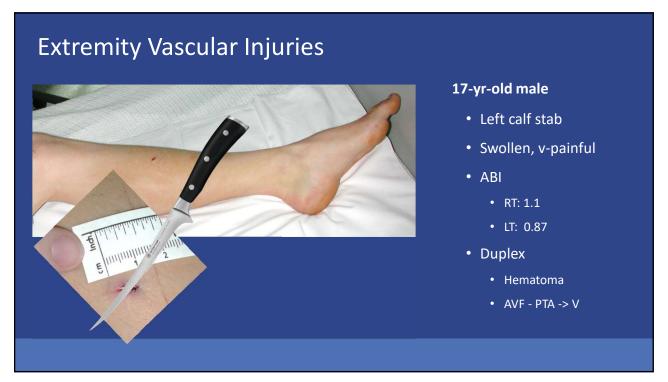
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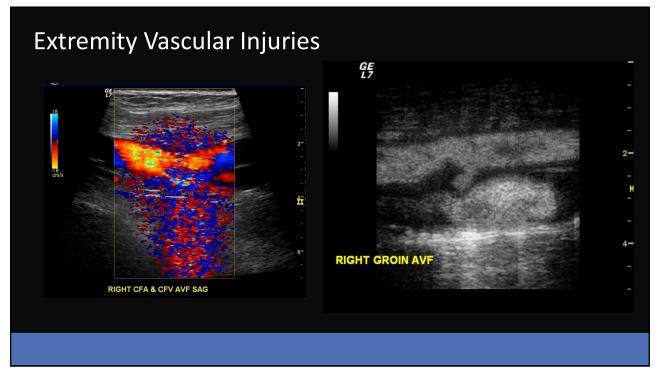


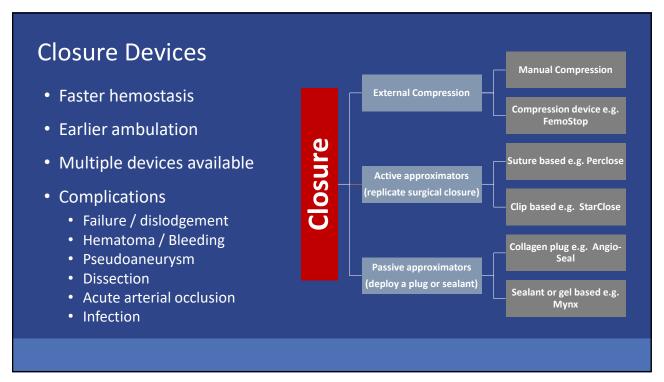
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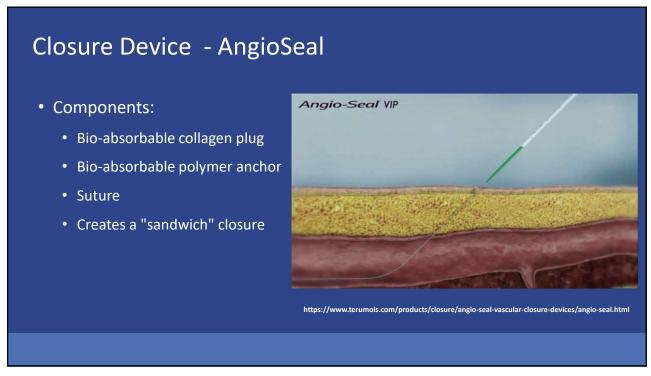


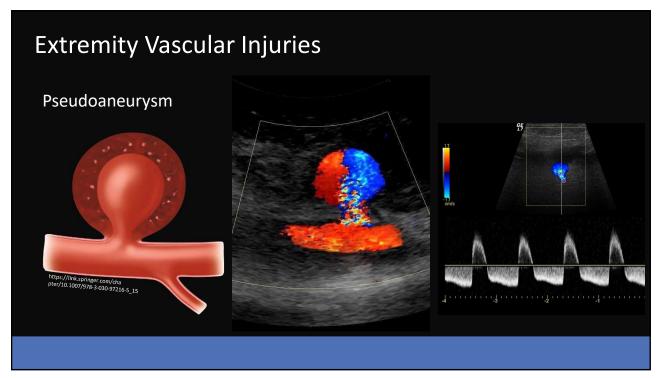
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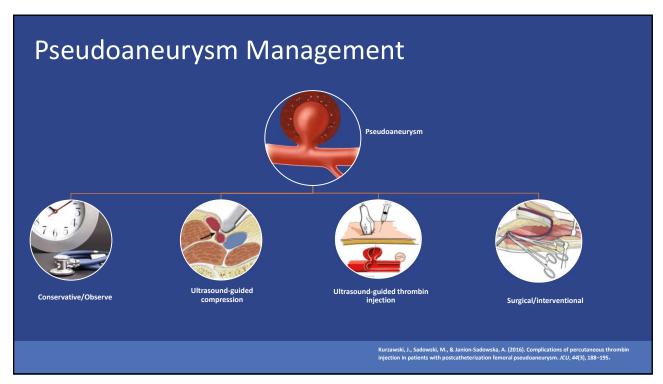


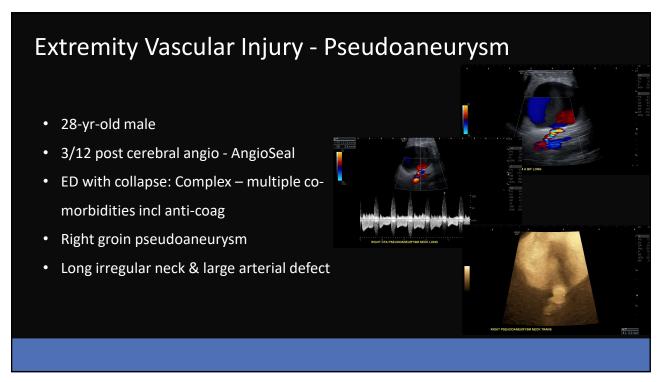
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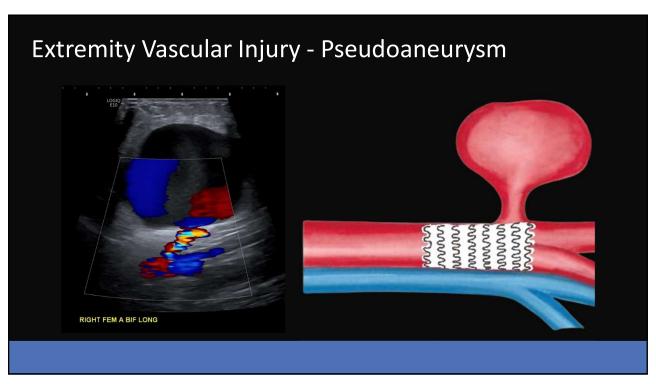


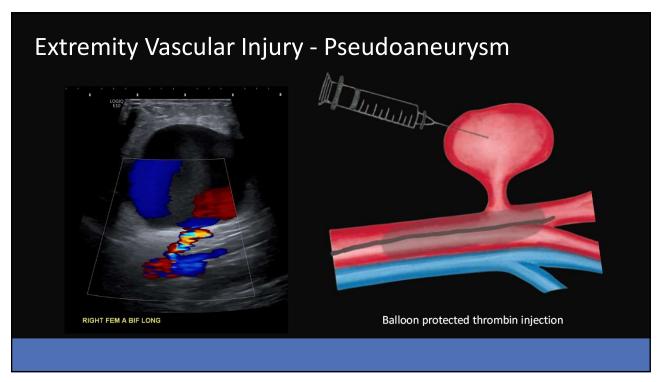
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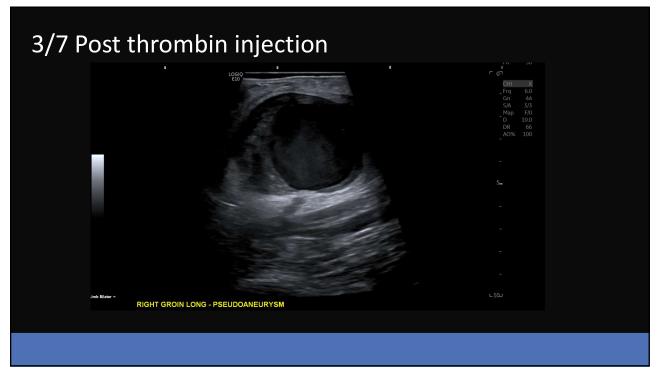


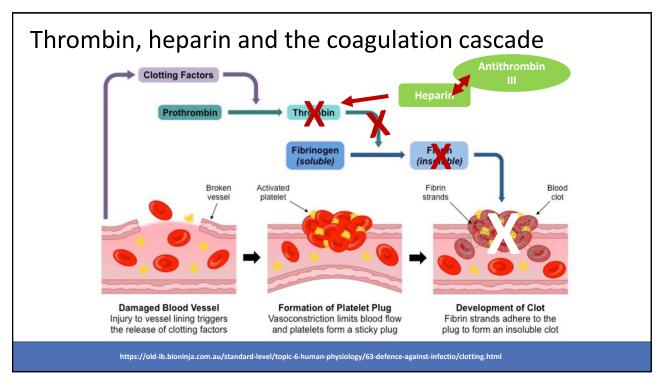
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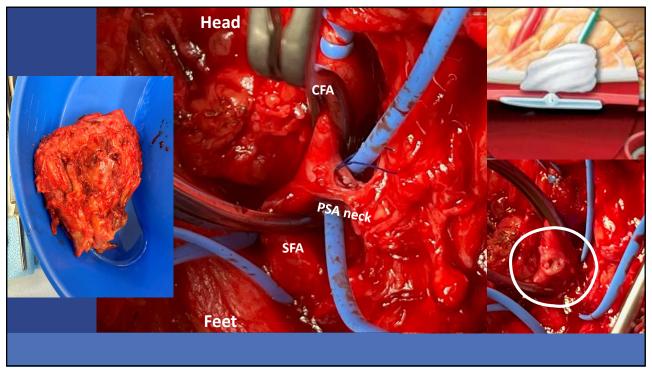


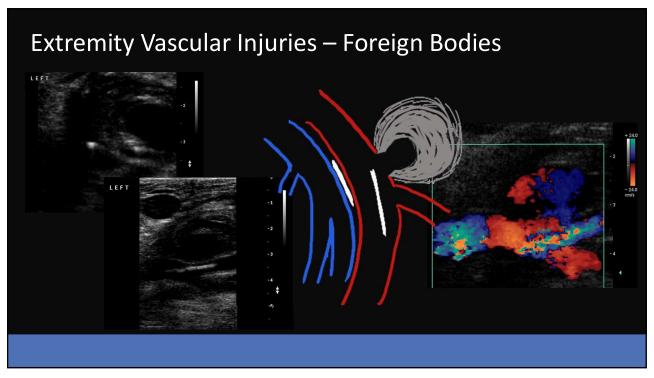
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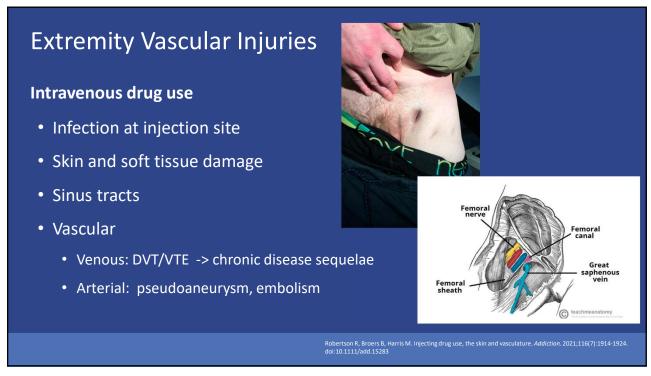


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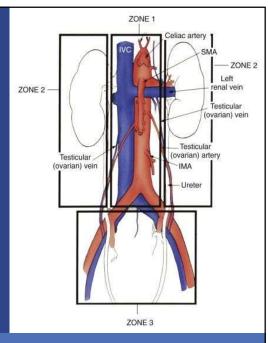


# Abdominal Vascular Injuries

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#### Abdomen & Pelvis

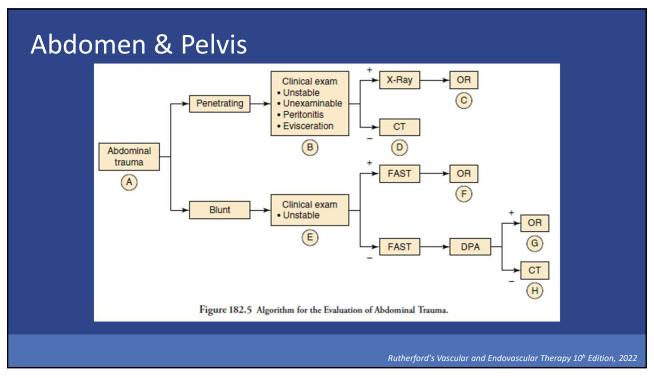
- Most common cause of death after penetrating abdominal trauma
- Hemorrhage control rapid transportation to a trauma center
- "Scoop and run"
- Focused Abdominal Sonography in Trauma (FAST)



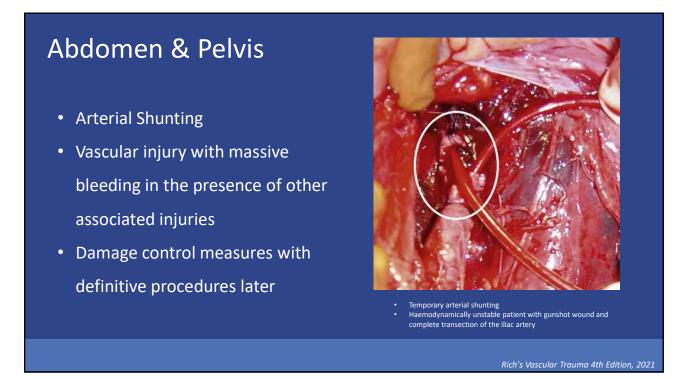
Rutherford's Vascular and Endovascular Therapy 10<sup>h</sup> Edition, 2022

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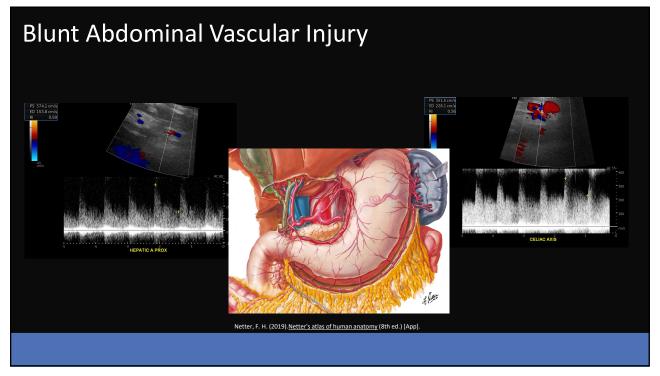


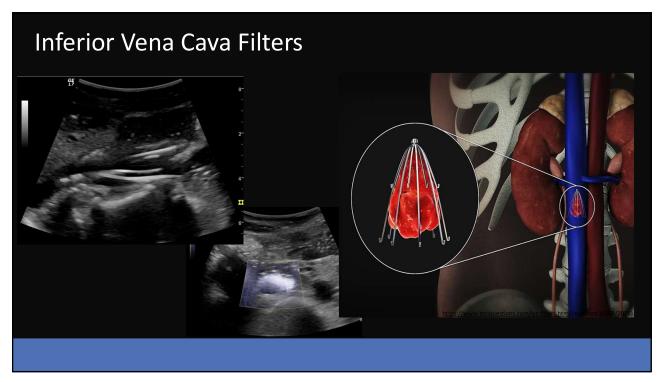
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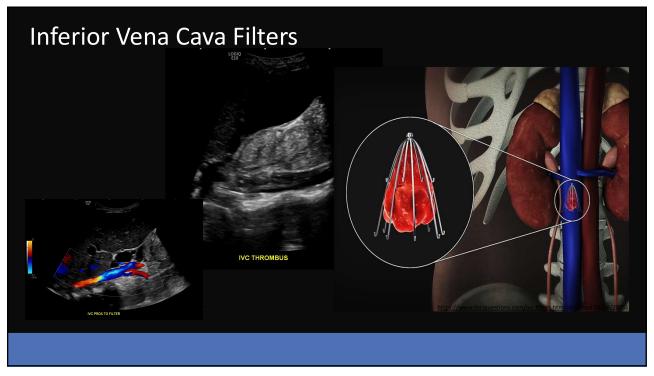
# Blunt Abdominal Vascular Injury 18-yr-old male • MVA • Multiple abdominal injuries • Celiac trunk and hepatic artery dissection

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# Thoracic Vascular Injuries

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#### Thorax

#### Penetrating and blunt trauma

- Great vessels aorta and brachiocephalic branches
- Pulmonary vessels
- Vena cava
- Heart

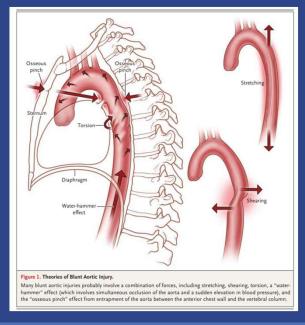
#### **Imaging**

- Ultrasound POC (FAST, subxiphoid pericardial)
- CXF
- "CT Trauma run" head, chest, abdo, pelvis
- CT Angiography
- TOE

#### Thorax

#### **Blunt aortic injury (BAI)**

- High energy MVA
- Exact incidence not known
- Second most common cause of death in blunt trauma after brain injury
- "Classic" site in desc. aorta at isthmus
- Deceleration injury



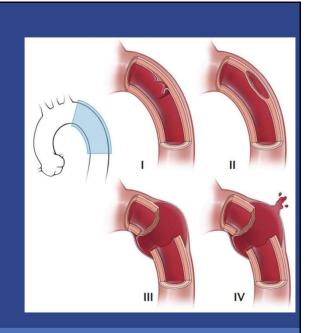
Neschis, D. G., Scalea, T. M., Flinn, W. R., & Griffith, B. P. (2008). Blunt aortic injury. Nei England Journal of Medicine, 359(16), 1708-1716.

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#### Thorax

#### Blunt aortic injury outcomes

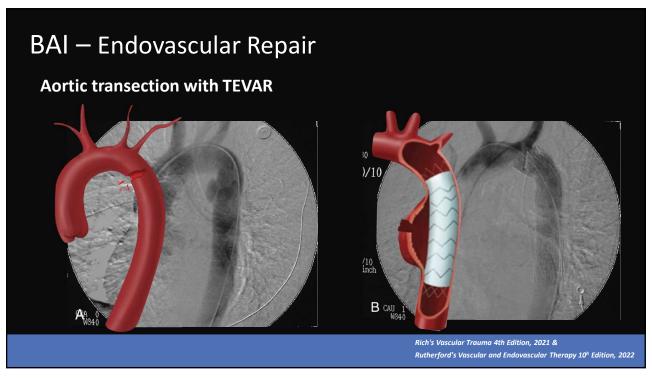
- Grade I IV
- Unstable versus stable
  - Unstable all cause mortality >90%
  - Stable time for work-up and staging of Tx
- Mortality in stable group lower



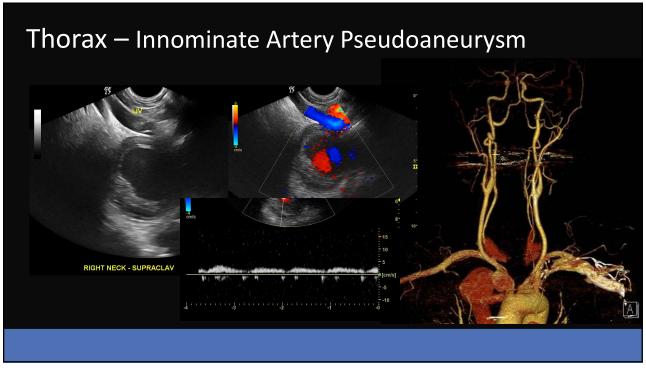
Adams, J. D., & Kern, J. A. (2014). Blunt thoracic aortic injury: current issues and endovascular treatment paradigms. Endovasc Today, 13, 38-42.

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# Upper Extremity & Neck Vascular Injuries

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# Upper Extremity Injury

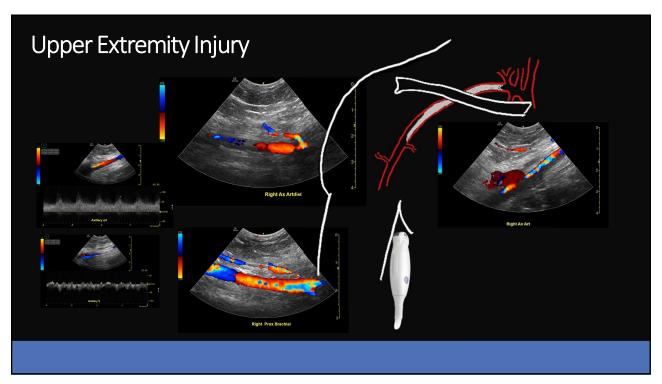


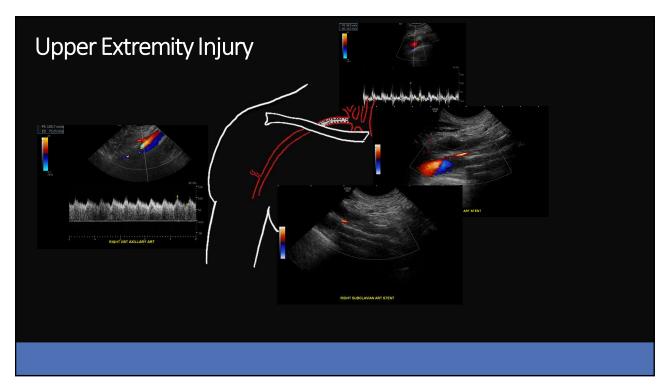
#### 22-yr-old male

- Multiple #
  - Comminuted displaced humeral #
  - Vertebral thoracic and lumbar
  - Ribs
  - Inferior scapula
- Transection of right subclavian artery & brachial plexus
- Hepatic laceration
- Cerebellar multifocal infarcts

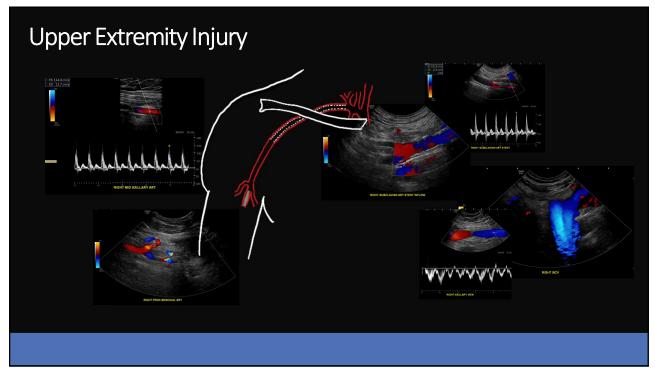


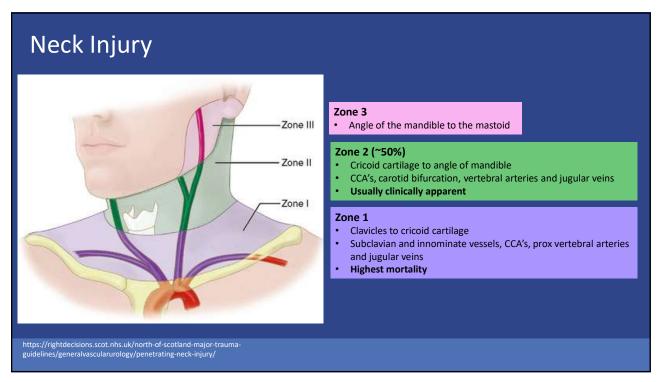
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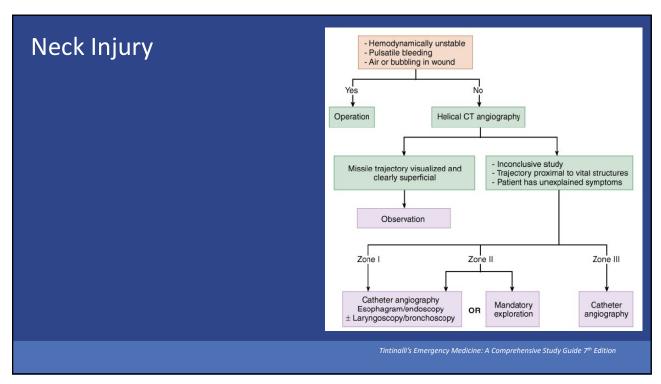


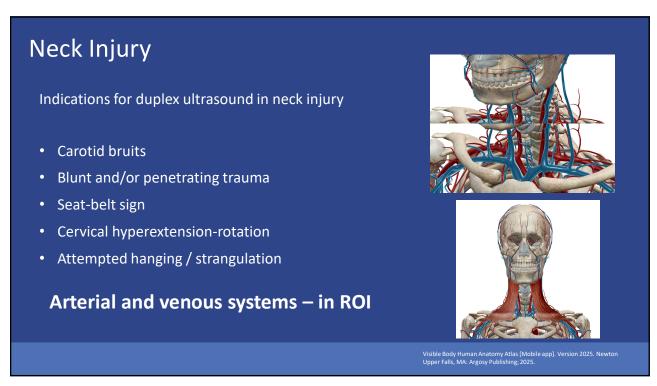
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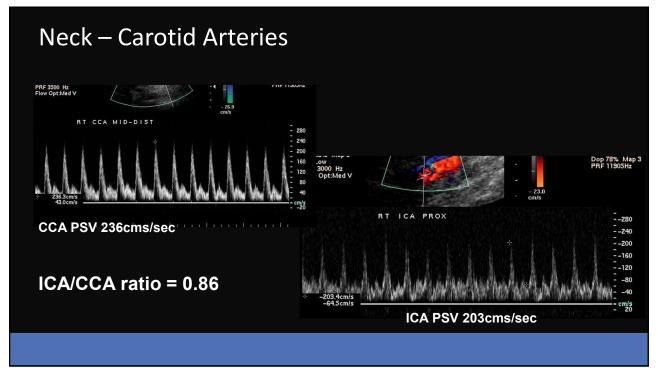


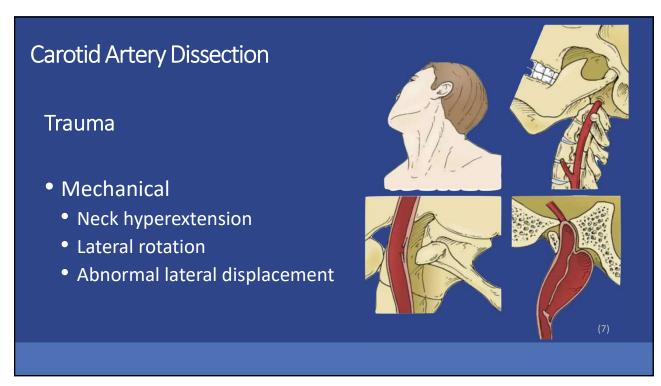
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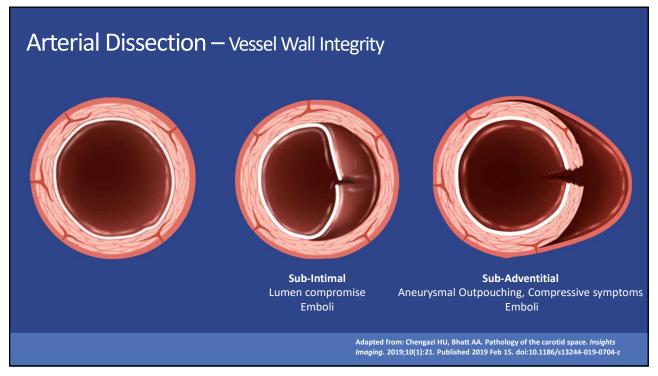


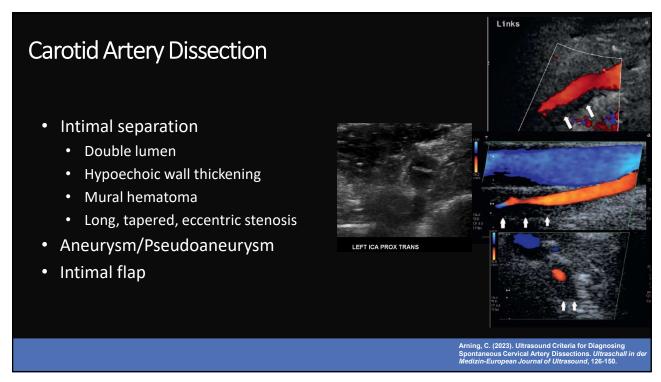
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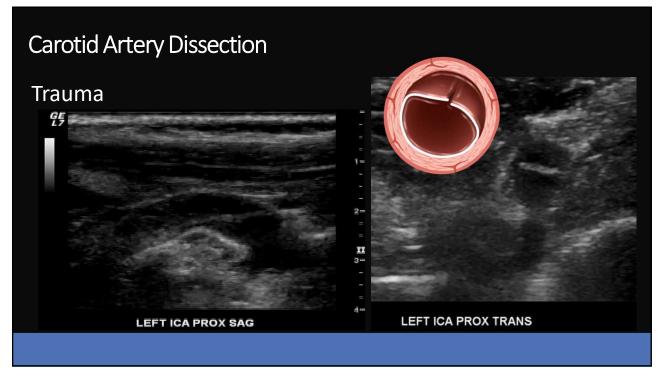


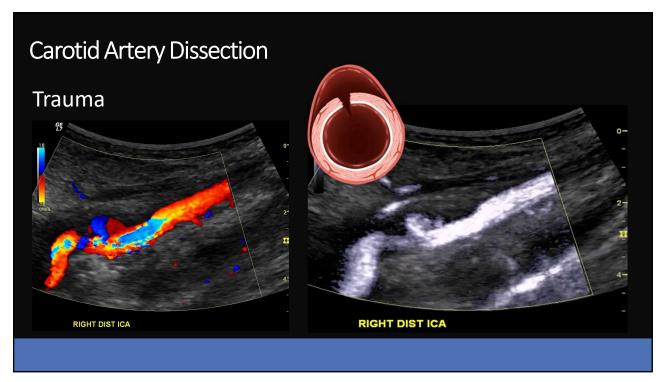
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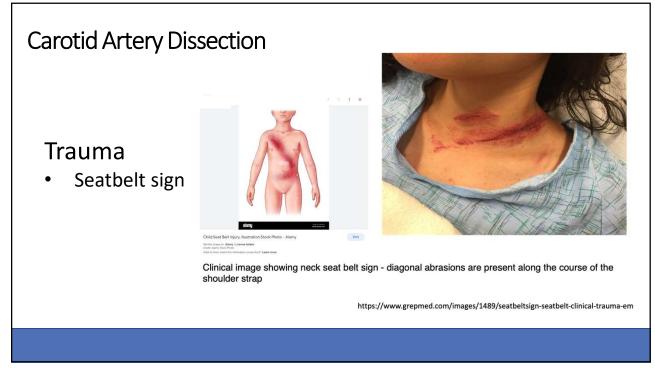


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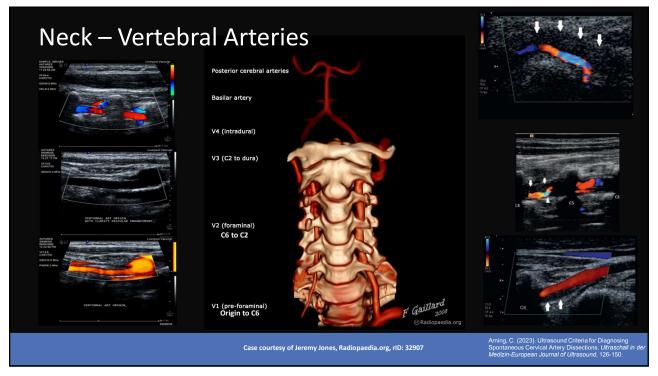


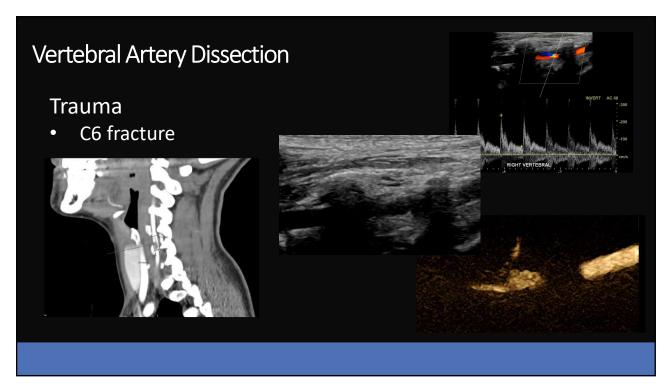
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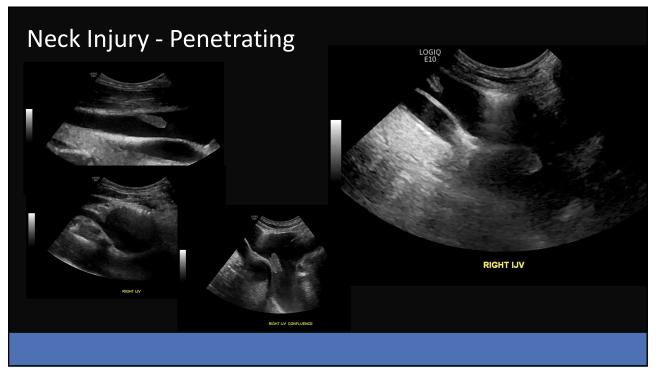


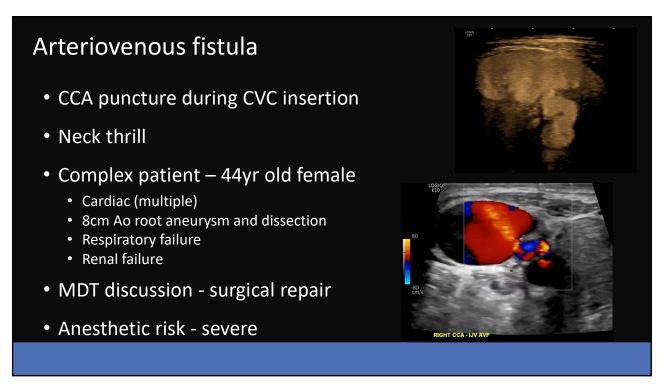
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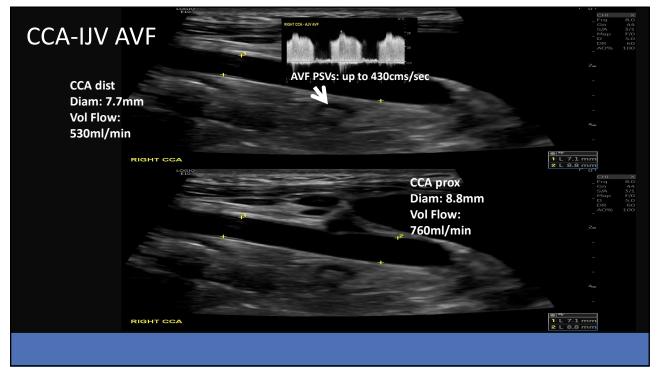


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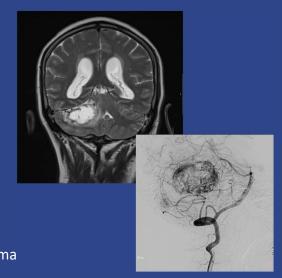
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### Carotid Artery Injury

#### 62-yr-old male

- Dizziness and lower limb weakness
- Von Hippel Landau Disease
  - PH of tumor resection
- Neuro / Neurovascular imaging
  - No cerebral infarct
  - Large post-contrast enhancing mass
  - Recurrent right cerebellar hemangioblastoma

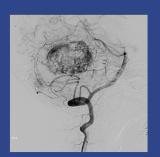


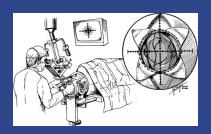
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## Carotid Artery Injury

#### Two-stage procedure

- Coil embolization
  - Right radial artery access
  - Right CCA, ECA and occipital arteries
- Right posterior fossa craniectomy and tumor resection
- Good post-op recovery





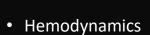
https://link.springer.com/referenceworkentry/10.1007/978-3-540-699

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# Carotid Artery Injury Post-op day 5 Right hemispheric symptoms Right middle cerebral artery embrations stroke CTA – intraluminal thrombus, coiled catheter in CCA extending into ICA

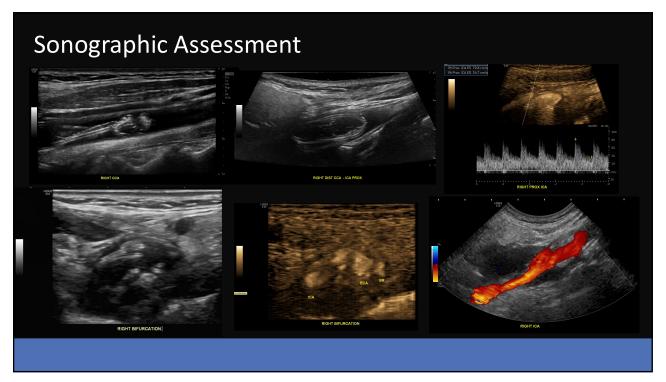
Sonographic Assessment



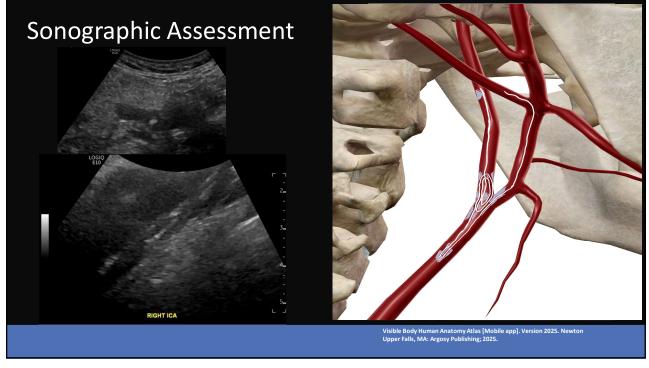
- Position of foreign body
- Thrombus burden



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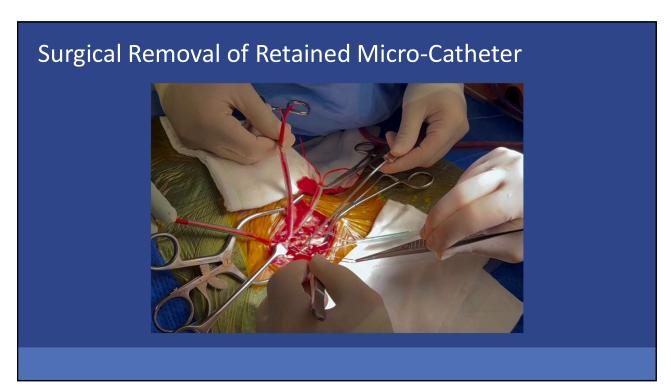
# Management

- Discussion
- Anticoagulation
- Close observation
- Surgical removal



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# Surgical Removal of Retained Micro-Catheter



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# Surgical Removal of Retained Micro-Catheter



- Complicated patient
- Role of serial sonographic

#### assessments

- Patency, thrombus, hemodynamics
- Non-invasive
- Monitoring during decision-making
- Reduced radiation and contrast doses



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