Acute Arterial Disease

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ACUTE ARTERIAL OCCLUSION

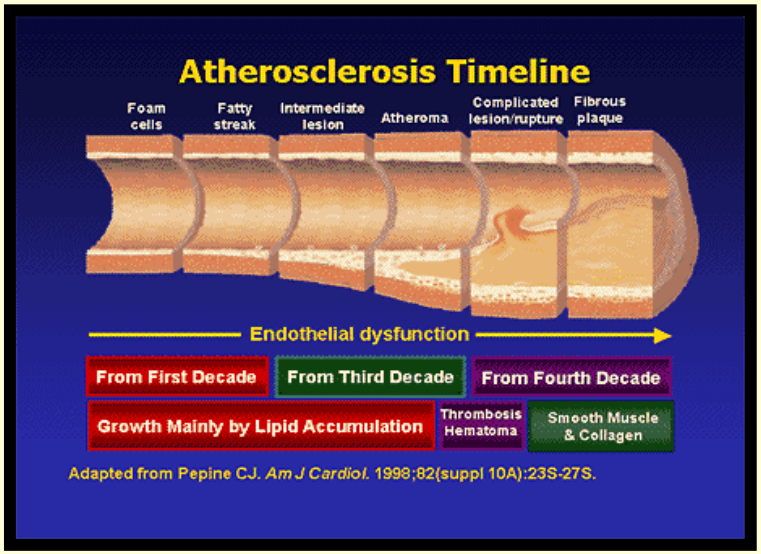
" The operation was a success but the patient died"

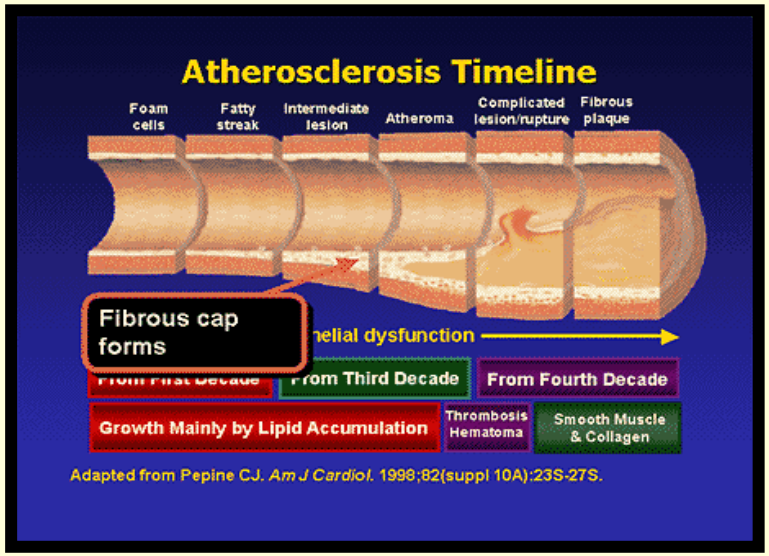
- High Morbidity and Mortality
  - Emergent operations in high risk patients
  - 20% mortality reported (Dale, JVS 1984)
  - Endovascular approaches may lower peri-procedural mortality while preserving outcomes

Etiology of Arterial Occlusion

- **Overview**
  - Atherosclerosis
  - Thrombotic occlusion
  - Embolic occlusion
  - Trauma
  - Treatment Options

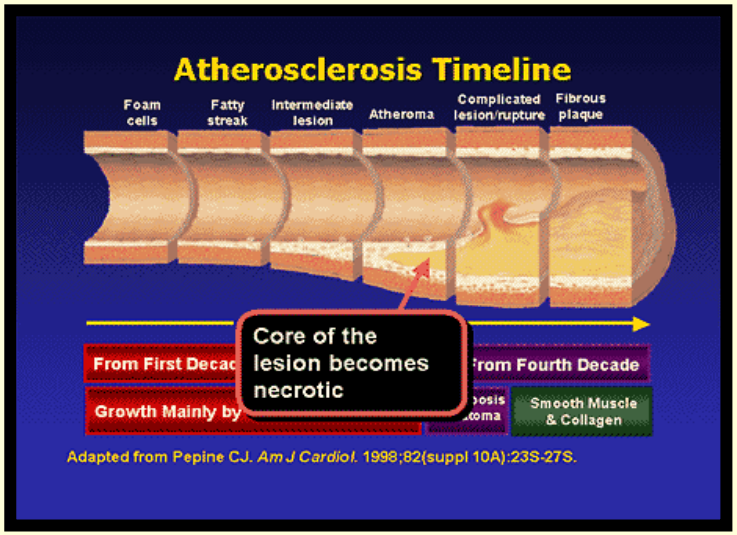
Evolutio of Atherosclerosis

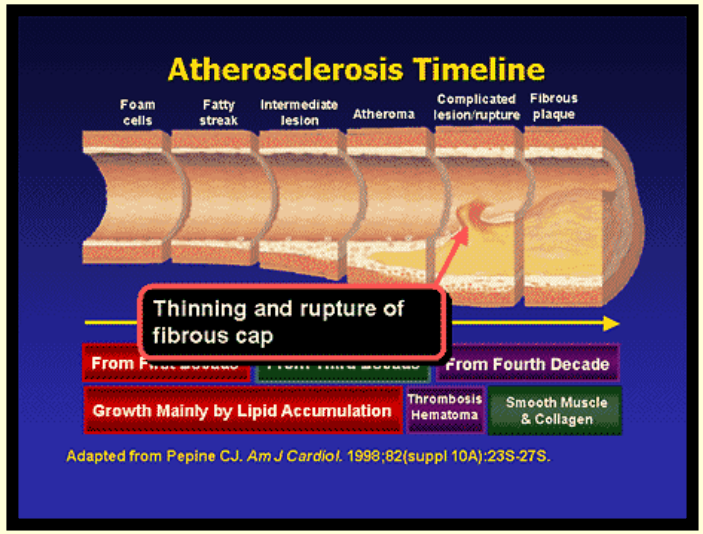




- Areas of low wall shear stress
- Increased endothelial permeability
- Sub-endothelial lipid and macrophage accumulation
- Foam cells
- Formation of Fatty Streak
- Fibrin deposition and stabilizing fibrous cap

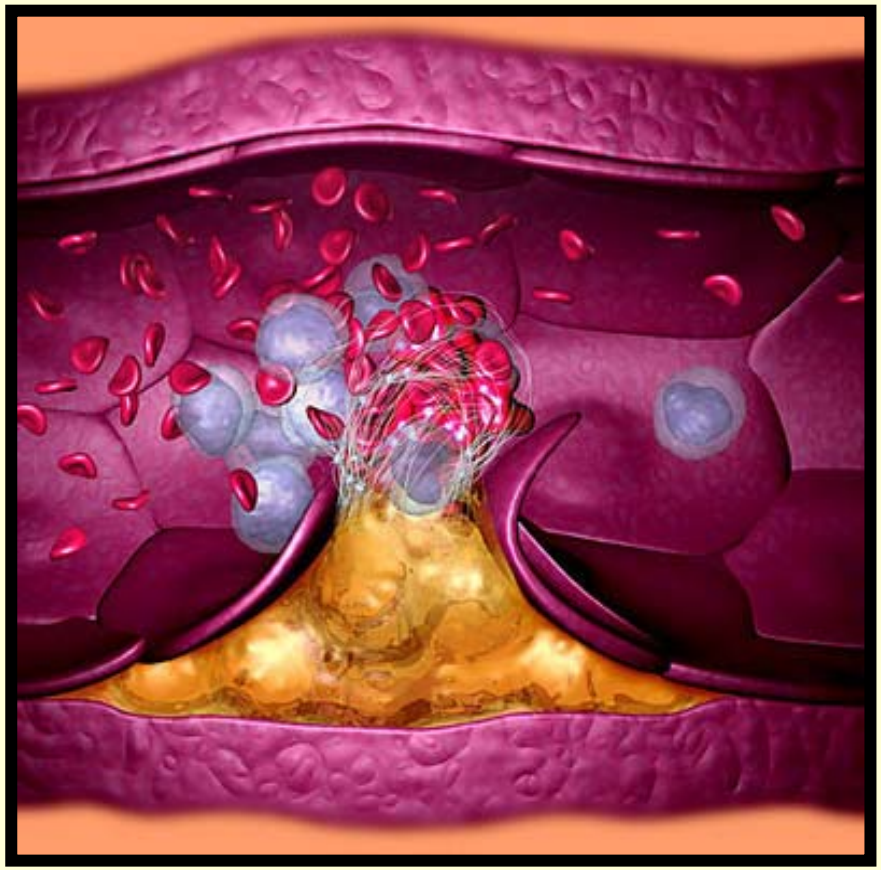
Evolutio of Atherosclerosis





- Necrosis
- Inflammatory environment
- Destabilization of fibrious cap

Evolution of Atherosclerosis



Rupture of Fibrous Cap

- Pro-thrombotic core Exposed to lumen
- **Acute thrombosis**
- **Embolization** of plaque materials and thrombus

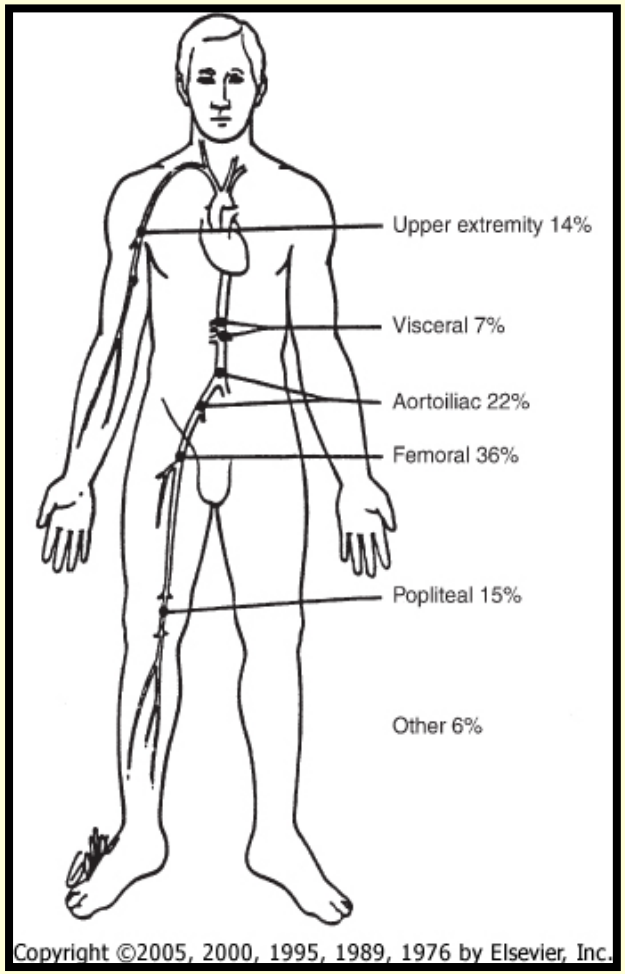
Thromboembolism

- Embolus- greek “embolos” means *projectile*
- Mortality of 10-25%
- Mean age increasing – 70 years
  - Rheumatic disease to atherosclerotic disease
- Classified by size or content
  - Macroemboli and microemboli
  - Thrombus, fibrinoplatelet clumps, cholesterol

Macroemboli

- **Cardiac Emboli**
  - Heart source 80-90% of thrombus macroemboli
  - MI, A.fib, Mitral valve, Valvular prosthesis
  - Multiple emboli 10% cases
  - TEE
    - Views left atrial appendage, valves, aortic root
    - not highly sensitive

Thromboembolism



- 75% of emboli involve axial limb vasculature
- Femoral and Polilteal
  - >50% of emboli
- Branch sites
- Areas of stenosis

Thromboembolism

Non-cardiac sources

- Aneurysmal (popliteal > abdominal)
- Paradoxical
  - Follows PE with PFO
- TOS
- Cryptogenic –5-10%
- Atheroemboli (artery to artery)

Atheromatous Embolizatio

- Shaggy Aorta
  - Thoracic or abdominal
- Spontaneous
- Iatrogenic
  - 45% of all atheroemboli
- “Blue toe syndrome”
  - Sudden
  - Painful
  - cyanotic
  - ***palpable pulses***
- livedo reticularis

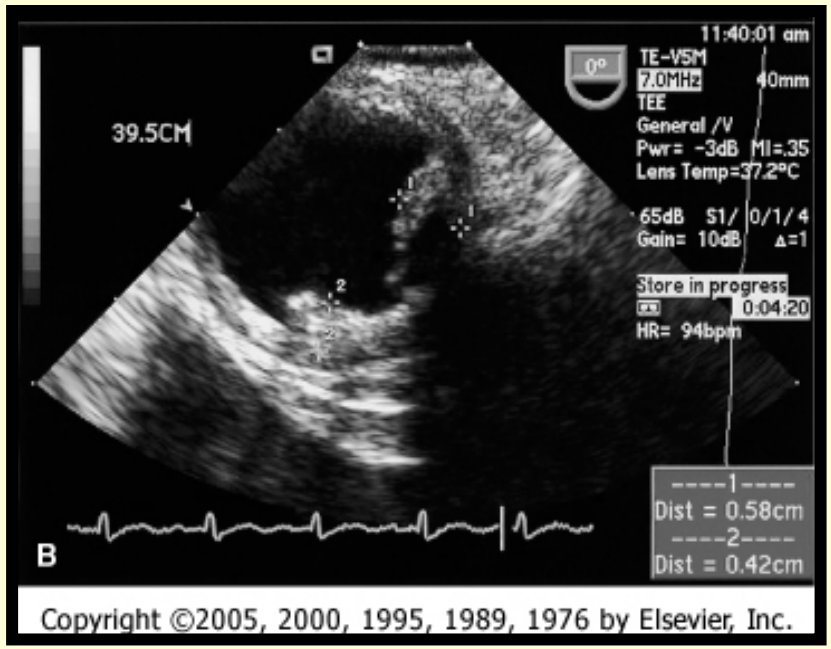
Blue Toe Syndrome

Atheromatous Embolizatio

- Risk factors: PVD, HTN, elderly, CAD, recent arterial manipulation
- Emboli consist of thrombus, platelet fibrin material or cholesterol crystals
- Lodge in arteries 100 –200 micron diameter

Atheromatous Embolizatio

- Affect variety of end organs
  - extremities, pelvis ,GI, kidney, brain
- Work-up:
  - TEE ascending aorta, CT Angio, Angiography
- Laboratory: CRP elevated, eosinophilia
- Warfarin my destablize fibrin cap and trigger emboli.



Atheromatous Embolizatio

- Reported incidence of 0.5-1.5% following catherter manipulation
  - Advance/remove catheters over guidewire
  - Brachial access? – controversial
- Limited Sx– Anti-coagulation/ observation
- Temporal delay up to 8 weeks before renal symptoms

Atheromatous Embolizatio

Therapy

- Prevention and supportive care
  - Statins, prostacyclin analogs (iloprost), ASA, Plavix
- Elimination of embolic source and reestablishing blood flow to heal lesions
- Surgical options: endaterectomy or resection and graft placement
  - Abdominal Aorta – Aorta-bi-fem bypass
  - Ligation of external iliac and extra-anatomic bypass if high risk
- Endovascular therapy
  - Angioplasty & stenting - higher rate of recurrence
  - Athrectomy – no data

Acute Thrombosis

- Graft thrombosis (80%)
  - intimal hyperlasia at distal anastamosis (prosthetic)
  - Retained valve cusp
  - Stenosis at previous site of injury
- Native artery
  - Intra-plaque hemmorhage
  - Hypovolemia
  - Cardiac failure
  - hypercoagable state
  - Trauma
  - Arteritis, popliteal entrapment, adventitial cystic disease

Acute Thrombosis

- Heparin Induced Thrombosis
  - White Clot Syndrome
  - Heparin dependent IgG anti-body against platelet factor 4
  - 3-10 days following heparin contact
  - Dx: thrombosis with > 50% decrease in Platelet count
  - Tx: Direct thrombin inhibiors: Agartroban & Hirudin
    - Avoid all heparin products
  - Morbity and Mortality: 7.4-61% and 1.1-23%

Other causes of Thrombosis

- Anti-thrombin III Defiency
- Protein C & S Defiency
- Factor V Leiden
- Prothrombin 20210 Polymorphism
- Hyper-homocystinemia
- Lupus Anti-coagulant (anti phospho-lipid syndrome)

“The Cold Leg”

- Clinical Diagnosis
  - Avoid Delay
  - **Anti-coagulate immediately**
  - Pulse exam
  - 6 P’s (pain, pallor, pulselessness, **parathesias**, **paralysis**,poiklothermia)
- Acute –vs- Acute on chronic
  - Collateral circulation preserves tissue
  - Traditional 4-6 hr rule may not apply
- The Two P’s-paralysis and paresthesia

Diagnostic Evaluation

SVS/ISCVS Classification

- "Rutherford Criteria"

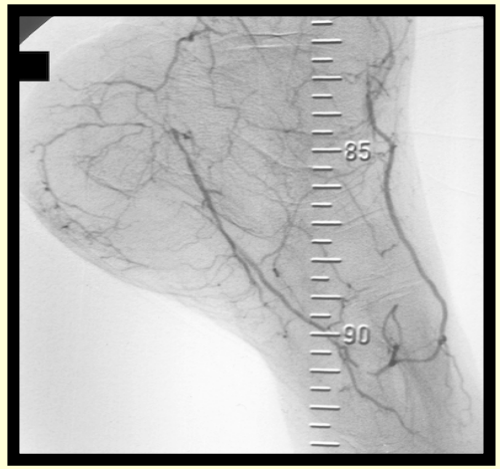
- Class I: Viable
  - Pain, No paralysis or sensory loss
- Class 2: Threatened but salvageable
  - 2A: some sensory loss, No paralysis >No immediate threat
  - 2B: Sensory and Motor loss > needs immediate treatment
- Class 3: Non-viable
  - Profound neurologic deficit, absent capillary flow,skin marbling, absent arterial& venous signal

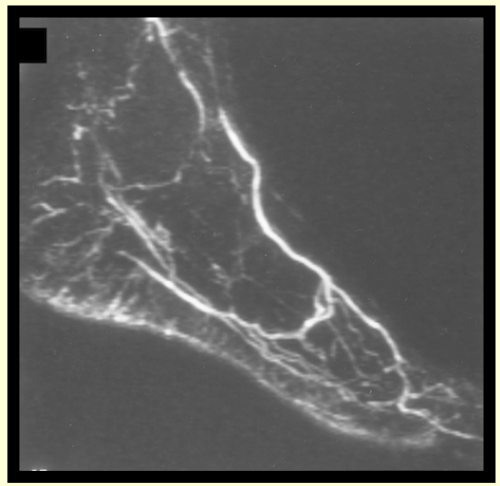
Therapeutic Options

- Class 1 or 2A
  - Anti-coagulation, angiography and elective revascularzation
- Class 2B
  - Early angiographic evaluation and intervention
  - Exception: suspected common femoral emboli
- Class3
  - Amputation

Diagnostic Evaluation

- Modalities
  - Non-invasive:
    - Segmental pressure drop of 30mmhg
    - Waveforms
    - CTA / MRA : avoid nephrotoxity
      - Center dependent
      - Wave of the future?
  - Contrast Angiography
    - Gold Standard





Thrombotic –vs- Embolic

- **Thrombotic**
  - History
    - Claudication, PVD
    - Bypass graft
  - Physical
    - Hair loss, shiny skin
    - Bi-lateral Dz
  - Angiographic
    - Diffuse disease
    - mid vessel occlusion
  - PVD confuses diagnosis
- **Embolic**
  - History
    - Cardiac events
    - Acute onset
    - Hx of emboli
  - Physical
    - Normal contralateral exam
    - A.fib
  - Angiographic
    - meniscus Cut-off in normal vessel
    - Bifurcations affected

Determination of etiology possible in 85% of cases

Treatment Options

- Multiple options available
  - Conventional surgery
    - embolectomy
    - endarterectomy
    - revascularization
  - Thrombolytic therapy
  - Percutanious mechanical thrombectomy

- Native vessel thrombosis often require more elaborate operations

The Six P's

- Pain
- Poikylothermia (Polar)
- Pallor
- Pulseless
- Paresthesia*
- Paralysis*

The Importan tTwo P's

- Indicate **impending tissue loss** and the need to revascularize now; not in six to eight hours
- **Paresthesia-**loss of nerve function; in the foot the peroneal nerve between 1st and 2nd toe
- **Paralysis-**loss of nerve and muscular function

Treatment Fundamentals

- Early recognition and anti-coagulation
  - Minimizes distal propagation and recurrent emboli
- Modality of Tx depends on:
  - Presumed etiology
  - Location/morphology of lesion
  - Viability of extremity
  - Physiologic state of patient
  - Available vein conduit for bypass grafting

Treatment : Thrombosis

Separate graft thrombosis into early and Late groups

Early thrombosis

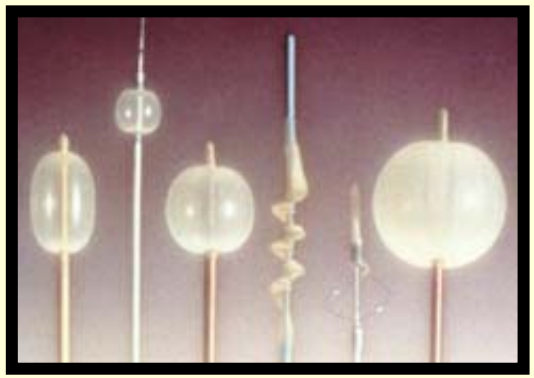
- Technical defect
- Repairable
- Avoid lytic Tx
  - 14 days vein
  - 30 days graft
- Explore both anastamosis
- On-table Angio
  - Twists, kniks,stenosis

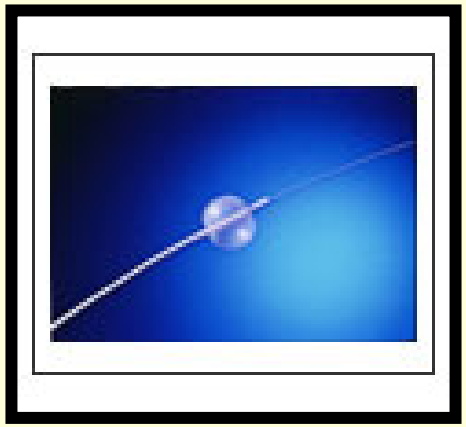
Late thrombosis

- Duration & degree of ischemia
- Lytic Thearpy (clas1-2a)
  - Good 1st approach
  - Unmasks lesion (valve/stenosis)
  - F/u endo or open repair
- Open surgery (2b)
  - Thrombectomy/patch
  - Re-bypass

Embolectomy

- Fogarty embolectomy catheter
  - Intoduced 1961
- Adherent clot catheter
- Graft thrombectomy catheter
- Thru-lumen catheter
  - Selective placement over wire
  - Administer: lytics, contrast





Embolectomy

Surgical Therapy

- Iliac and femoral embolectomy
  - Common femoral approach
  - Transverse arteriotomy proximal profunda origin
  - Collateral circulation may increase backbleeding
  - Examine thrombus

Embolectomy

- Popliteal embolectomy
  - 49% success rate from femoral approach
  - Blind passage selects peroneal 90%
  - may expose tibial-peroneal trunk & guide catheter
  - Idrectly cannulate distal vessels
- Distal embolectomy
  - Retrograde/antegrade via ankle incisions
  - Frequent Rethrombosis
  - Thrombolytic Tx viable alternative

Embolectomy

- Completion angiography
  - 35% incdence of retained thrombus
  - IVUS more sensitive then angio
- Failure requires
  - Thrombolytic thearpy
  - revascularization

Thrombolytic Therapy

Advantages

- Opens collaterals & microcirculation
- Avoids sudden reperfusion
- Reveals underlying stenosis
- Prevent endothelial damage from balloons

Risks

- Hemorhage
- Stroke
- Renal failure
- Distal emboli transiently worsen ischemia

Surgery –vs- Thrombolysis

- STILE Trial
- Surgery vs Thrombolytics for Ischemia of Lower Extremity
  - 393 pts with non-embolic occlusion
  - Surgery vs r-TPA or r-UK
- Thrombolytics : improved amputation free survival and shorter hospital stay (0-14 days)
- Surgery: revascularization more effective for ischemia of > 14 days duration

Ann Surg 1994, 220:251

Surgery –vs- Thrombolysis

TOPAS Trial

- 2 phase
- 544 patients
- r-UK vs Surgery
- Need for surgery Reduced 55%
- Similar amputation and mortality rates

NEJM 338, 4/16/98

h dication s for Thrombolysis

Category 1-2a limbs should be considered

- Class 2b : Two schools of thought
  1)“Delay in definitive Tx”
  2)“Thrombolytics extend window of opportunity”
- Clots <14days most responsive
  - But even chronic thrombus can be lysed
- Large clot burden
  - Better response to lytic tx than surgery
  - Requires longer duration of thrombolytics

Techn ique of Thrombolysis

- Guide Wire Traversal Test (GTT)
  - Abilty to traverse lesion best predictor of success
  - Use 0.035 in angled glide wire
  - “knuckling-over” indicates sub-intimal plane
  - Attempt pro-grade, Anti-grade, lytic bolus

Techn ique of Thrombolysis

- Catheter directed delivery
  1) Lace clot via catheter with side holes
  2) Pulse-Spray technique (mechanical component)
- Urokinase and TPA equally effective
- 4 hr treatment followed by angiogram
  - 4000IU/min x4hr, 2000Iu/M=min x 48h
    - r-UK (TOPAS Trial)
  - no improvement after 4hr >> surgery
- Continue Heparin gtt
- Fibrinogen levels

Mechanical Thrombectomy

- Percutaneous aspiration embolectomy
  - Viable alternative in selected patents
  - Varity of devises
  - Combines diagnostic and therapeutic procedure
  - Removes non-lysable debris
  - Effective in distal vessels
  - Risk distal embolization
    - Combine with lytic Tx

Reperfusion Syndrome

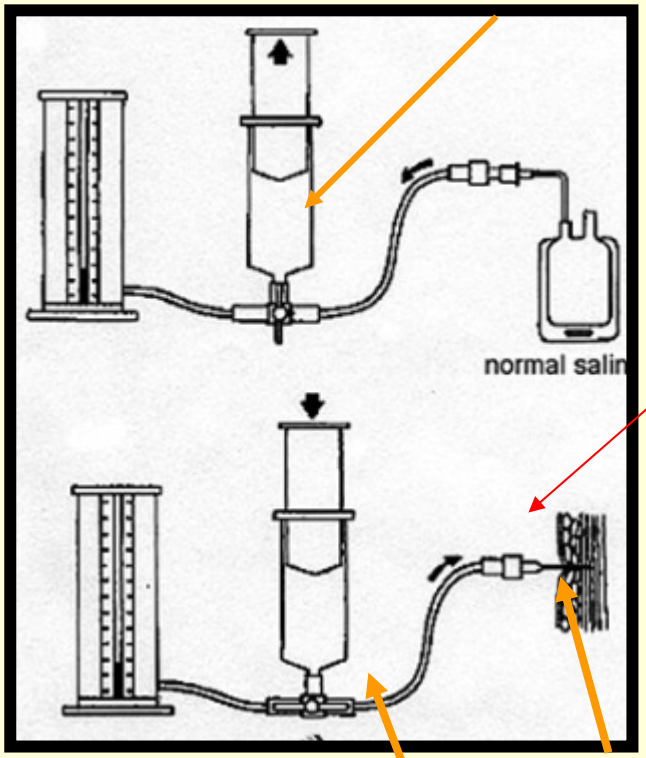
- Ischemic-reperfusion syndrome
  - Local: endothelial damage, capillary permeability, Transudative swelling, cellular damage
    - Compartment Syndrome
    - Tx: Fasciotomy
  - Systemic: Lactic Acidosis, Hyperkalemia, Myoglobin, Inflammatory Cytokines
    - Cardiopulmonary complications
  - Renal Tubular necrosis
    - Myoglobin precipitates
    - Tx: Volume, Urinary alklinization

Compartment Syndrome

- Increased Intracompartmental pressure; the **Two P's**
- Less than 30 mm Hg difference between ICP and MAP, or 10 mmg difference between ICP and diastolic, or greater than 15mm pressure by Whiteside technique
- Ischemia/reperfusion, trauma,venous outflow obstruction, fracture, crush
- Whiteside catheter

Compartment Pressure

15cc saline

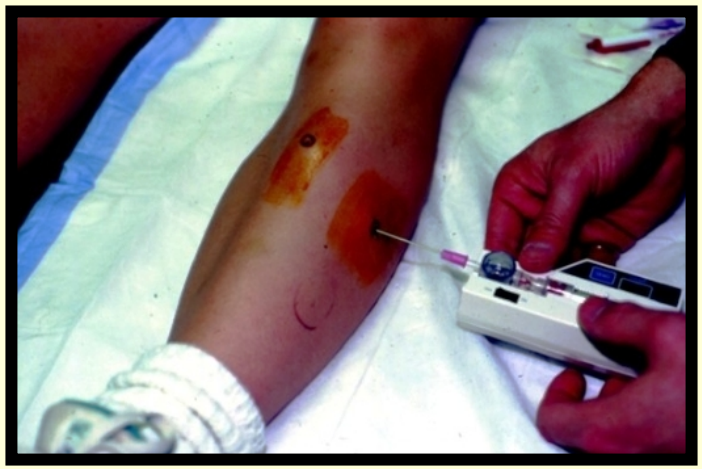


20cc syringe

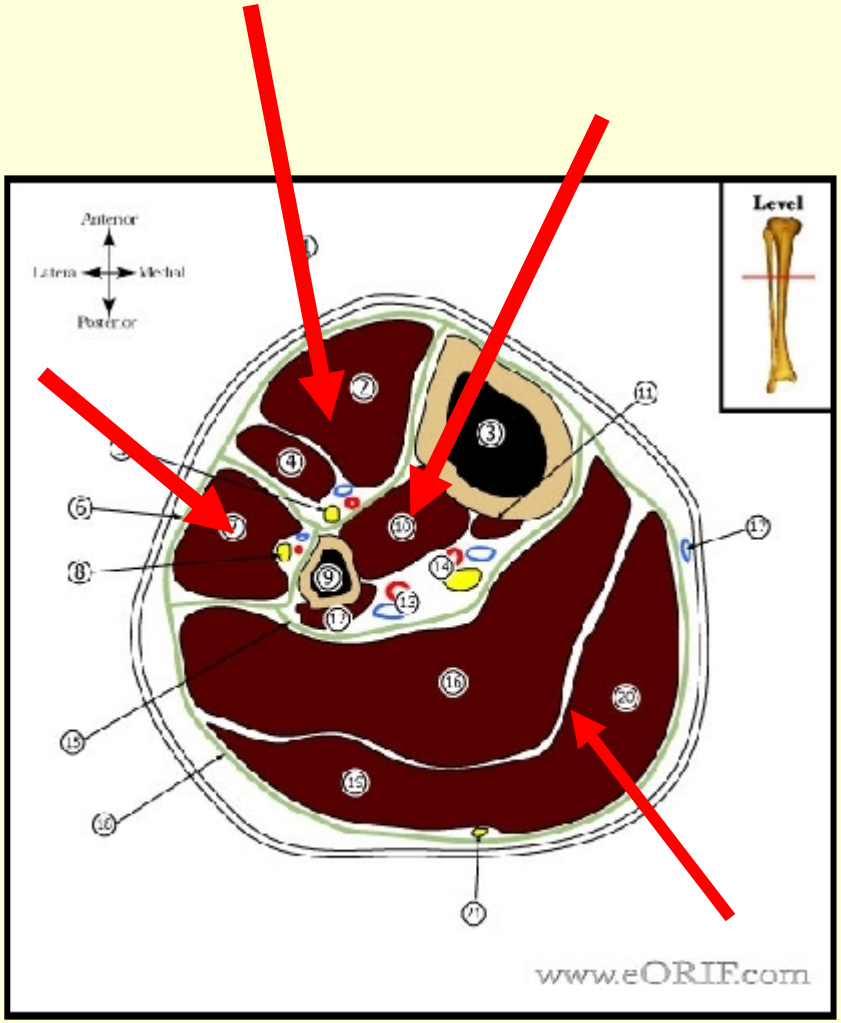
18 gauge needle

Inject into compartment slowly until meniscus moves and measure pressure on manometer-15 mmHg or less is normal

Struker system



Fasciotomy


Anterior
Lateral
Medial
Posterior
Level
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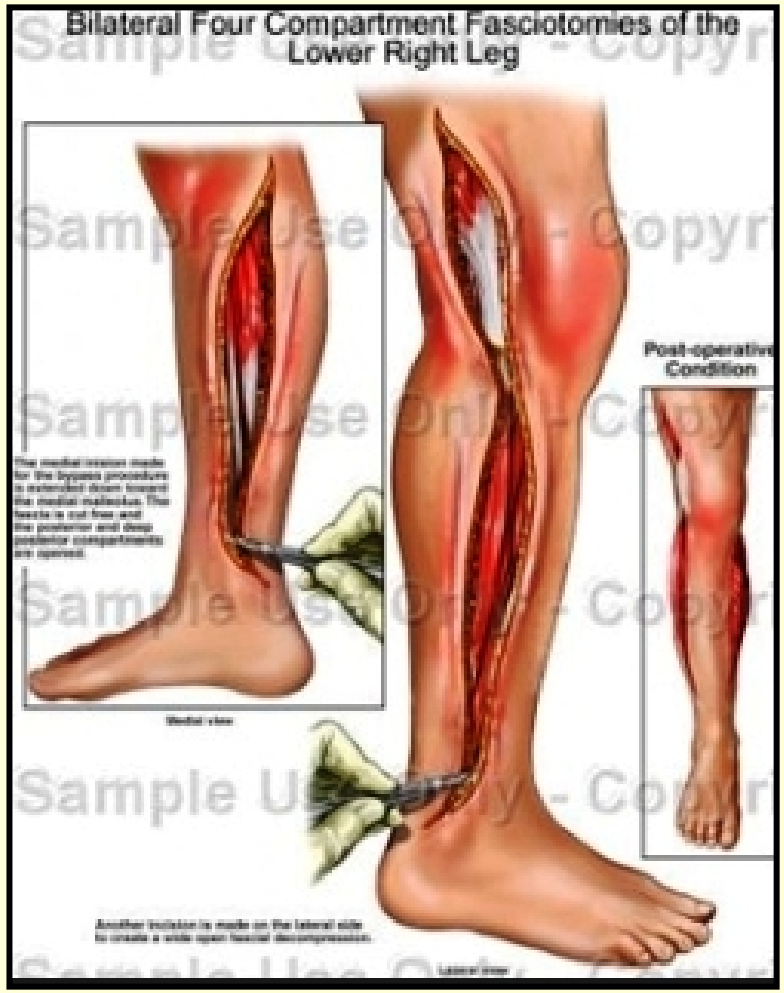
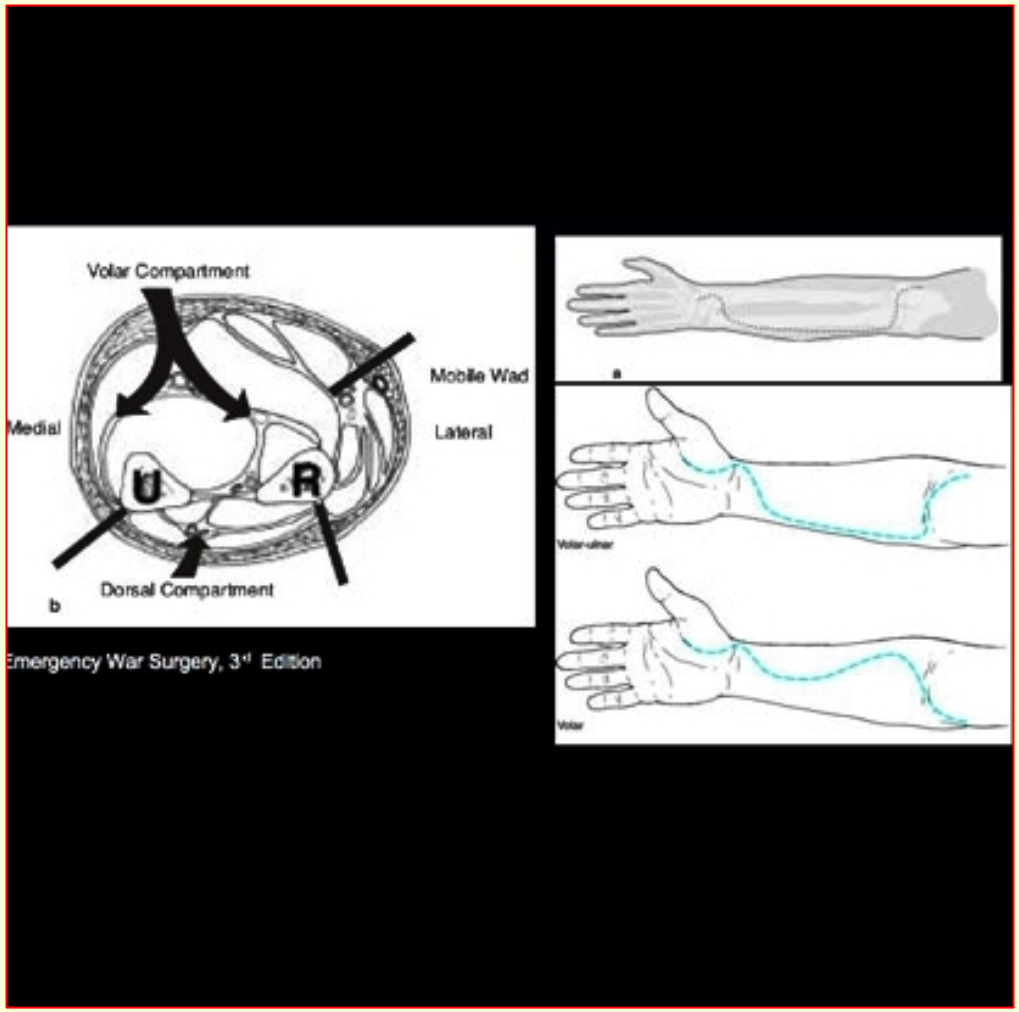

Bilateral Four Compartment Fasciotomies of the Lower Right Leg
Post-operative Condition

Arm Fasciotomy



Reperfusion ARF

- Myoglobulinemia, myoglobinuria, hyperkalemia, acidosis
- Bicarbonate on releasing the fascia
- Alkalinze urine
- Hydrate
- Mannitol

Summary

- Thrombotic and embolic occlusions are separate processes with different presentations and treatments
- Treatment pathways in AAO are complex and vary depending on clinical situation
- Catheter-based treatments preserve outcomes with less overall morbidity
- Consider fasciotomy on clinical grounds

Vascular Trauma

Cervical Trauma

Zones

- Zone 1-Below the cricoid cartilage
  - Cervical incision plus anterior thoracotomy or median sternotomy
- Zone 2-Cricoid cartilage to angle of jaw
  - Cervical incision
- Zone 3-Above angle of jaw
  - Jaw subluxation

Cervical Injury

- Penetrating versus Blunt
- Treatment with stroke-early revascularization
- Tracheobronchial, esophogeal or spinal injury1-7%
  - Subcutaneous emphysema
  - hematemesis

Hard Signs/Soft Signs Penetrating Trauma

Hard

- Shock
- Pulsatile bleeding
- Loss of pulse with evolving neurologic deficit
- Expanding hematoma

Soft

- History of bleeding
- Proximity
- Nerve injury
- Stable hematoma
- Unequal blood pressure measurement

Usually exploration

Diagnostic measures

Penetrating Cervical Trauma

- CTA/CT-penetrating trauma without hard signs
- Occult injury-
  - Flaps-watch
  - Dissections-repair if easy, anticoagulate if not
  - Pseudoaneurysms-repair large ones early
- Anticoagulate only large flaps if can’t operate-not great data!

Blunt Cervical Trauma

- Hyperextension of neck
  - Lateral articular processes of C1-C3
  - dissection
- Direct blow
- Laceration by bone

Screening for Carotid Injury

Denver Criteria

- **Hemorrhage, hematoma**
- **Bruit**
- **Neuro exam inconsistent with head findings**
- **Stroke on CT**
- **Focal deficit**
- **LeFort II or III**
- **Basilar skull fx involving carotid canal**
- **GCS<6**
- **C-spine fx**
- **Hanging with anoxic injury**

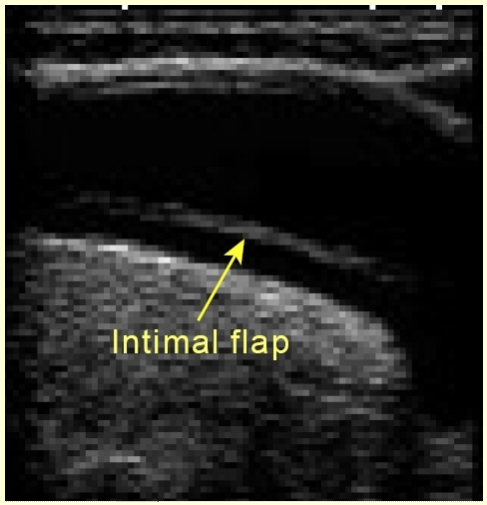
18% of screened had injury

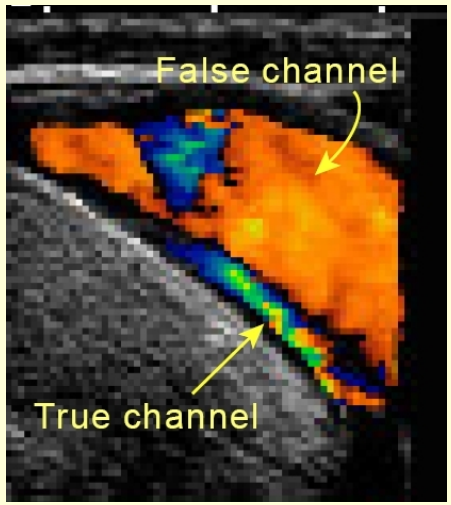
Memphis Criteria

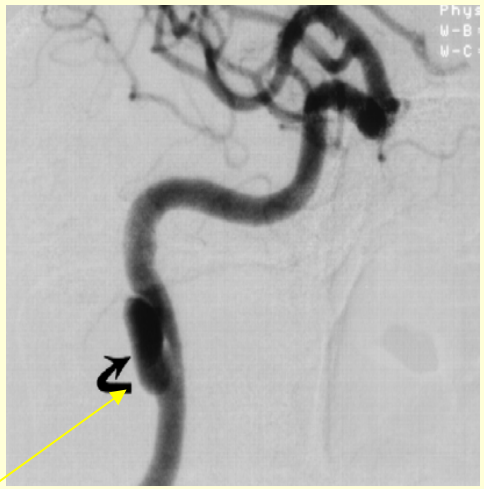
- **Nero exam not explained by brain injury**
- **Horner's syndrome**
- **Neck soft tissue injury**
- **Le Fort II or III**
- **Basilar skull fracture**
- **C spine fracture**

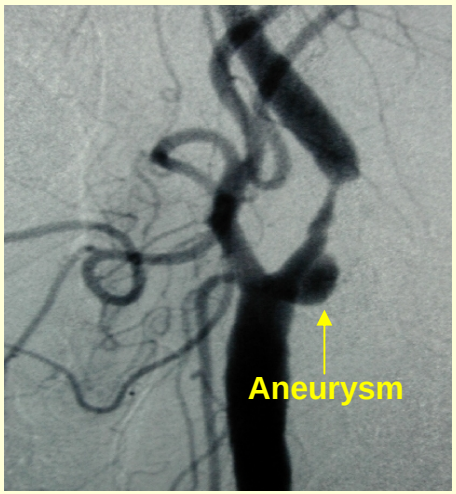
29% of screened had injury

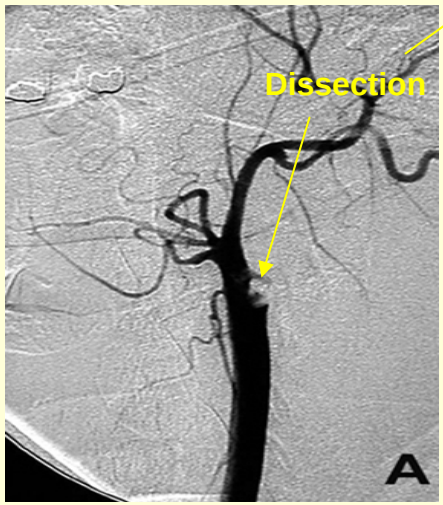
Cervical Arterial Injury

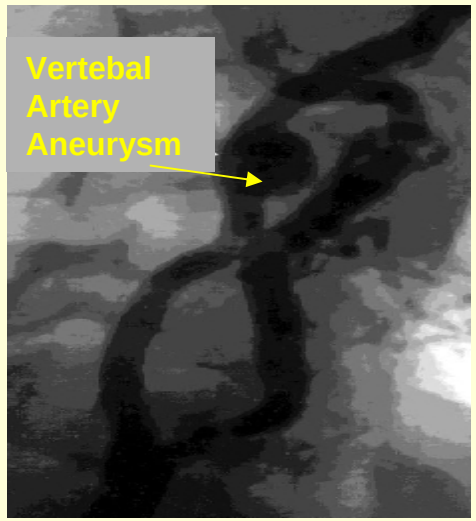








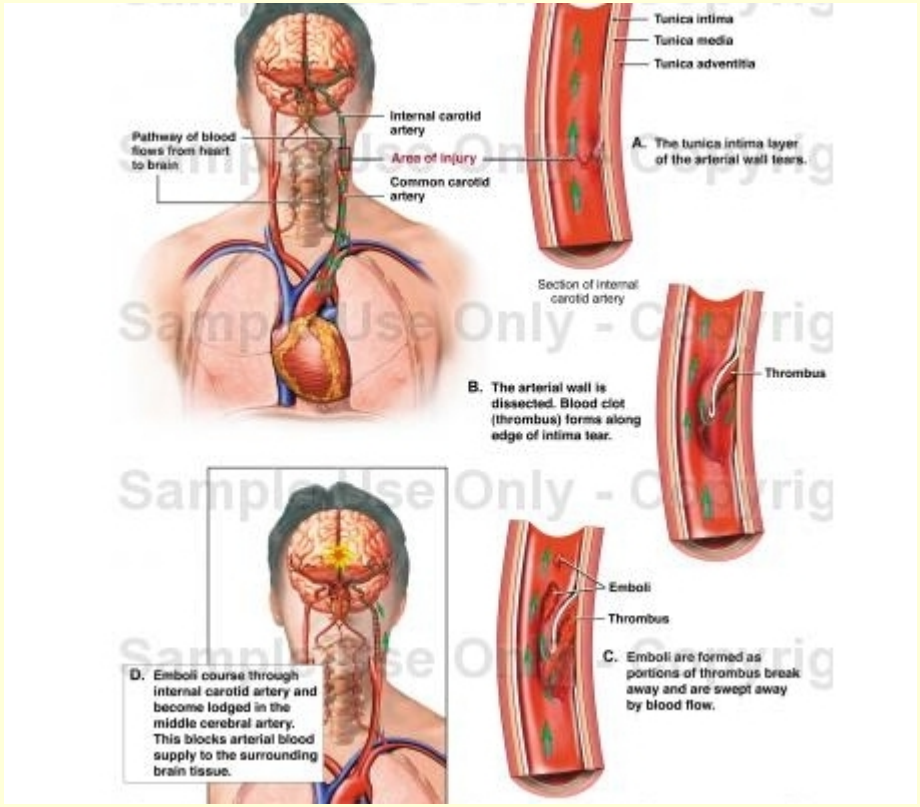




Classic Stretch Injury

- History of hyperextension (i.e. swimming)
- Severe neck to head ache near ear
- Horner’s syndrome
- Hypoglossal n. injury
- Stroke

Carotid Dissection



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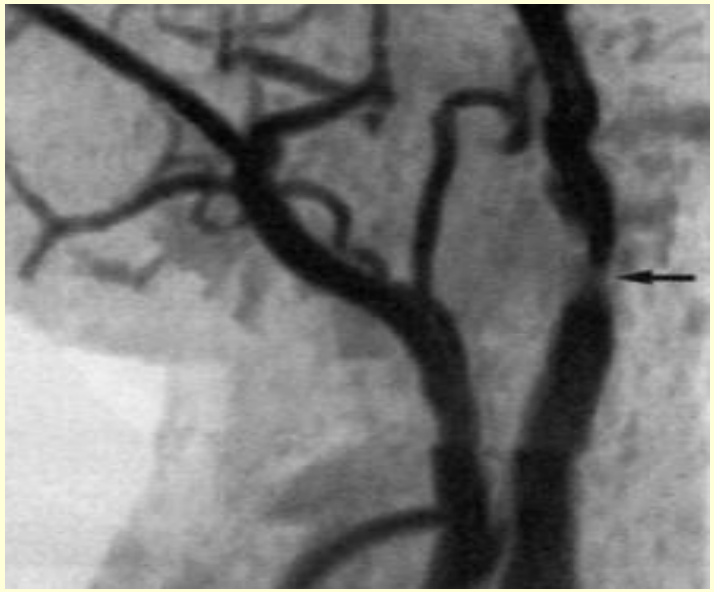

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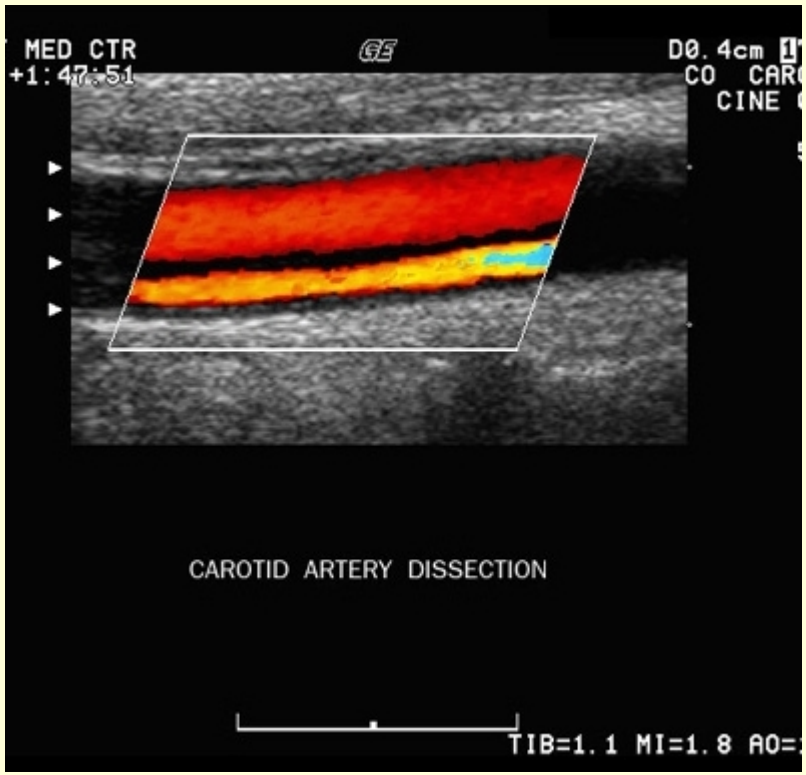


Carotid Dissection

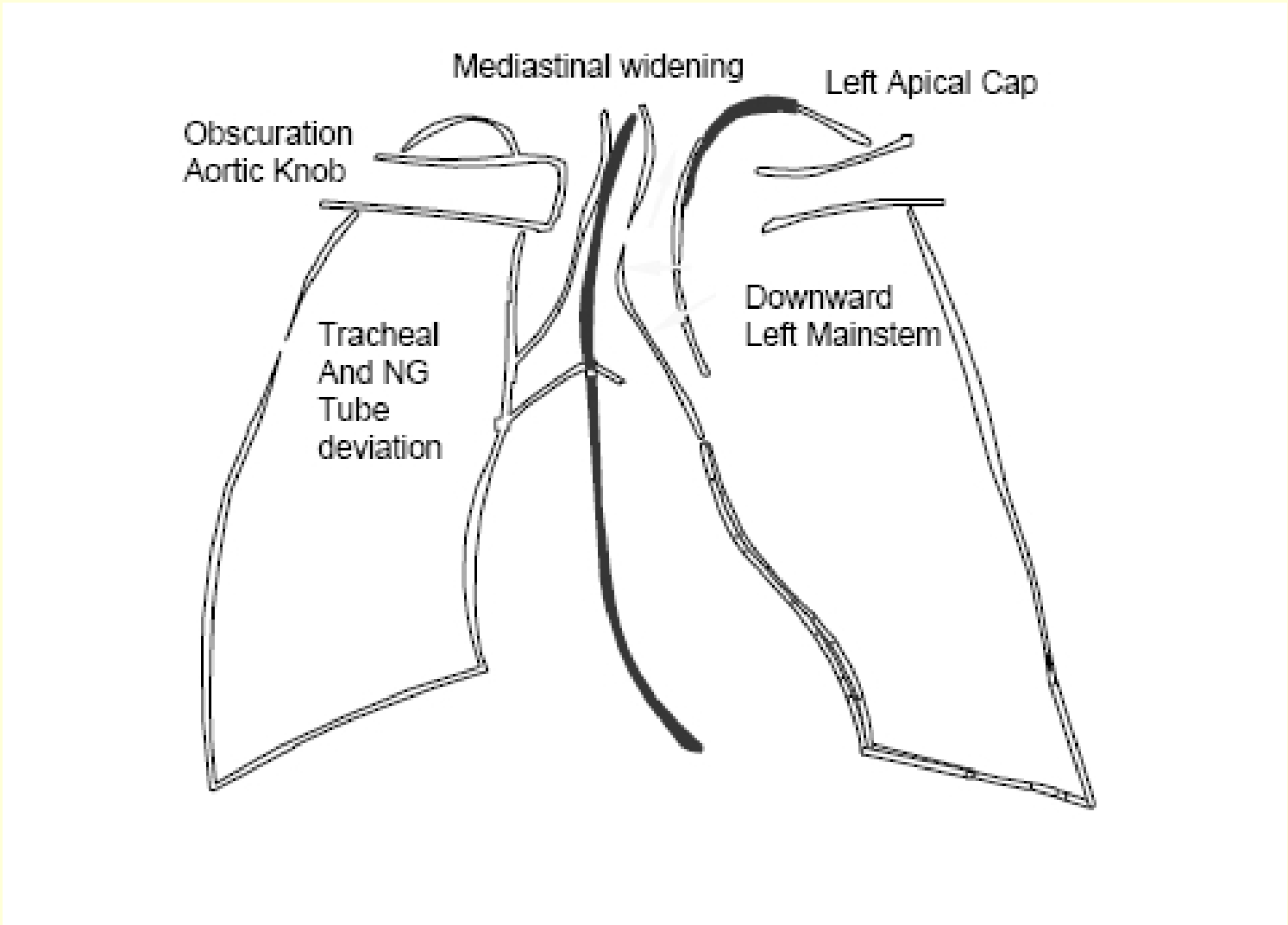
- Thrombosis-After 1-3hrs, no treatment
- Massive stroke-no Rx, anticoagulate if not contraindicated
- No or mild stroke and accessible-repair or stent
- Mild or no stroke and inaccessible-anticoagulate if not contraindicated

Blunt Thoracic Injury

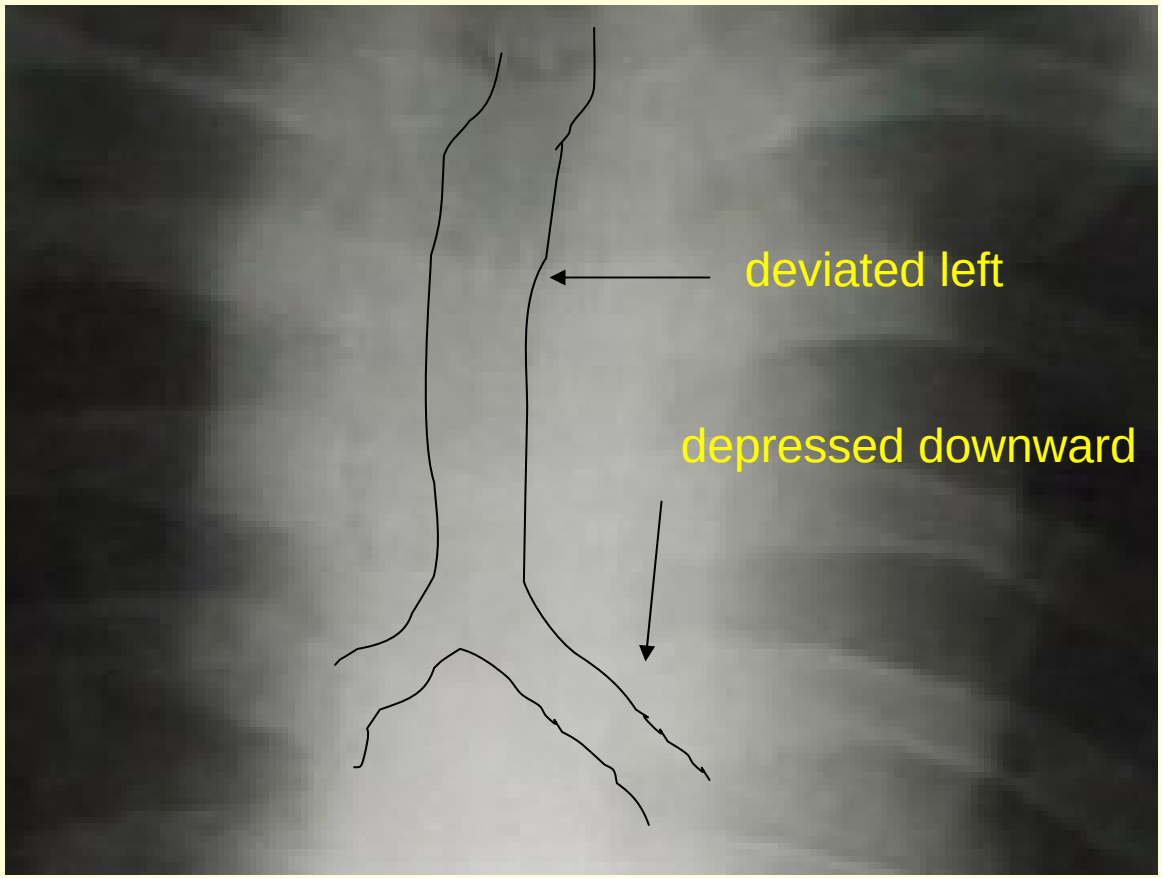
Blunt Aortic Injury

- Below the subclavian artery
- Shearing stress-fixed vs non-fixed aorta, rib cage compression, ligamentum arteriosum
- Mechanism of injury
  - Seat belt strap
  - Fractures of clavicle, ribs, strenum
  - Reversed Toyota sign
- Xray
  - Apical Cap
  - Widening of mediastinum
  - Indistinct aortic nob
  - Trachaia deviation, bronchus depressed
- CT

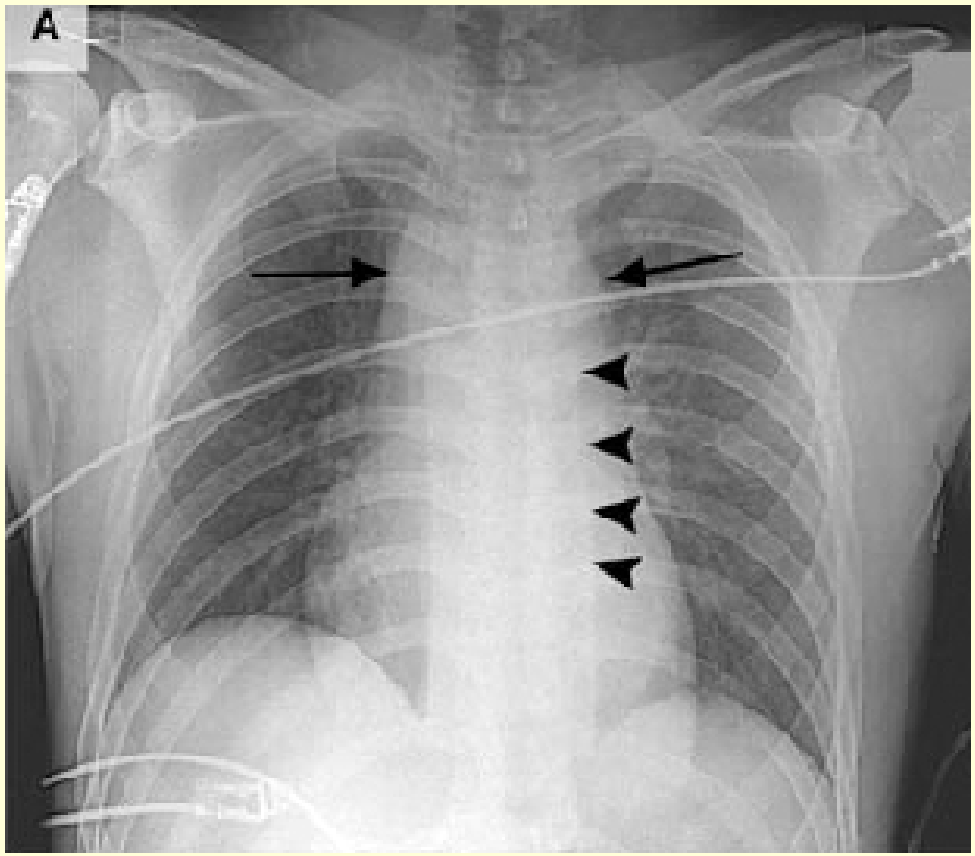
Xray


Mediastinal widening
Left Apical Cap
Obscuration
Aortic Knob
Downward
Left Mainstem
Tracheal
And NG
Tube
deviation

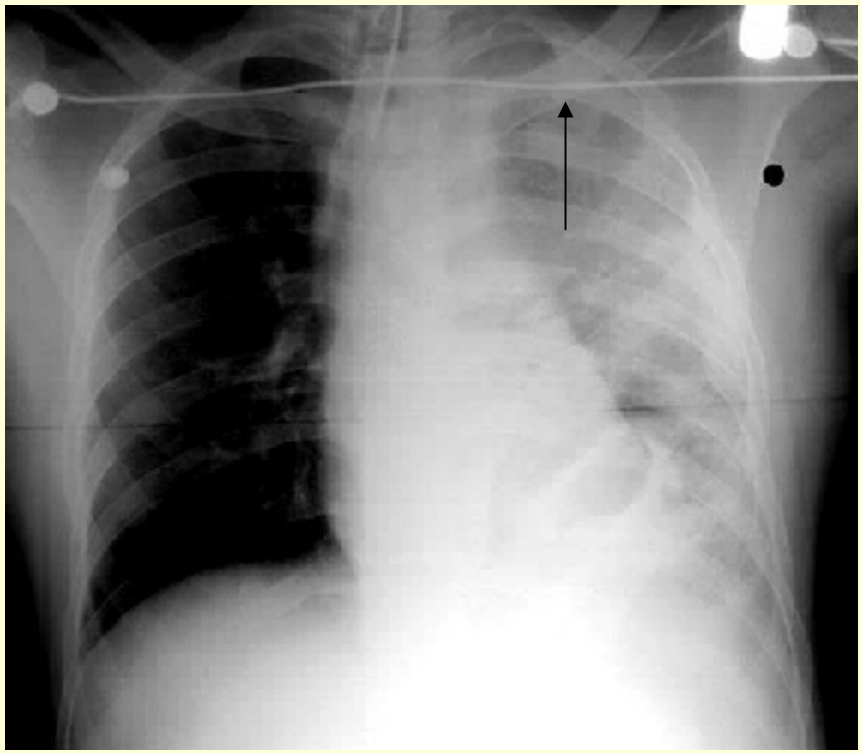
Deviated Trachea



Widened Mediastinum/Aortic Knob



Apical Cap



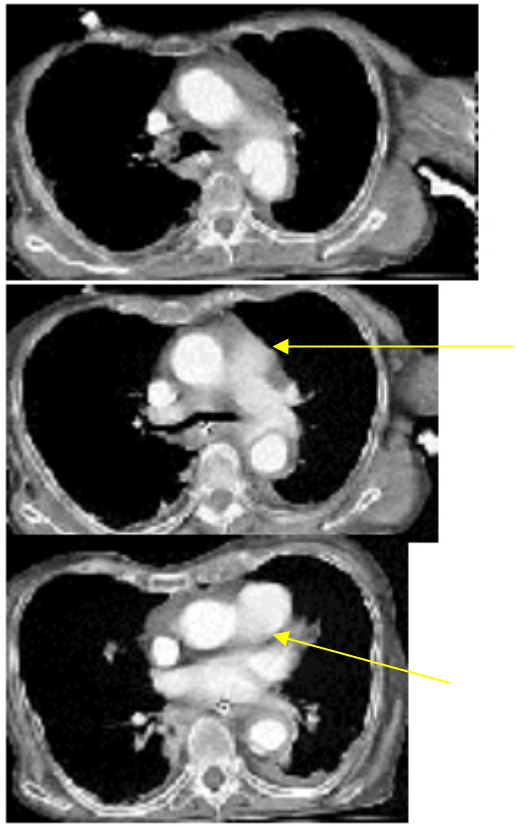
Xray

Chest x-ray screen

Positive predictive value	10%
Negative predictive value	98%

Too many false positives

CT



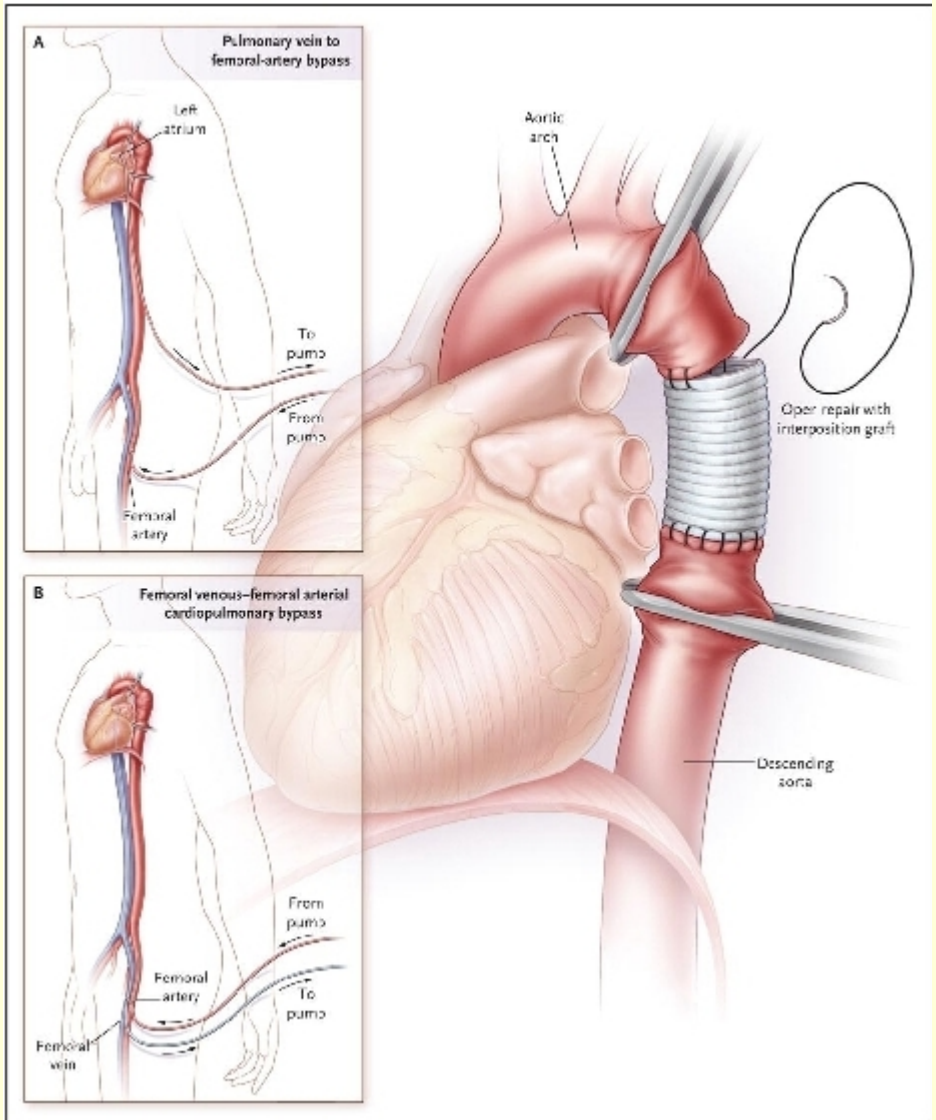
Treatment

- Emergency treatment-hemodynamically unstable **because of aortic injury**
- Expectant
  - Hemodynamically unstable because of other injuries
  - Hemodynamically stable
- No treatment-missed, lost to followup

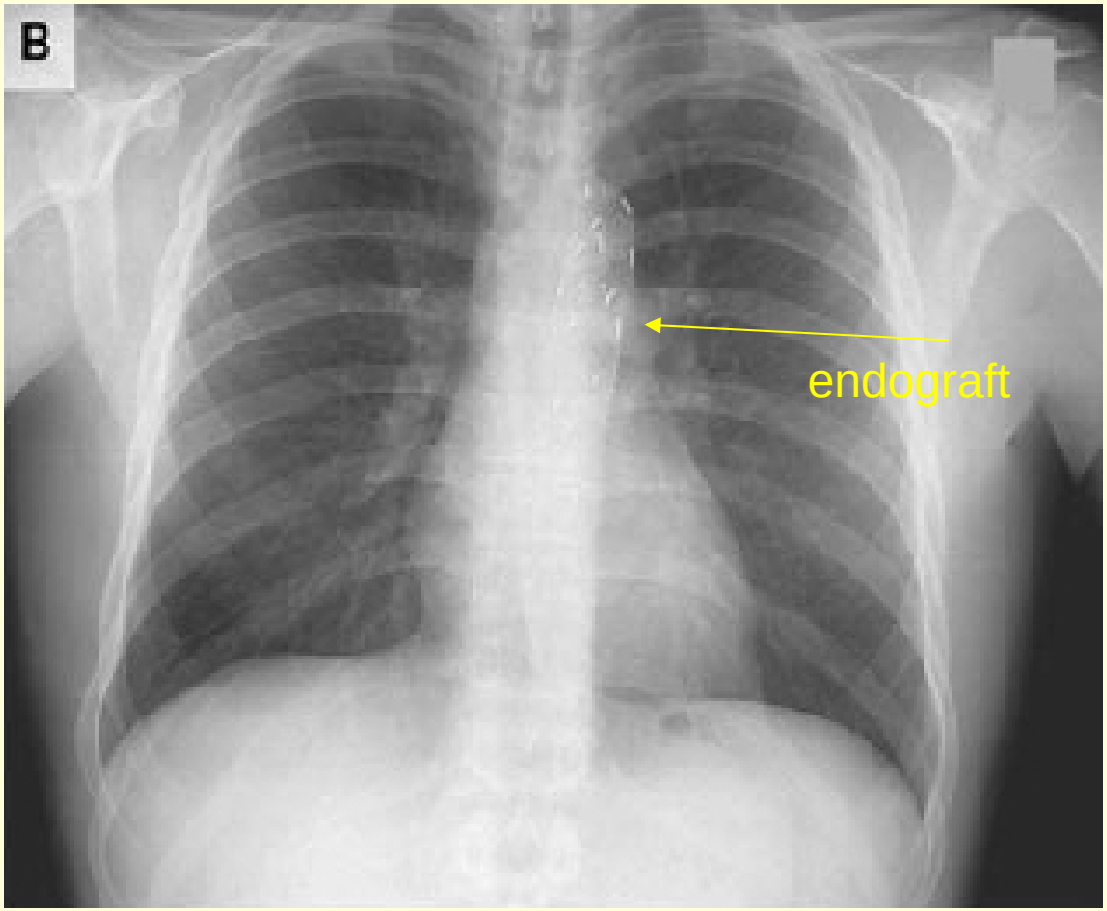
Treatment

- Initial blood pressure control
- Surgery
  - Bypass
  - Clamp and sew
- Endovascular surgery

Surgery


A
Pulmonary vein to femoral-artery bypass
Left atrium
To pump
From pump
Femoral artery
B
Femoral venous–femoral arterial cardiopulmonary bypass
From pump
Femoral artery
To pump
Femoral vein
Aortic arch
Oper repair with interposition graft
Descending aorta

Endovascular Surgery



Results

Table 1. Comparison of Operative Approaches to Blunt Aortic Injury.

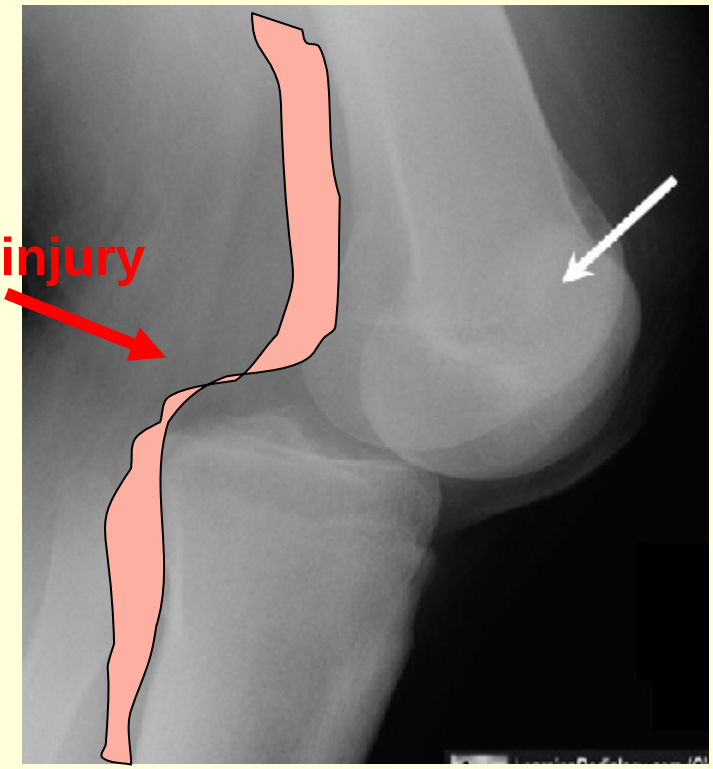
Variable	Relative Degree of Risk*		
	Clamp and Sew	Shunt–Bypass	Endovascular Repair
Complication			
Operative stress	High	Medium	Low
Blood loss	Medium	Medium	Low
Operative time	Medium	High	Low
Paraplegia	High	Medium	Low
Clinical scenario			
Patient with high surgical risk	High	Medium	Low
Patient with severe lung injury	High	Medium	Low
Patient with severe head injury	High	High	Low
Patient with challenging anatomy	Medium	Low	High

* Relative degree of risk refers to a general comparison among the three operative procedures.

Peripheral Injury

- Hard signs–explore-especially the 2 p's
- Soft signs-diagnostic test to rule out or watch
- Mandatory diagnostic test-posterior dislocation of knee or elbow
- Blunt trauma associated with injury to vessels
  - Supracondylar fracture of arm or leg
  - Dislocation fracture at ankle

Posterior Dislocation



Intimal Flap

- May occur in penetrating or blunt trauma without hard signs
- Issue is when to assess invasively and when to intervene
- Risks are thrombosis, embolism and pseudoaneurysm
- Consensus that most may be observed
- Anticoagulation unnecessary-possible ASA

Observation

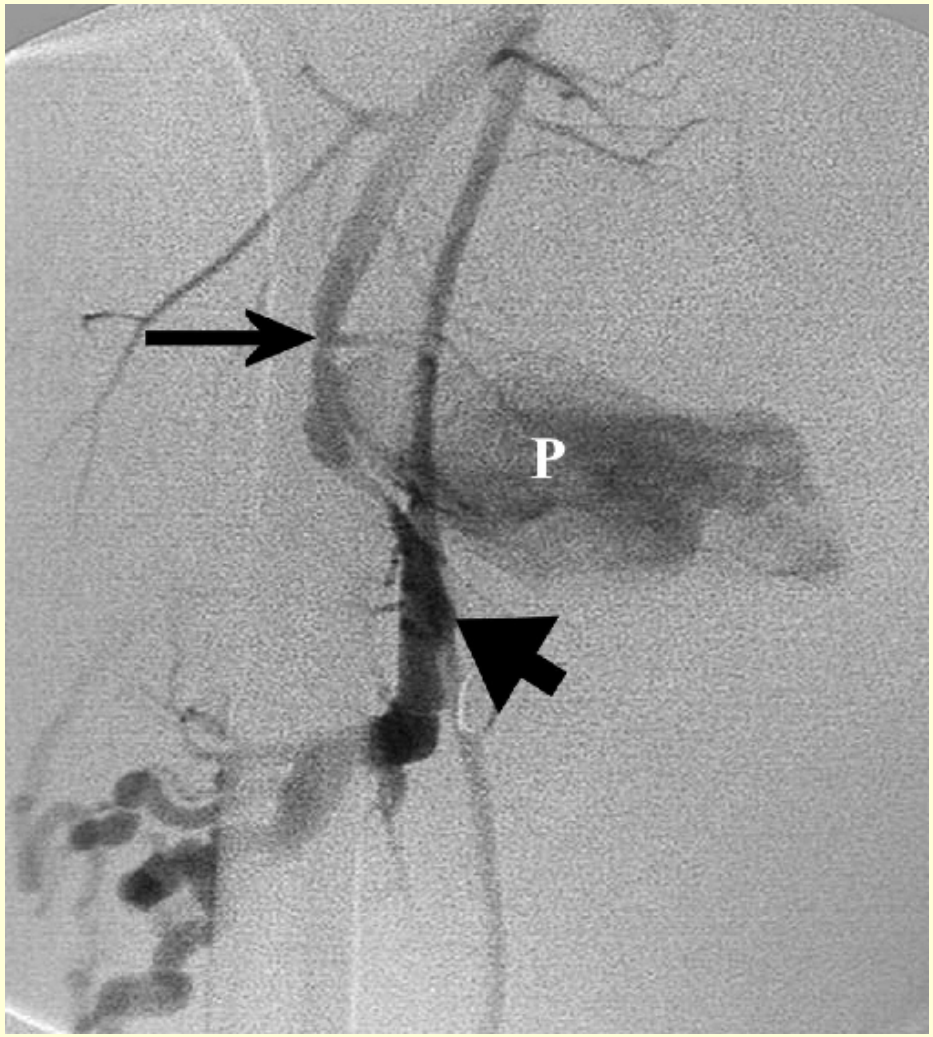
- Most have no sequallae
- May thrombose
- Long term
  - Fistula
  - Pseudoaneurysm
- Embolism

Intimal Flap

At Injury

No treatment-6 weeks

A-V Fistula



Posttraumatic Pseudoaneurysm