

Complications of Indwelling Catheters

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Case Presentation

77 y/o AA female presented to LICH on 7/13/05 with abdominal pain, fever, chills, N/V and non bloody diarrhea secondary to perforated sigmoid diverticulitis with phlegmon. Pt initially underwent VIR drainage of LLQ collection and was found to have feculent drainage with extravasation. Pt subsequently underwent operative exploration with sigmoid colon resection and end colostomy on 7/15/05.

PMHx: DM, HTN, sigmoid diverticulosis
no history of PVD

Hospital Course

Pt subsequently had protracted ICU course complicated by:

- ❖ multiple bouts of sepsis
- ❖ acute renal failure
- ❖ ARDS/ pulmonary edema
- ❖ pneumonia
- ❖ CVA (right occipital)
- ❖ respiratory failure (s/p tracheostomy 7/29)

Hospital Course

- POD # 21: pt was hypotensive and febrile to 103 with increased WBC of 33. Blood cultures were positive and patient was started on ABx therapy for repeated bout of sepsis.
- Femoral artery line was placed for hemodynamic monitoring.
- POD # 36 : pt required revision of her wound. Pt underwent exploratory laparotomy, small bowel resection and placement of feeding jejunostomy.

OR time: 6.5 hours

EBL: 500 cc

Fluid replacement: 2 u PRBC/ 3 L LR

Urine output: 150 cc

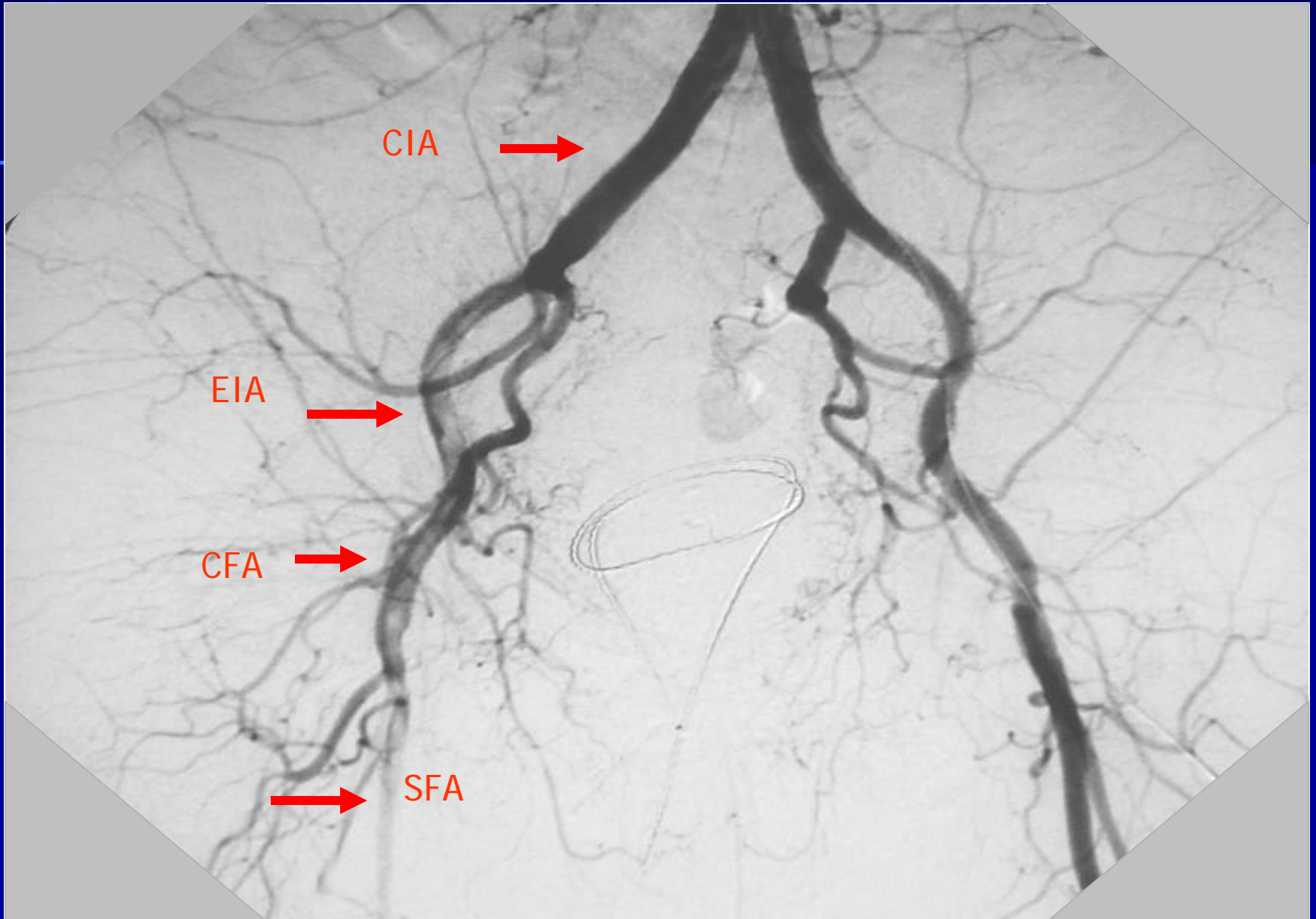
Hospital Course

- On POD # 37/1: pt noted to be oliguric, with poor response to fluid challenges, secondary to profound fluid losses during the previous 24 hours and inadequate volume resuscitation

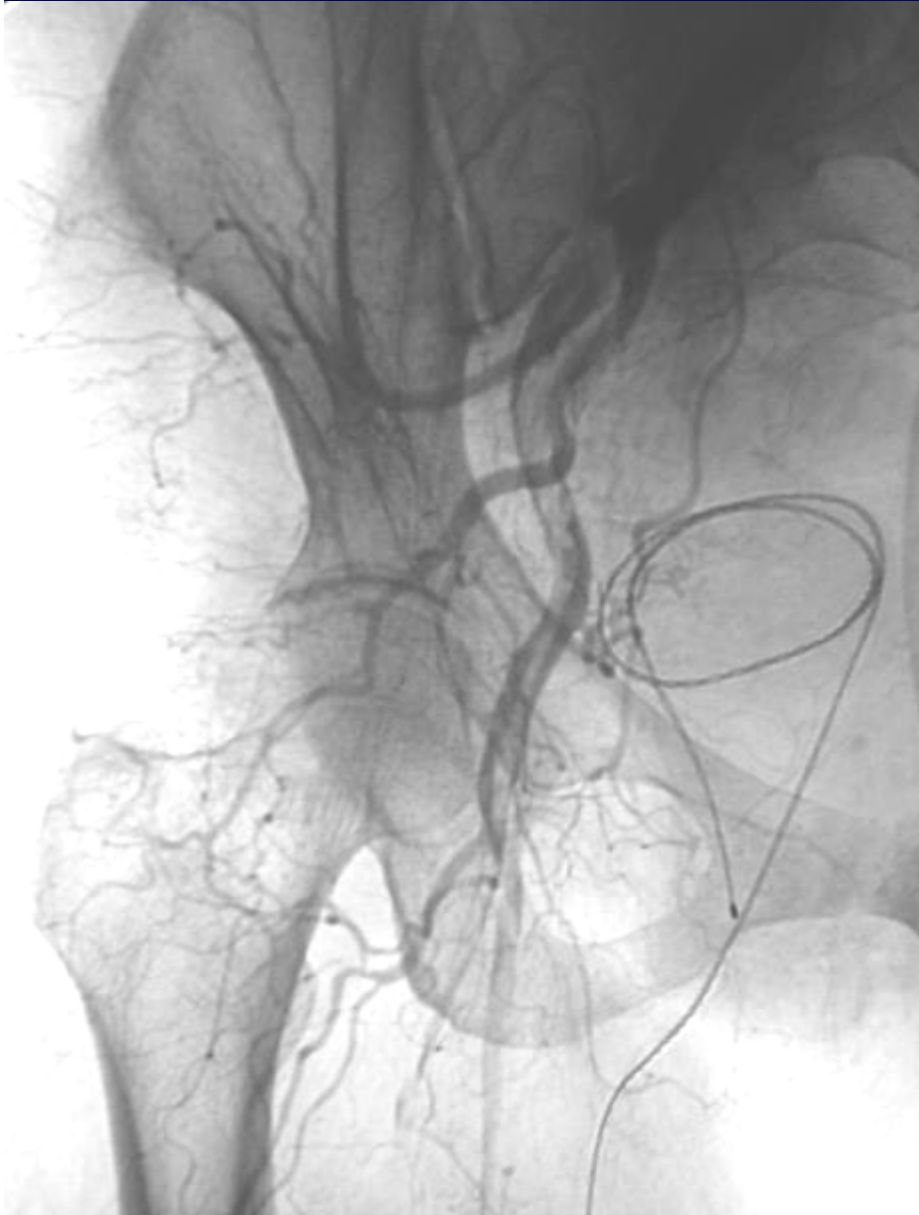
Pt required aggressive fluid resuscitation and brief pressor support. During this time patient required continued hemodynamic monitoring with CVP and a-line.

- POD # 38/2: Pt became hemodynamically normal, off pressor support; femoral arterial line discontinued (day 16)
- POD # 39/3: Pt found to have acutely cold right lower extremity without palpable pulses.
 - Vascular Consult
 - Heparin drip started immediately
 - STAT Angiogram to delineate anatomy prior to operative exploration

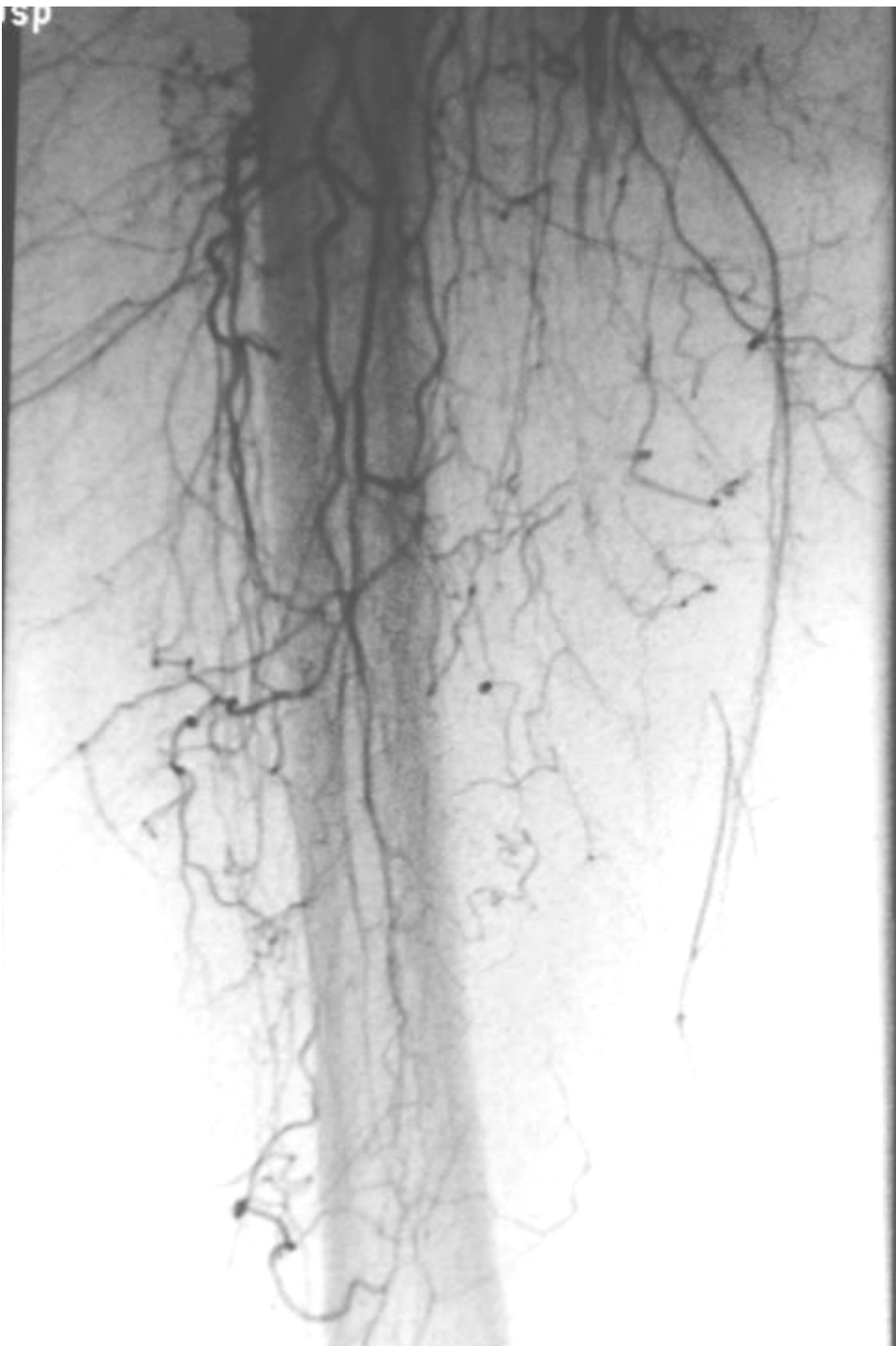
IMAGING - ANGIOGRAM



IMAGING - ANGIOGRAM



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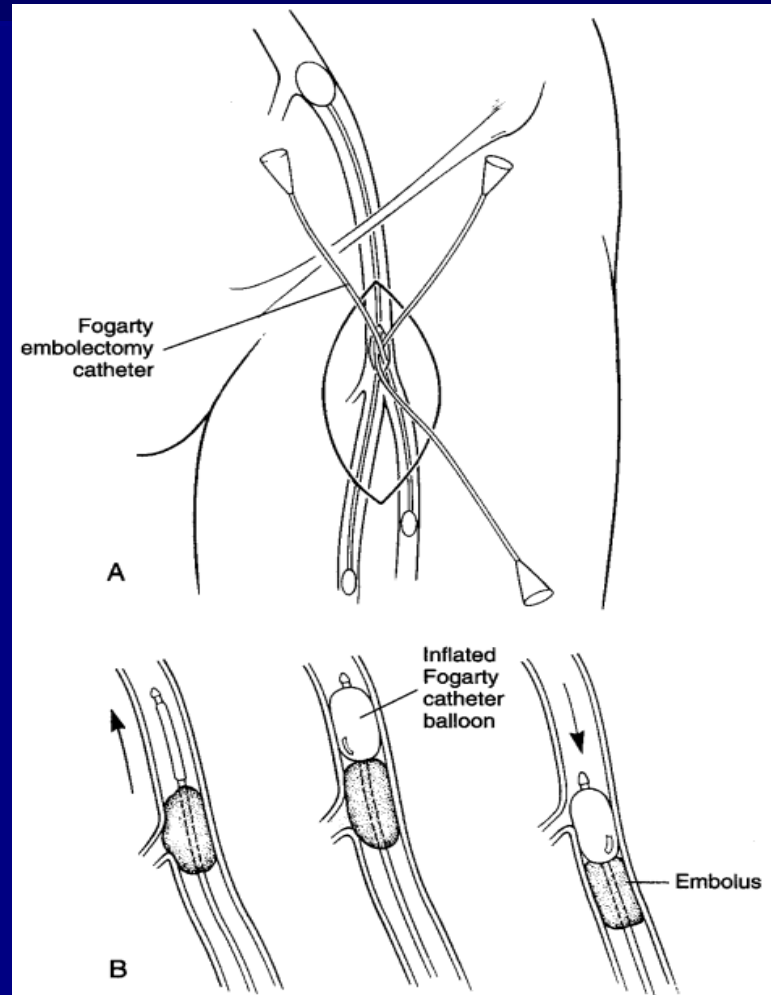
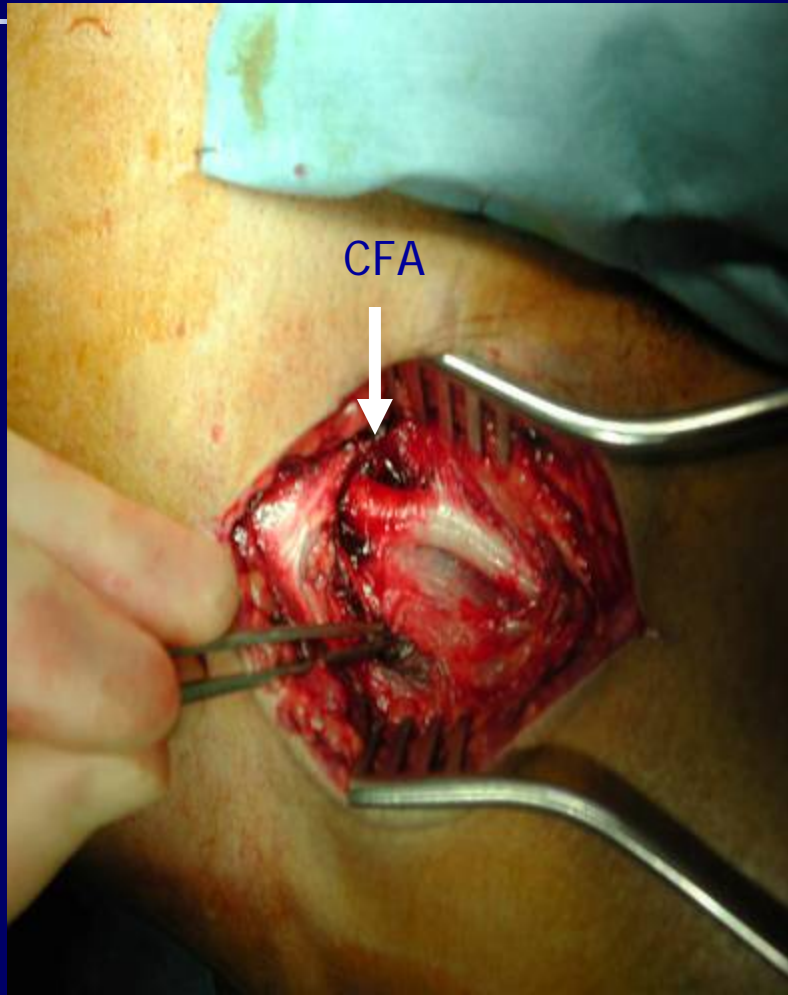


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Operative Course

- Right groin exploration
- Right CFA arteriotomy with fluoroscopy assisted thrombectomy; clots removed from CIA, CFA, DFA, SFA
 - TPA infused
 - On table angiogram revealed poor perfusion distally
- Right distal anterior tibial arteriotomy with thrombectomy performed; pulsatile flow restored, however, foot remained mottled
- 4 compartment fasciotomy performed



Post-Operative Course

Patient initially had palpable distal pulses; with cold extremity from ankle to foot

On POD 40/3/1 palpable pulse was lost; no doppler signal appreciated. Lower extremity remained cool without evidence of gangrenous change

The patient's family was informed about need for AKA; refused all further interventions and made patient DNR; Pt continued to have complicated course and clinically deteriorated; Pt expired on POD # 68

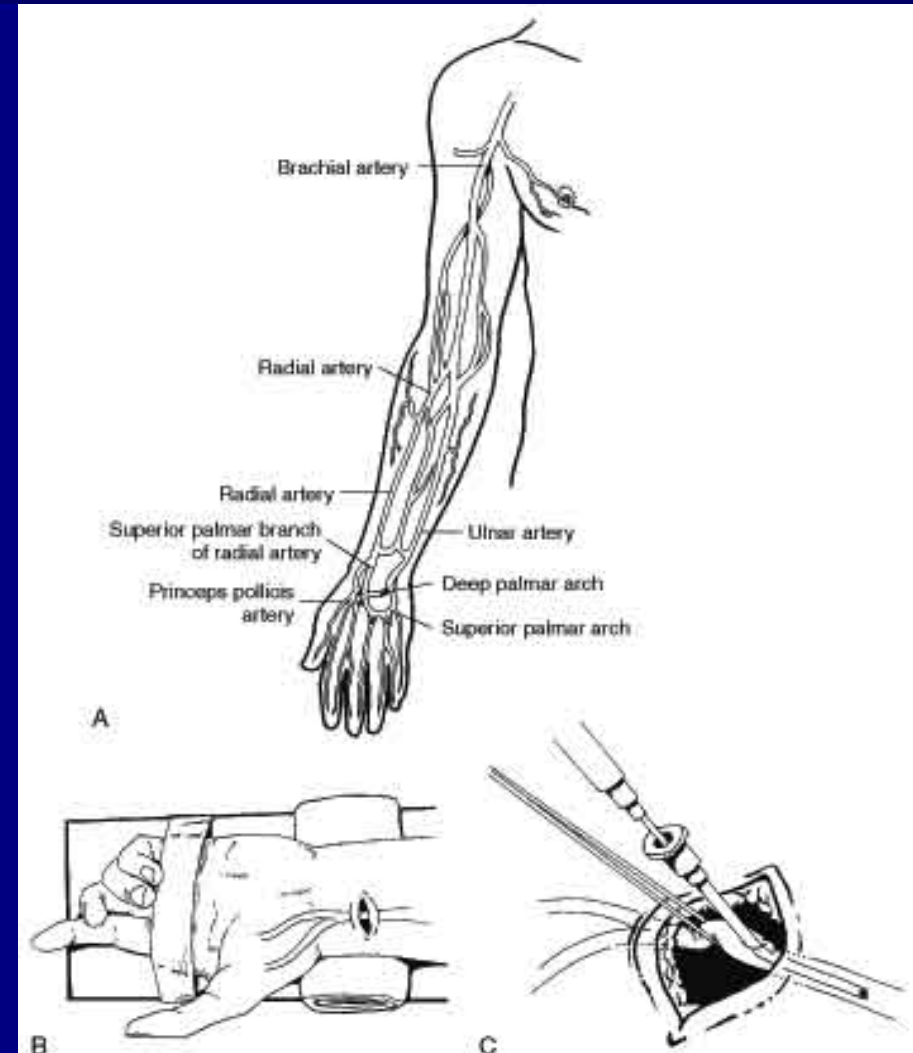
Contributing Patient Factors

- Hypotension and Low perfusion state
- Use of vasopressor medications
- Intrinsic vascular disease
- Elderly Female
- Repeated attempts at cannulation
- Long duration of femoral catheterization

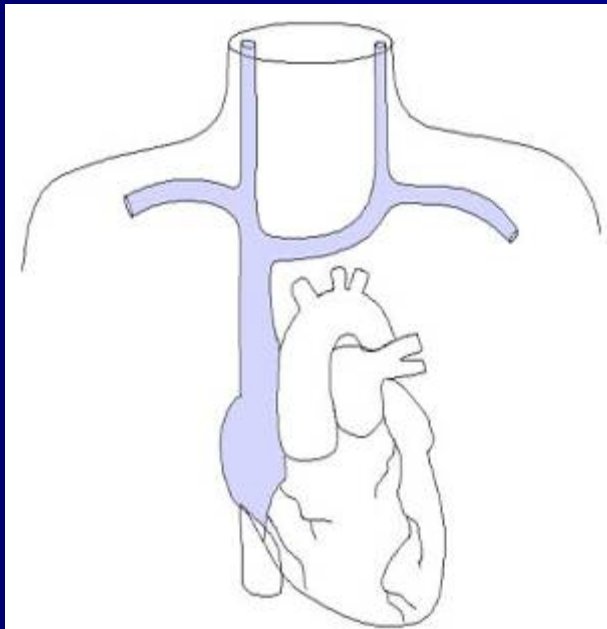
Civetta. Critical Care 3rd ed. 1997

Prevention??

- Attempting to gain access at preferred sites via open exposure (i.e. radial artery cut down)
- Alternate site: Axillary artery
- Avoiding femoral site secondary to high probability of underlying PVD
- Avoiding prolonged femoral catheterization

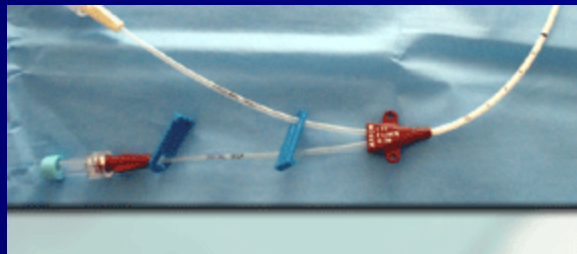


Complications of Indwelling Catheters



Introduction - CVC

- More than 5 million central venous catheters are inserted every year
- More than 15% of patients who receive these catheters have complications
 - Mechanical complications 5-19% of patients
 - Infectious complications 5-26% of patients
 - Thrombotic complications 2-26% of patients



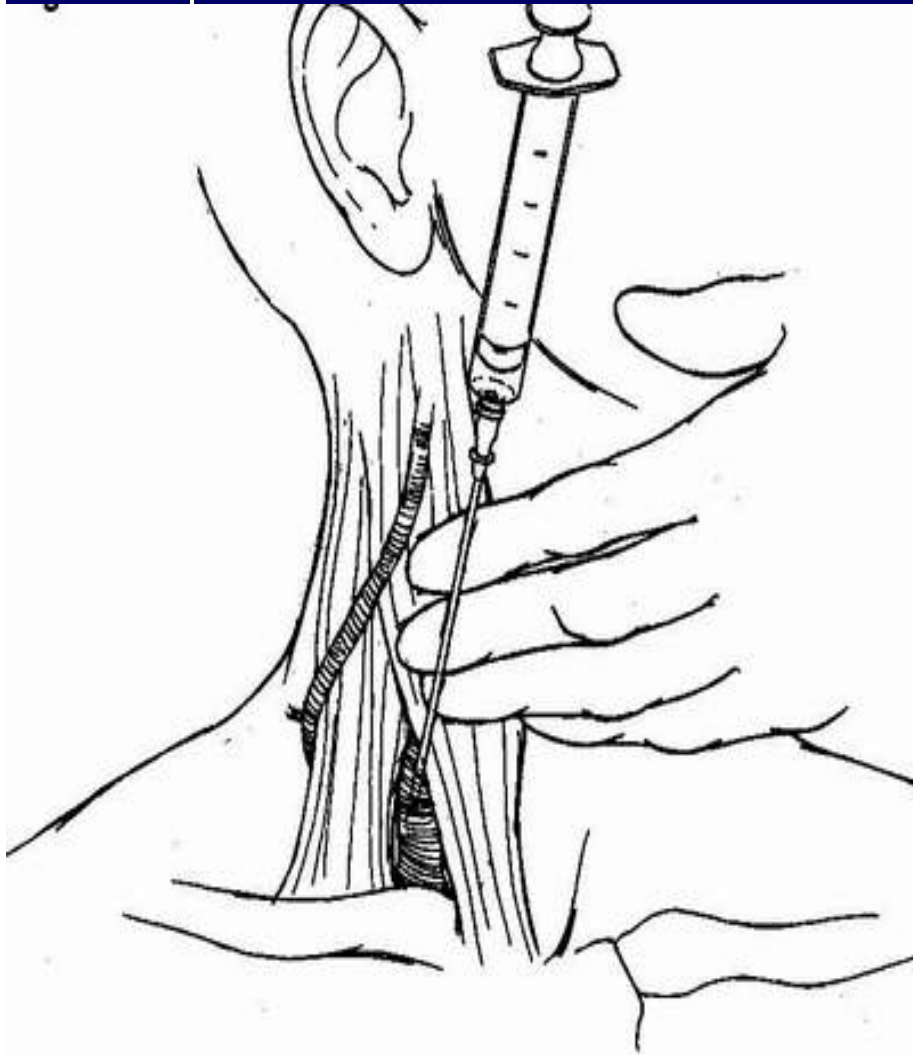
McGee DC, Gould MK. Preventing Complications of Central Venous Catherizations. N Engl J Med. 2003; 348 (12): 1123-33

Indications for Central Access

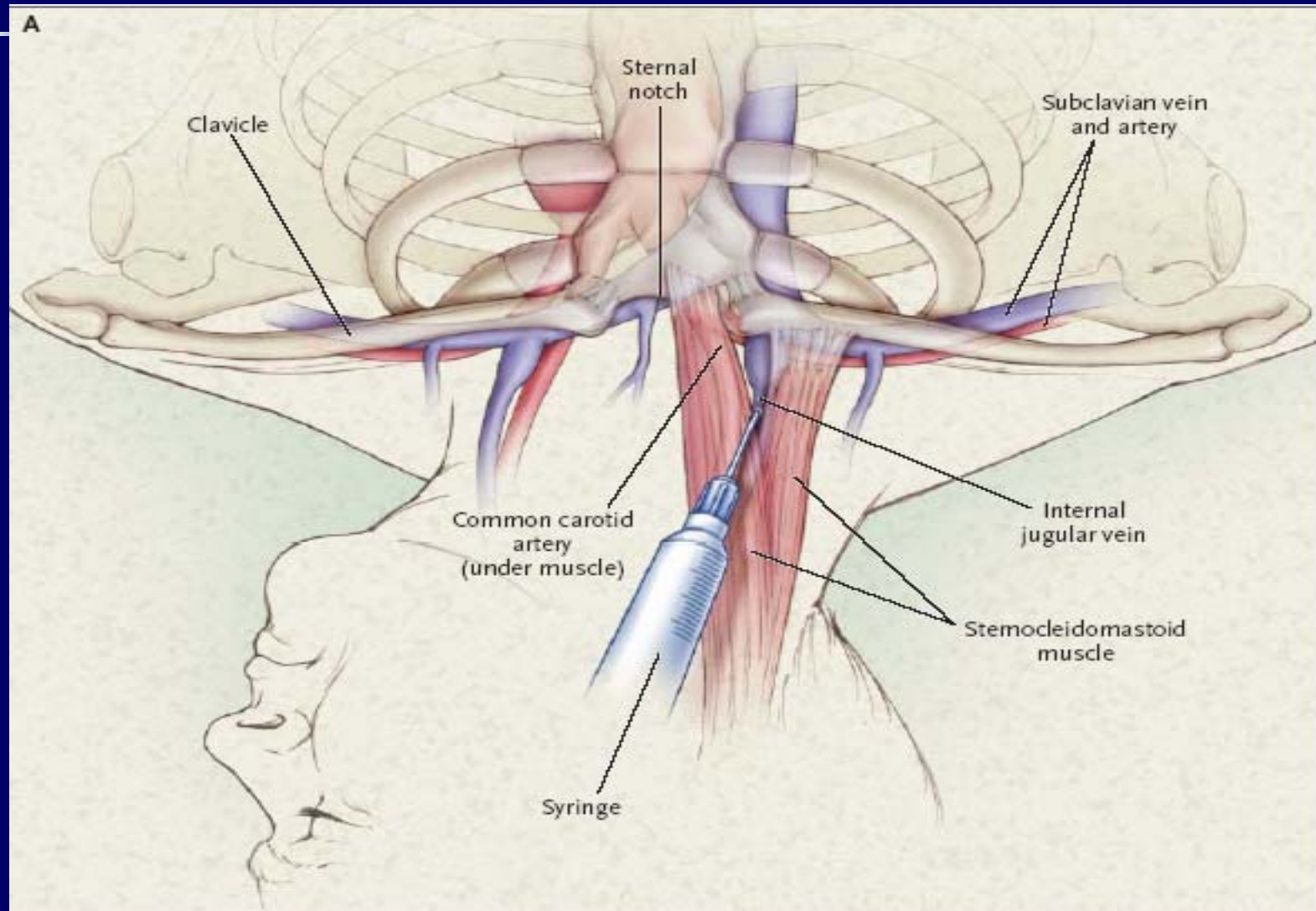
- Hemodynamic monitoring of CVP
- Rapid fluid resuscitation
- Lack of accessible peripheral veins
- Administration of vasopressors
- Total Parenteral Nutrition
- Administration of drugs or solutions that are irritating to peripheral veins (i.e KCL and chemotherapy agents)

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management* 1997

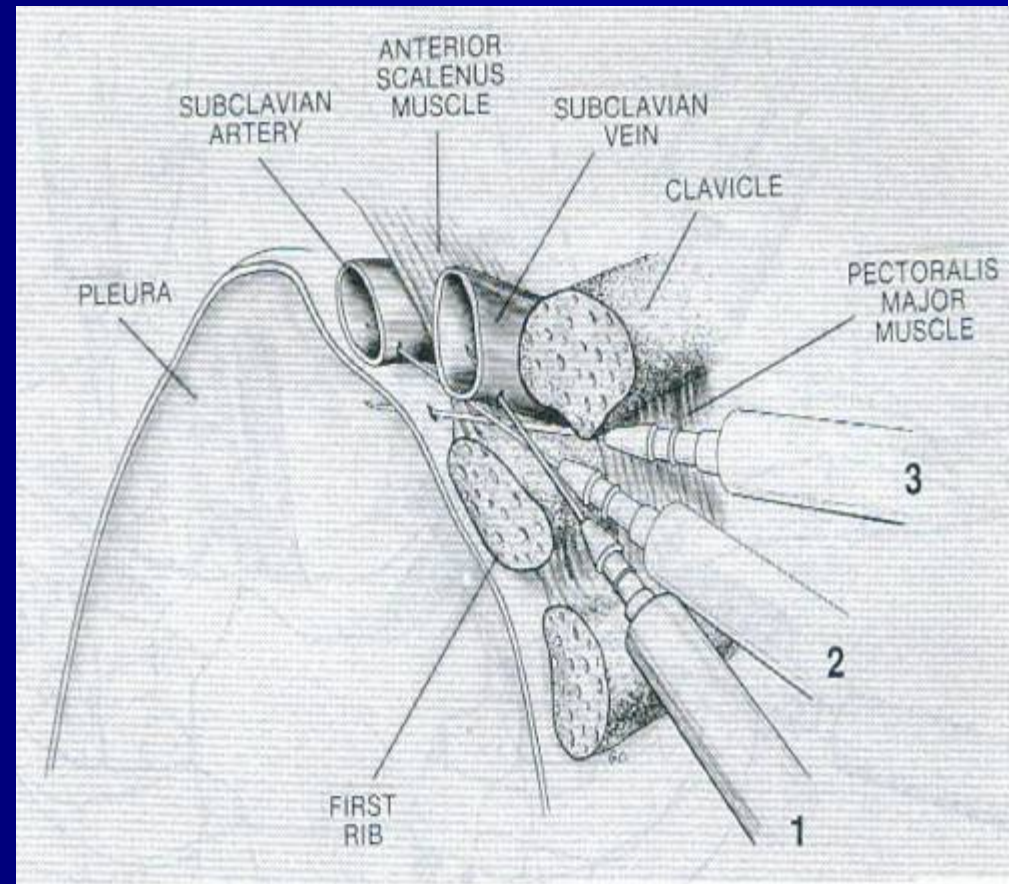
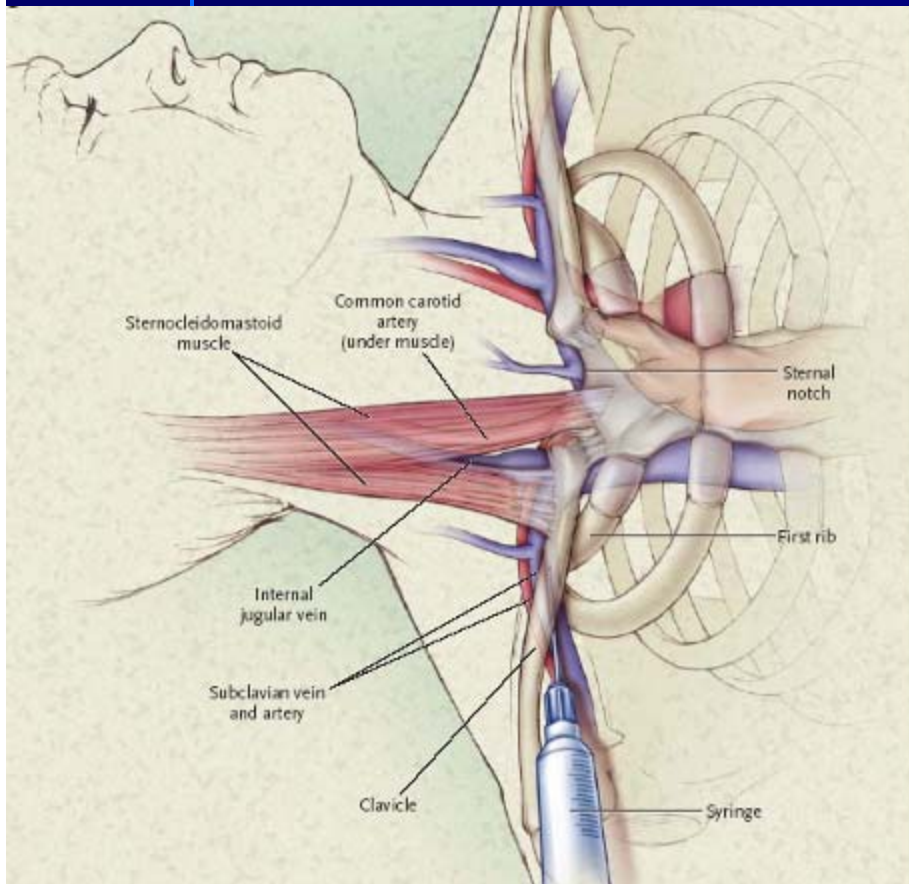
Anatomy – Internal Jugular



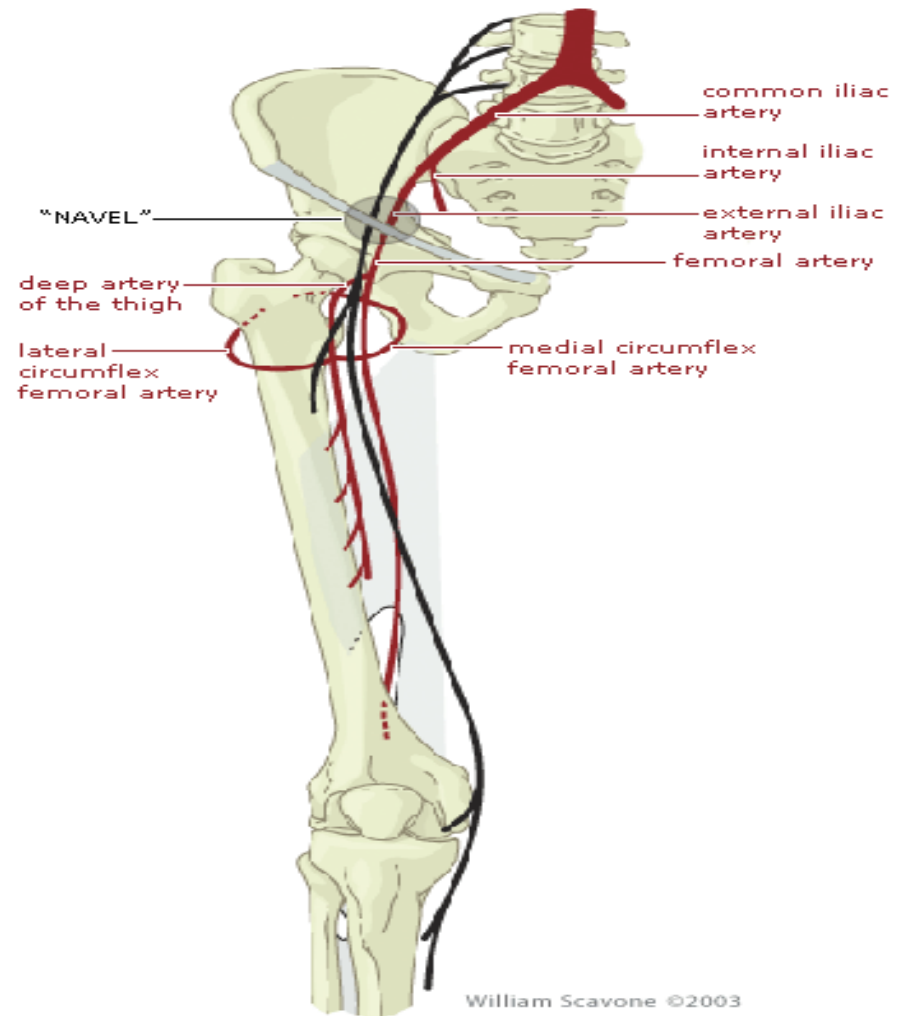
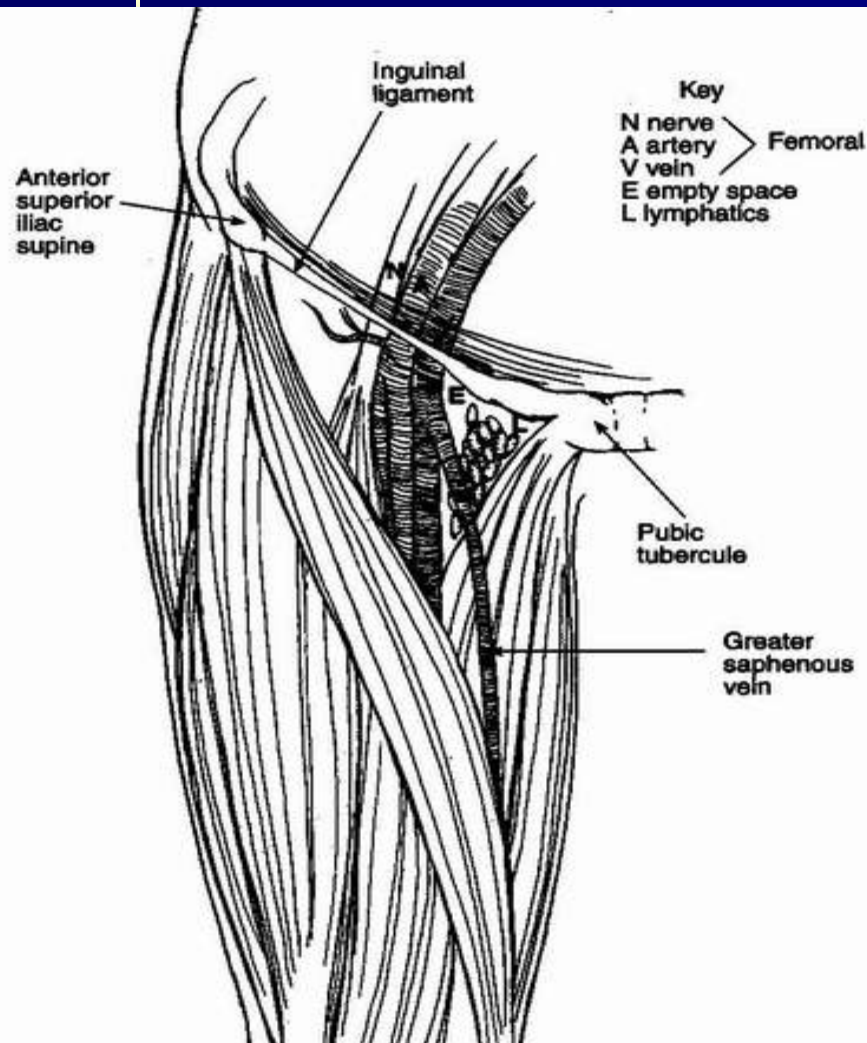
Internal Jugular Cannulation



Anatomy- Subclavian Vein



Anatomy of Femoral Vessels



Complications of Central Venous Catheters

- Pneumothorax
- Arterial Puncture
- Hematoma
- Dysrhythmias
- Vascular/Cardiac Perforations
- Thrombosis
- Air Embolism
- Airway Injury/Compromise
- Catheter Malposition
- Nerve Injury
- Infection
- Thoracic Duct Injury

Thrombosis

- Etiology of catheter-related thrombosis is best described by Virchow's Triad: local trauma, stasis and altered coagulability
 - Local trauma on the central vein is influenced by the difficulty of insertion, duration of use, and the size, flexibility and composition of the catheter used
- Thrombotic material is usually found on the tip of catheters; can lead to local or distal embolization of thrombotic material; especially after catheter removal
- Can lead to limb ischemia; RARE
- Greater frequency of complications in female patients (smaller vessel lumens compared to size of catheter) and in those with existing PVD
- Predisposing Factors: low flow states, dehydration, sepsis, hypercoaguable states

1. Barnes RW, Peterson JL, Krugmire RB. Complications of femoral artery catheterization. *Am.J.of Cardiology.* February 1974 (33): 259-263

2. Edirisinghe NK, Gilchrist B, Lessin MS. Iatrogenic Vascular Lesions: Surgical Perspective. 2003 March

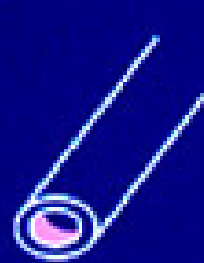
Thrombosis Con't

- Clinical importance is undefined; all have potential for embolization
- Catheter-related thrombosis occurred in 21.5 % of FVC and in 1.9% of SVC
- Risk of thrombosis is 4x greater with internal jugular lines compared to SC

Prevention

- Insert the catheter at the subclavian site; Subclavian catheterization carries a lower risk of catheter-related thrombosis than femoral or internal jugular catheterization
- Avoid trauma to vein

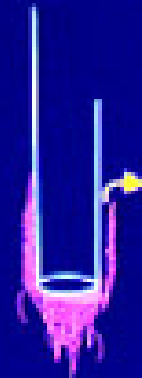
Patterns or Types of Thrombotic Occlusion



Intraluminal
Occlusion



Fibrin
Tail



Fibrin
Sheath



Mural
Thrombus

Clinical Consequences

- Signs and symptoms of vascular injuries are usually apparent immediately; pulselessness, pallor and paralysis
- Particular attention must be paid to poor capillary refill, coolness, diminished pulses, bruits, thrills, blanching, bluish discoloration, lack of movement and mottling
- Signs may be transient or may progress rapidly; depends on type of occlusion and collateral blood flow

Edirisinghe NK, Gilchrist B. Lessin MS. Iatrogenic Vascular Lesions: Surgical Perspective. 2003 March; e-medicine citation

Fibrin Sleeve

Pathophysiology of Thrombosis:

- Fibrin sleeves form on the catheter as soon as 24 hours post insertion
- Stripping of the sleeve with removal of the catheter may result in subsequent occlusion at the puncture site or distal embolization
- The arterial injury is often at the level of the common femoral artery secondary to multiple attempts to gain arterial access in the groin

Edirisinghe NK, Gilchrist B. Lessin MS. Iatrogenic Vascular Lesions: Surgical Perspective. 2003 March; e-medicine citation

Effect of Existing PVD

- Proximal obstructions may cause difficulty in passing the catheter; increased risk of arterial dissection or thrombosis
- Distal disease limits arterial run-off, limb is more susceptible to ischemia after the occurrence of distal thromboemboli that may be well tolerated in patients with normal vasculature

Barnes RW, Peterson JL, Krugmire RB. Complications of femoral artery catheterization. Am.J.of Cardiology. Febuary 1974 (33): 259-263

Mechanical Complications

Prevention

- Recognize risk factors for difficult catheterization
- Use ultrasound guidance during internal jugular catheterization; reduces the rates of unsuccessful catheterization, carotid artery puncture and hematoma formation
- Do not schedule routine catheter changes; each insertion at a new site increases the risk of mechanical complications for the patient
- A physician should only make 3 attempts; the incidence of mechanical complications after three or more insertion attempts is six times the rate after one attempt

Mechanical Complications

Table 2. Frequency of Mechanical Complications, According to the Route of Catheterization.*

Complication	Frequency		
	Internal Jugular	Subclavian <i>percent</i>	Femoral
Arterial puncture	6.3–9.4	3.1–4.9	9.0–15.0
Hematoma	<0.1–2.2	1.2–2.1	3.8–4.4
Hemothorax	NA	0.4–0.6	NA
Pneumothorax	<0.1–0.2	1.5–3.1	NA
Total	6.3–11.8	6.2–10.7	12.8–19.4

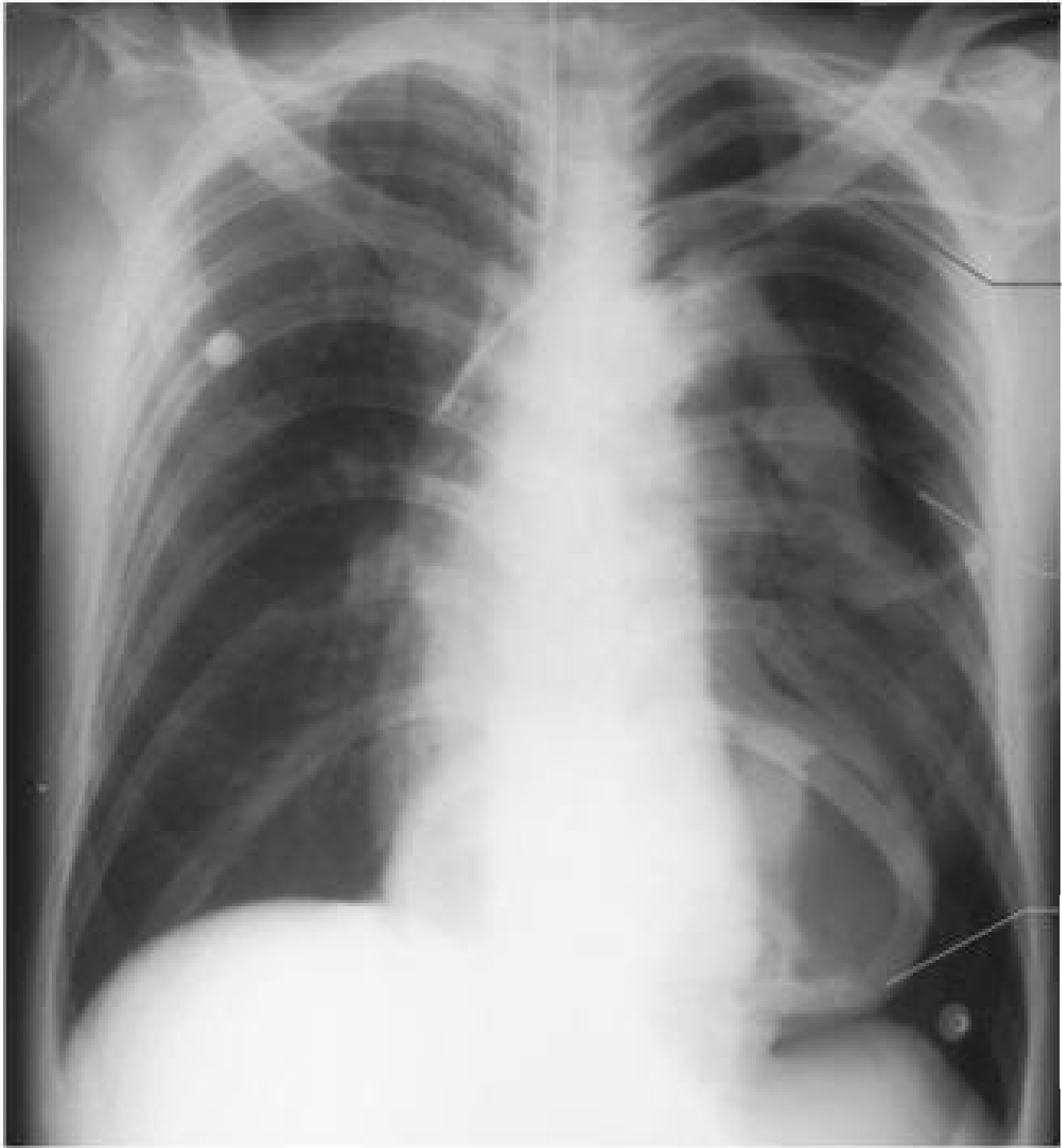
McGee DC, Gould MK. Preventing Complications of Central Venous Catherizations. *N Engl J Med.* 2003; 348 (12): 1123-33

Pneumothorax

- One of the most serious and potentially life-threatening complications of central line placement
- Reported incidence ranges from 0-6%
- Incidence is higher with subclavian vein approaches
- Clinical presentation: pleuritic CP, dyspnea, diminished breath sounds, tracheal deviation or hypotension; 1/2 of patients may be asymptomatic
- Presence of PTX must be ruled out after any failed central line attempt; especially prior to attempting line placement on the opposite side

Prevention

- **Must clearly identify landmarks and optimize patient positioning**
- **Proper supervision**
- **Use alternative approaches in high risk patients (pts with COPD, bullous disease, high PEEP, obese patients); consider IJ or femoral over subclavian access**
- **Avoid repeated probing with the needle if the vein is not located on 1st or 2nd attempt**
- **Always place the patient in Trendelenburg position to maximize the size of the vein making successful cannulation on first attempt more likely**



Left
subclavian
central line

Line related
pneumothorax

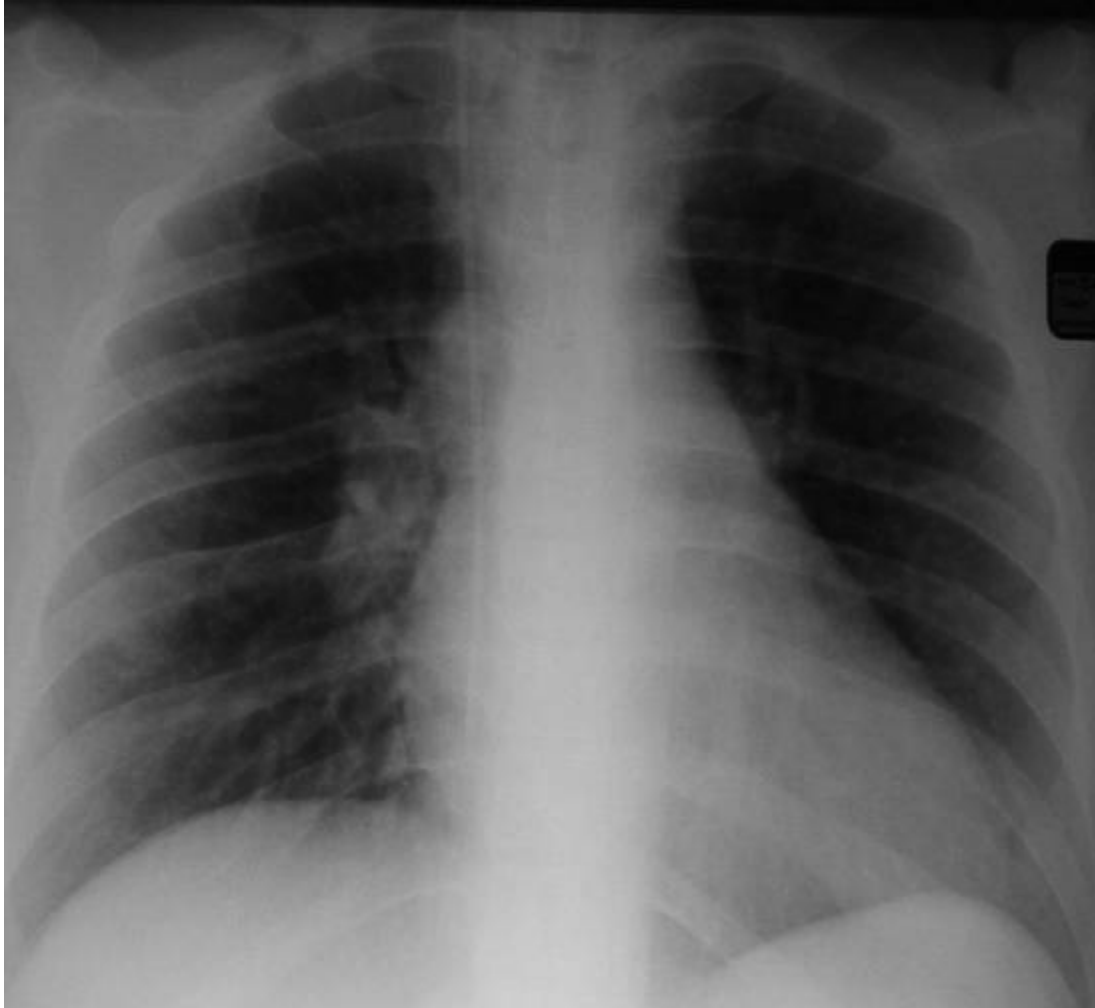
Arterial Puncture

- The incidence ranges from 0.9% to 19%
- In a patient with normal BP and arterial oxygen tension, arterial puncture is easy to identify
- In patients with profound hypotension and hypoxemia it is more obscure
- Often results in hematoma formation; must apply local pressure; Inadvertent puncture of the carotid artery in the neck can lead to large hematoma formation with possible subsequent airway compromise
- Patients at higher risk for significant bleeding are those with arterial hypertension with SBP >180 mmHg and those on anticoagulation

Prevention:

- Avoid multiple cannulation attempts
- Identify landmarks; if obscure use ultrasound guidance
- Correct coagulopathy
- Use small finder needle to locate the vein; limits potential size of arterial rent
- If in doubt; DO NOT use DILATOR
- Send an ABG
- Avoid subclavian approach in patients with coagulopathy

Dysrhythmias



- Atrial and ventricular arrhythmias frequently accompany the insertion of CVP lines
- These arrhythmias occur as a direct result of myocardial stimulation by the guidewire or catheter that has been advanced too far
- Can be minimized by using the shortest catheter that will place the tip of the CVP catheter into the SVC just above the right atrium; estimate appropriate distance of the catheter prior to cannulation

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management*. 1997

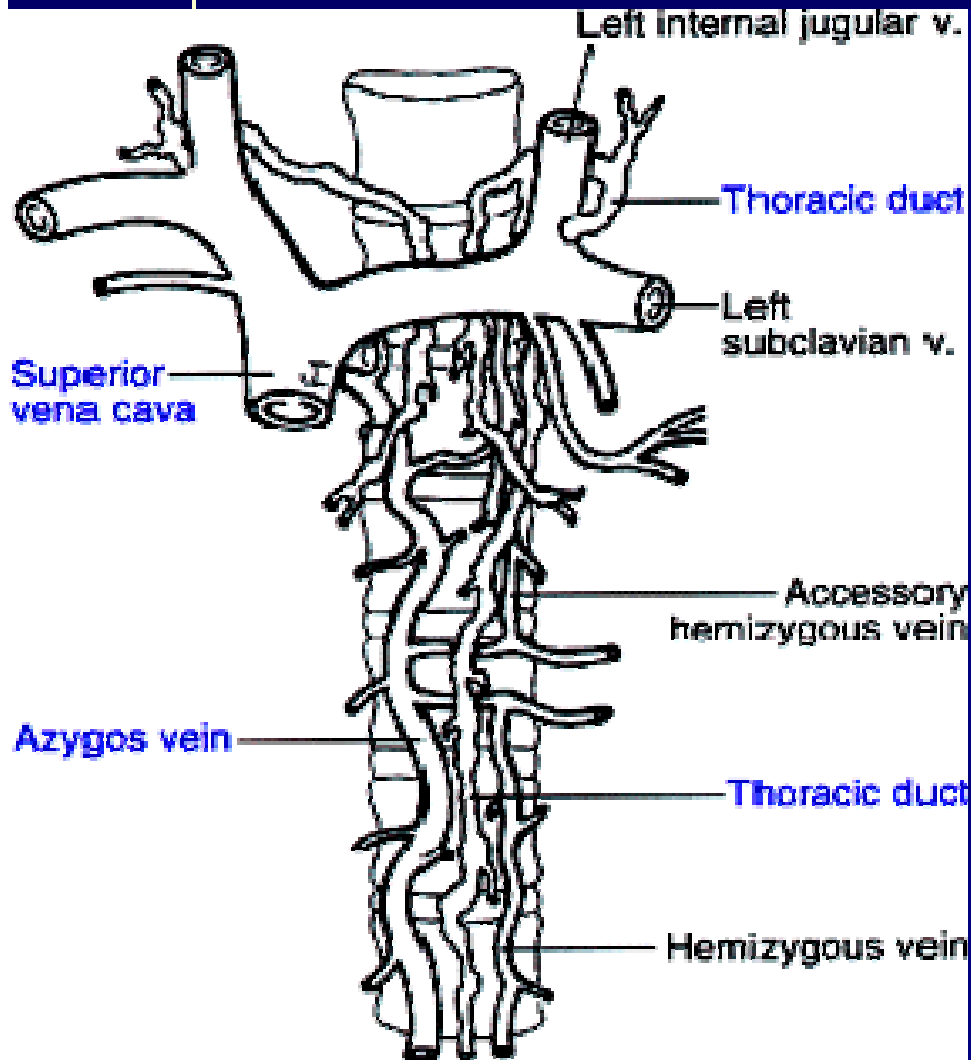
Air Embolism

- Air may enter the great veins directly after the needle is inserted; majority of cases occur during use or catheter maintenance
- Conditions that lower intravenous pressure (hypovolemia and tachycardia) and those that raise intra-thoracic pressure (hyperventilation) allow air to enter the venous system more easily
- A spontaneously breathing patient generates negative intra-thoracic pressure during inspiration. If a catheter is left open to room air, negative ITP can draw air into the vein
- Can be fatal if it is transmitted to systemic circulation via atrial or ventricular septal defect

Prevention

- Catheter hubs should be occluded at all times
- Patients should be placed in Trendelenburg's position during insertion; increases CVP and reduces the likelihood of air entry

Thoracic Duct Injury

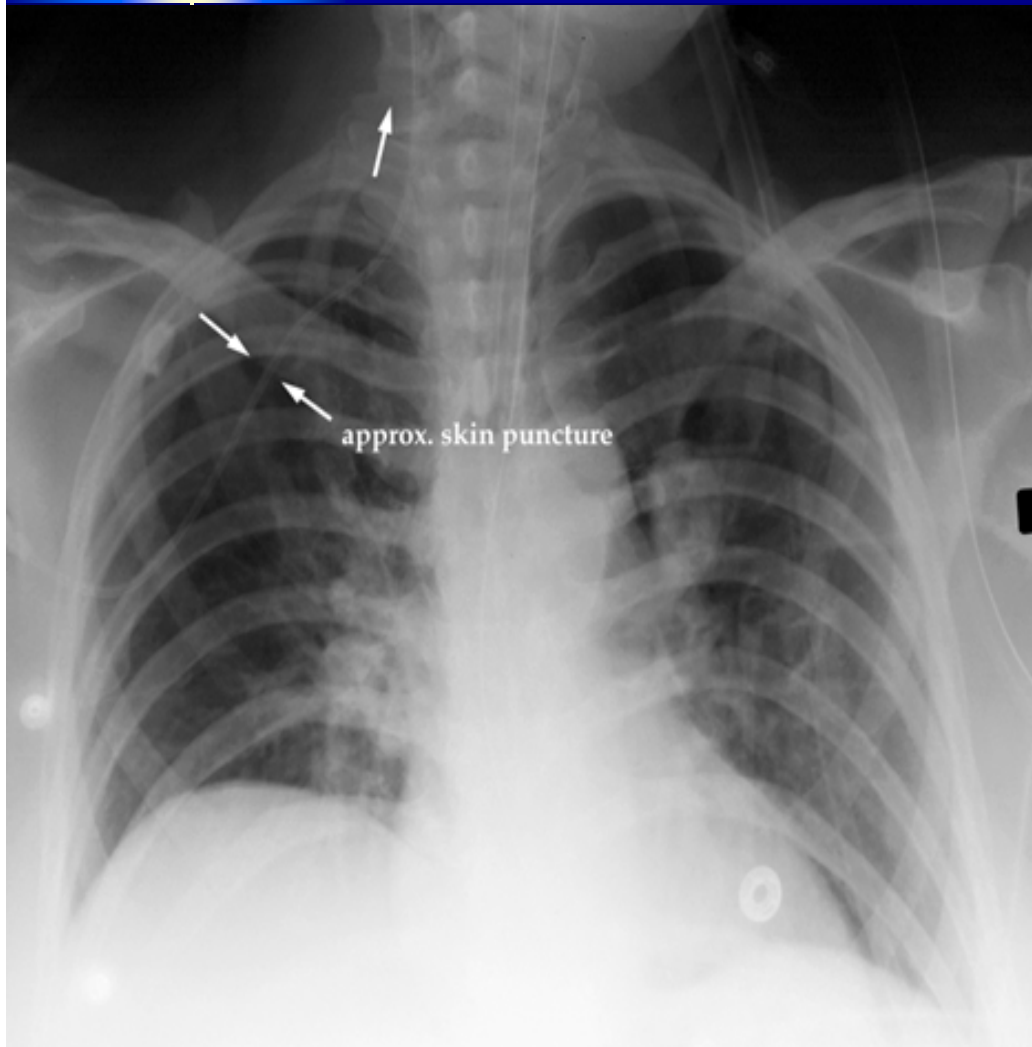


- The thoracic duct arches over the dome of the left lung lateral to the left internal jugular vein and joins the subclavian vein at the internal jugular-subclavian angle
- Reported incidence of injury is 1%
- Most commonly occurs with left sided subclavian cannulation

Prevention:

TD injury can be minimized by avoiding supraclavicular approaches to the left subclavian vein and by preferentially using the right side when possible

Catheter Malposition



Catheter position should be confirmed with CXR; should be repeated on regular basis secondary to potential for migration

Other Complications

- Catheter/Guidewire fragmentation and embolism
- Loss of guidewires into venous circulation
- Guidewire kinking or knotting
- Dislodging of Greenfield filters



Infection

Several Mechanisms:

1. Infection of the exit site with migration of the pathogen along the external catheter surface
2. Hub contamination intraluminal colonization
3. Hematogenous seeding of the catheter

Prevention

- In RCT's, the use of antimicrobial impregnated catheters has been shown to lower the rate of catheter-related bloodstream infections (4.6% to 1.0%)
- Insert catheters at the subclavian site
- Do not perform routine catheter changes

McGee DC, Gould MK. Preventing Complications of Central Venous Catherizations. N Engl J Med. 2003; 348 (12): 1123-33

Scheduled Catheter Changes

- Scheduled, routine replacement of CVC at a new site does not reduce the risk of catheter-related bloodstream infections
- Scheduled, routine exchange of catheters over a guidewire is associated with a trend towards **increased** catheter-related infections

McGee DC, Gould MK. Preventing Complications of Central Venous Catherizations. N Engl J Med. 2003; 348 (12): 1123-33

Indications for Arterial Lines

- Continuous arterial blood pressure monitoring; immediate feedback in hemodynamically unstable patients to direct therapeutic interventions
- Hypotension or hypertension requiring vasoactive drugs
- Repeated blood sampling and arterial blood gas analysis
- Major surgery for intra-operative monitoring: cardiac and NS procedures

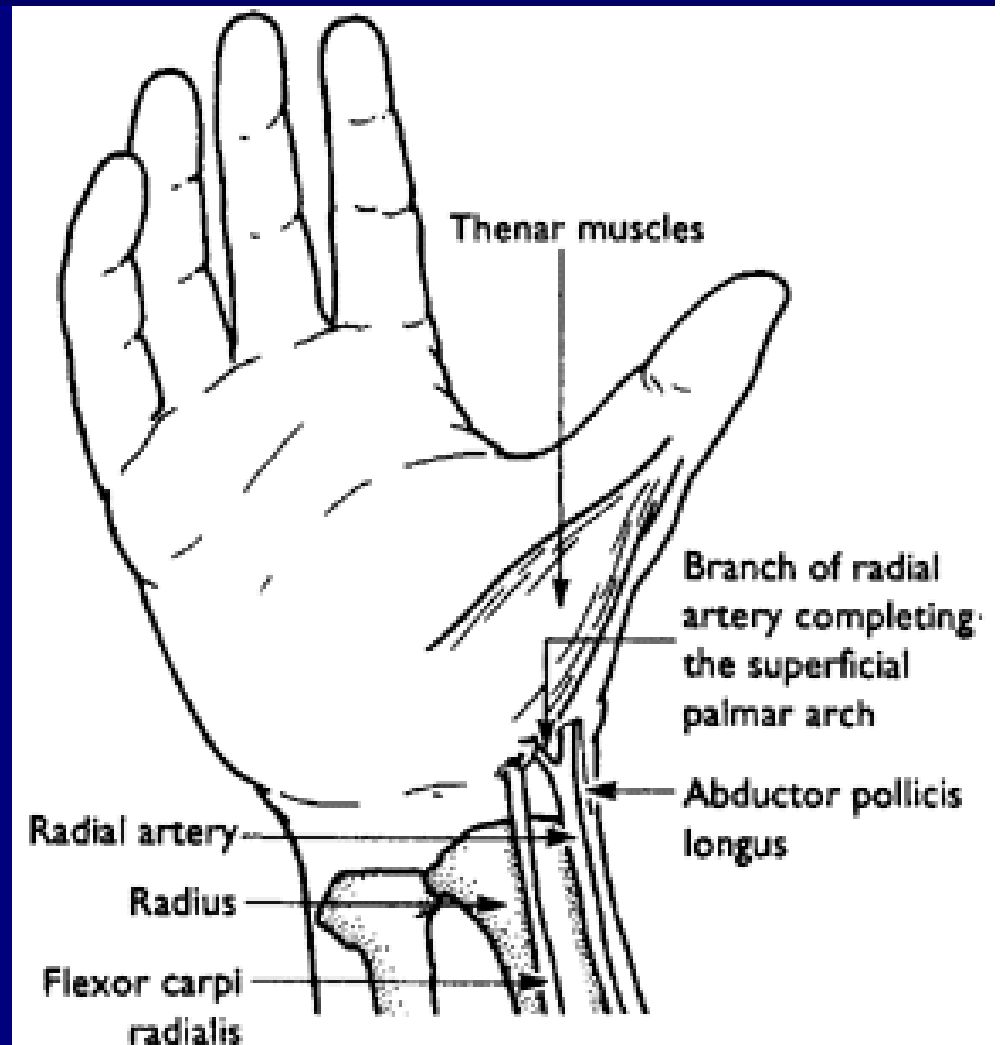
Frezza EE, Mezghebe H. Indications and Complications of Arterial Catheter Use in Surgical or Medical Intensive Care Units: Analysis of 4932 Patients. The American Surgeon. Feb 1998; 64:127-131

Anatomy – Radial Artery

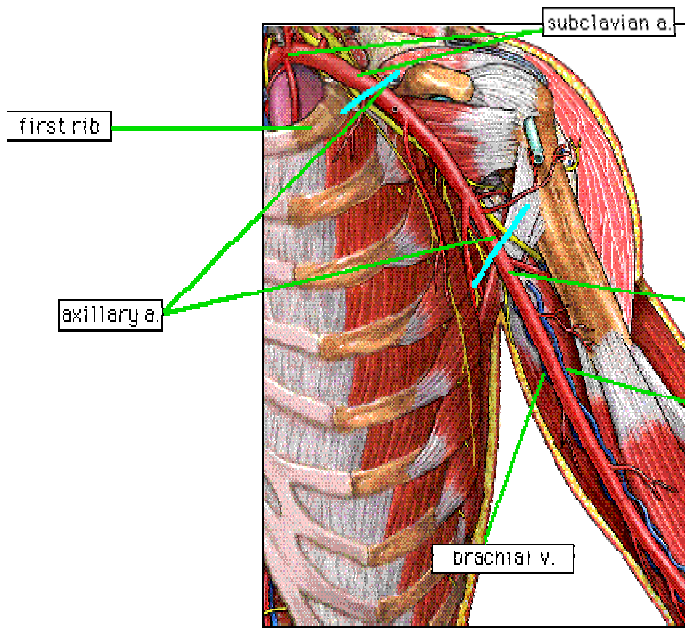
Allen's Test:

Evaluates collateral flow to hand

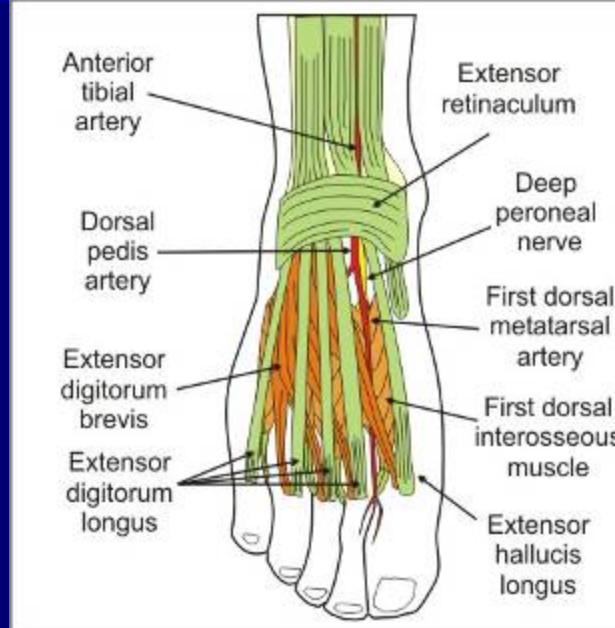
Occlude radial and ulnar arteries; Elevate the arm above the head and have patient open and close the hand until fingers turn white; release ulnar artery and determine the time for return of normal color; $nl < 7$ seconds; inadequate collaterals > 14 seconds



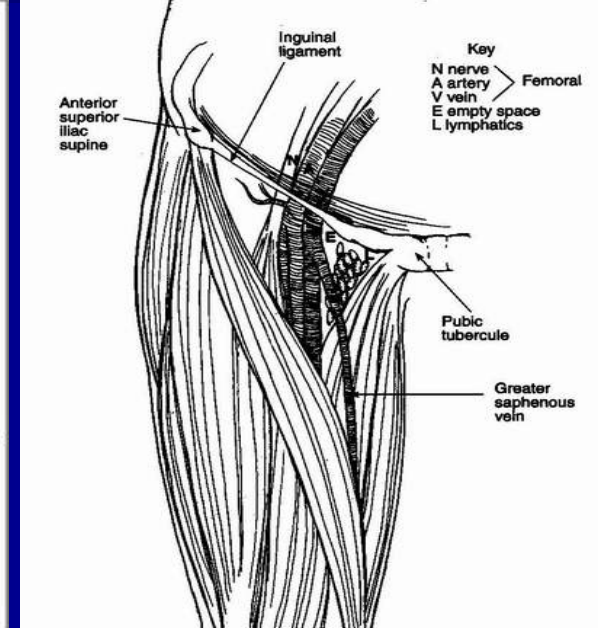
Arterial Access



Axillary Artery



Dorsalis Pedis



Femoral Artery

Site of Insertion of Arterial Lines

Site	MICU	SICU
Radial artery	52%	78%
Femoral artery	45%	11.5%
Brachial artery	1.6%	3%
Ulnar artery	0.06%	0.5%

Vascular insufficiency (spasm, thrombosis and pulselessness) was the most common complication in both units

Frezza EE, Mezghebe H. Indications and Complications of Arterial Catheter Use in Surgical or Medical Intensive Care Units: Analysis of 4932 Patients. The American Surgeon. Feb 1998; 64:127-131

Complications of Arterial Catheters

- Arterial Injury
(spasm, pseudo-aneurysm, A-V fistulas)
- Hematoma
- Thrombosis
- Embolism
- Ischemic Necrosis
- Nerve Injury
- Infection

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management* . 1997

Complications of Femoral Artery Cannulation

- Infection
- Groin / Retroperitoneal Hematoma
- Pseudo-aneurysm
- AV fistula formation
- Femoral arterial thrombosis
- Limb Ischemia

Riker AI and Gamelli RL. Vascular Complications after Femoral Artery Catheterization in Burn Patients. Journal of Trauma. 1996; 41 (5): 904-606

Ischemia / Thrombosis

- The risk of vascular complications is higher with catheter insertion in the upper extremity compared to femoral site
- 50% of catheters are associated with intra-arterial thrombus
- <1% are clinically significant; 1/500 patients needs embolectomy; typically takes 1-4 weeks to recannulize
- Major risk factors: size of the catheter relative to the vessel; multiple sticks and duration of catheter placement

% of patients with partial occlusion for 20 g Teflon catheter
1-3 days: 11% / 4-10 days: 29%

Risk Factors for Vascular Complications

- Circulatory Shock
- Use of Vasopressors
- Atherosclerosis
- Large catheter size
- Prolonged duration of catheterization

Catheterization of a larger vessel, such as femoral artery has the potential advantage over smaller vessels during low flow states ²

1. Clark VL, Kruse JA. Arterial Catheterization. *Critical Care Clinics* 1992; 8: 687-97

2. Puri VK, Carlson RW, Bander JJ et al. Complications of vascular catheterization in the critically ill. *Critical Care Medicine* 1980; 8:9

Thrombosis

Prevention:

- Use of smallest gauge, non tapered, Teflon catheters; avoid multiple attempts at cannulation
- Examination of the catheter site and distally for evidence of ischemia several times during the day
- Remove the catheter as soon as it is no longer needed; **when the waveform appears dampened or if sampling becomes variable, remove catheter**
- In patients with high risk of forming thrombosis (hemodynamic instability, PVD, DM, vasculitis), the catheter should be changed as frequently as every three days

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management* 1997

Removal of Arterial Catheters

- Reversible subclinical occlusion is common after removal of arterial catheters
- 25% of arterial catheterization sites show signs of occlusion 1 week post removal
- Ischemic necrosis occurs in <1 % of cases

A syringe should be attached to arterial catheters and suction applied while it is being removed; decreases the incidence of arterial thrombotic occlusion subsequent to removal of the catheter by removing developed clots

Civetta. Critical Care 3rd ed. 1997

Hematoma/ Hemorrhage

- The incidence of hematoma associated with arterial lines ranges from 0-10%
- Commonly occurs after multiple attempts at catheter placements have been made or after removal of the catheter
- Avoid placement in patients with bleeding disorders or coagulopathy
- Hemorrhage can result from disconnection
- Significant blood loss can result from frequent sampling; Pt with a lines have an average of 944 ml of blood removed compared to 300 ml in those without arterial lines; transfusion may be required

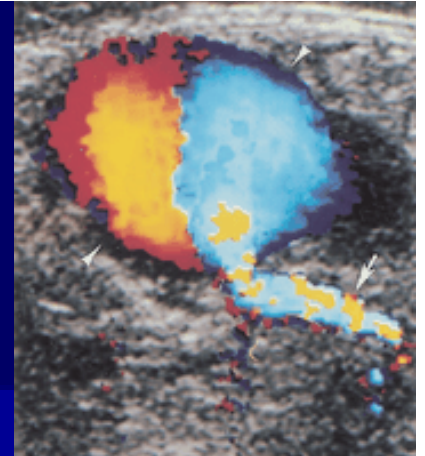
Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management* 1997

Prevention

- Use the most distal artery available for cannulation; most compressible
- Avoid in patients with bleeding or coagulopathy
- Avoid multiple attempts at cannulation
- Apply pressure at the catheter site for at least ten minutes after catheter removal

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management* . 1997

Arterial Injury



- Vasospasm
- Pseudo-aneurysm
 - PA of the radial artery have been reported from days to weeks after decannulation of the artery
- Arterio-venous fistulas

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In Complications in the ICU: recognition, prevention and management 1997

Infection

- % of arterial catheter tip that are culture positive = 16%
- Incidence of bacteremia secondary to arterial catheters is = 1%
- Risk factors for arterial catheter infection:
 - Cut Down technique (increases risk 9-fold)
 - Co-existent bacteremia
 - Length of time in place
 - Local inflammation

Bowyer MW, Bonar JP. Non-infectious complications of invasive hemodynamic monitoring in the intensive care unit. In *Complications in the ICU: recognition, prevention and management* . 1997

Summary

- The majority of complications associated with central venous and arterial catheterizations are iatrogenic and therefore **preventable**
- Strict adherence to safe insertion techniques is mandatory
- Appropriate **credentials** are required prior to performing invasive procedures; Proper supervision is required
- Awareness of procedure-related complications is necessary
- **All catheters should be removed as soon as possible**

Questions???