Identification and Management of Central Vascular Access Device Complications

David Hahn, MD

Interventional Radiology

NorthShore University HealthSystem

Evanston, Illinois

Disclosures

- Consultant, AngioDynamics, Inc

Learning Objectives

1. Identify 2 complications associated with CVADs.

2. Describe interventions appropriate to various CVAD complications.

Objectives

- Identify complications associated with central venous access devices (CVAD)
- Become familiar with imaging findings related to CVAD complications
- Review management strategies for CVAD related complications

Central Venous Access

- Devices essential in management of oncology patient
- Four main types of catheters:
  - Non tunneled central line
    - Short term use
  - Tunneled central line
    - Intermediate to long term access
  - Fully Implantable
    - Ports, more specialized implantation technique
  - PICCs
    - Short term

What could go wrong?

Complications

- Mechanical
  - Related to placement
  - Early and late
- Infection
  - Bloodstream (CRBSI)
  - Local (skin)
- Thrombosis
  - Catheter occlusion
  - Catheter related deep venous thrombosis

QI Guidelines for CVCs

- 95% success rate
  - Complications
    - Early (<24h), early (<30d), late (>30d)

Table 3
Complication Rates and Suggested Thresholds for Central Venous Access

Specific Major Complications for Image-guided Central Venous Access	Rate (%)	Suggested Threshold (%)
Subclavian and jugular approaches		
Pneumothorax	1–2	3
Hemothorax	1	2
Hematoma	1	2
Perforation	0.5–1	2
Air embolism	1	2
Wound dehiscence	1	2
Procedure-induced sepsis	1	2
Thrombosis*	4	8

Silberzweig et al. Reporting Standards for Central Venous Access. JVIR, 2003;14:S443-S452.

Table 2a
Early Complications (Usually <24 Hours)

Persistent bleeding at venous puncture site
Persistent bleeding at catheter exit site
Soft tissue swelling
Hematoma
Cardiac arrhythmia
Arterial injury
Venous injury
Cardiac perforation
Arteriovenous fistula
Intimal injury
Venous thrombosis
Vasovagal reaction
Pneumothorax
Hemothorax
Air embolism
Allergic reaction
Contrast reaction
Persistent pain at catheter site
Anesthetic-related complications
Inability to access device
Catheter kinking
Suture occlusion of catheter

Table 2b
Early Complications (<30 Days)

Catheter tip migration
Catheter occlusion
Catheter fragmentation
Inadvertent catheter removal
Catheter-port/hub connection failure
Wound dehiscence
Venous thrombosis
Extremity swelling
Infusate infiltration around access device
Inability to access the device
Catheter-related infection

Table 3
Late Complications (>30 Days)

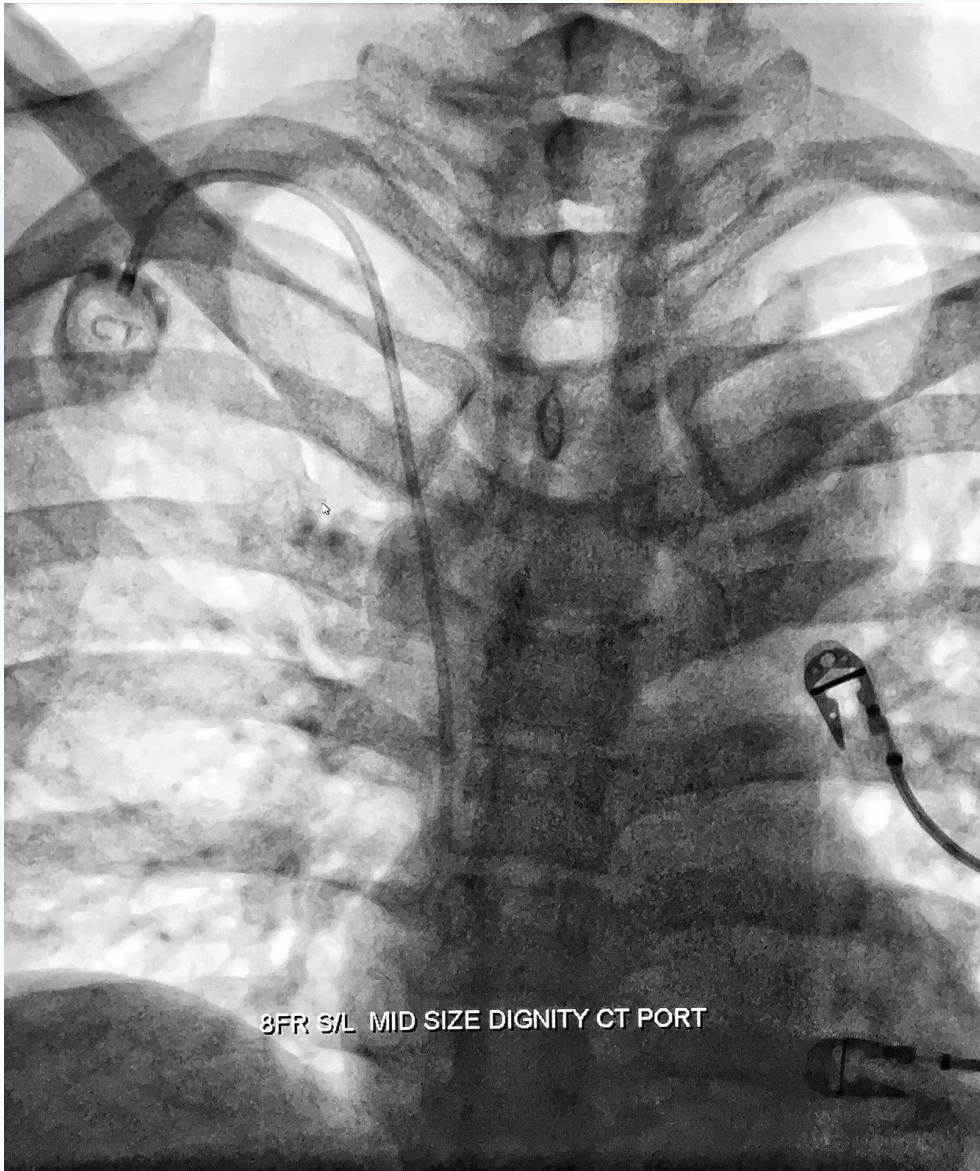
Catheter-related infection
Venous thrombosis
Extremity swelling
Catheter tip migration
Venous perforation
Cardiac perforation
Cardiac arrhythmia
Inadvertent device removal
Catheter-port/hub connection failure
Catheter fracture
Catheter occlusion/fibrin sheath formation
Catheter erosion through vessel wall
Erosion of port/catheter through the skin
Infusate infiltration around access device
Inability to access the device

Complications

- Procedural
  - Malposition
  - Pneumothorax
  - Air embolism
  - Vessel, cardiac perforation
- Late
  - Infection, thrombosis,
  - Fibrin sheath
  - Catheter pinch off, fracture, malposition

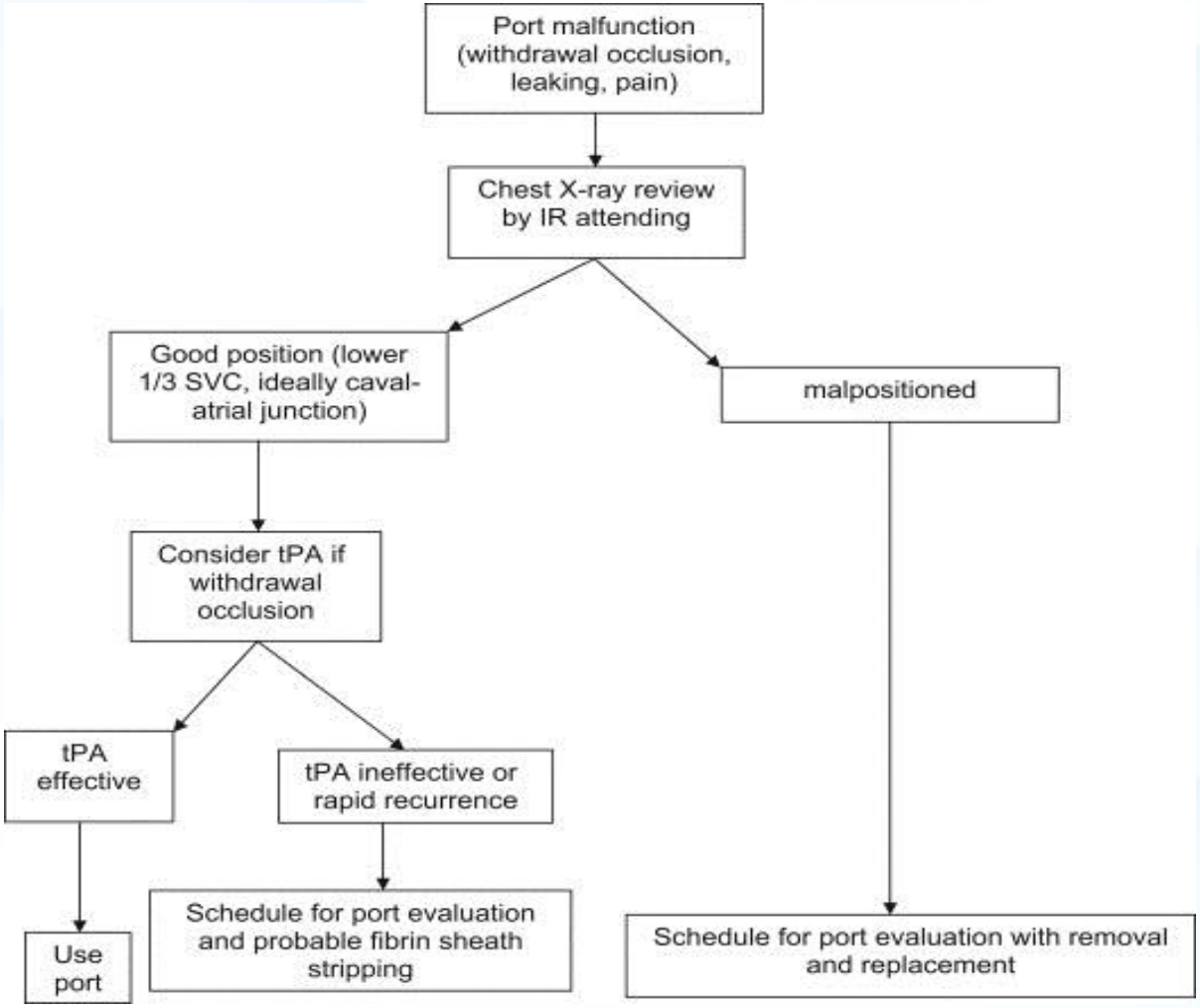
Catheter Tip Position

- Ideally SVC/RA unless HD cath
- 2 vertebral bodies below carina
  - Baskin KM et al. JVIR 2008; 19:359-365
- Too high
  - Malfunction, thrombosis, erosion, poor flows
- Too low
  - Generally better flows, less thrombus, although risk of arrhythmias



CXR-based Algorithm for Troubleshooting Ports

- Nadolski G et al. JVIR 2013; 24:1337-1342



SVC/RA Junction

Right Tracheobronchial Angle

Right mainstem bronchus is upper margin of SVC

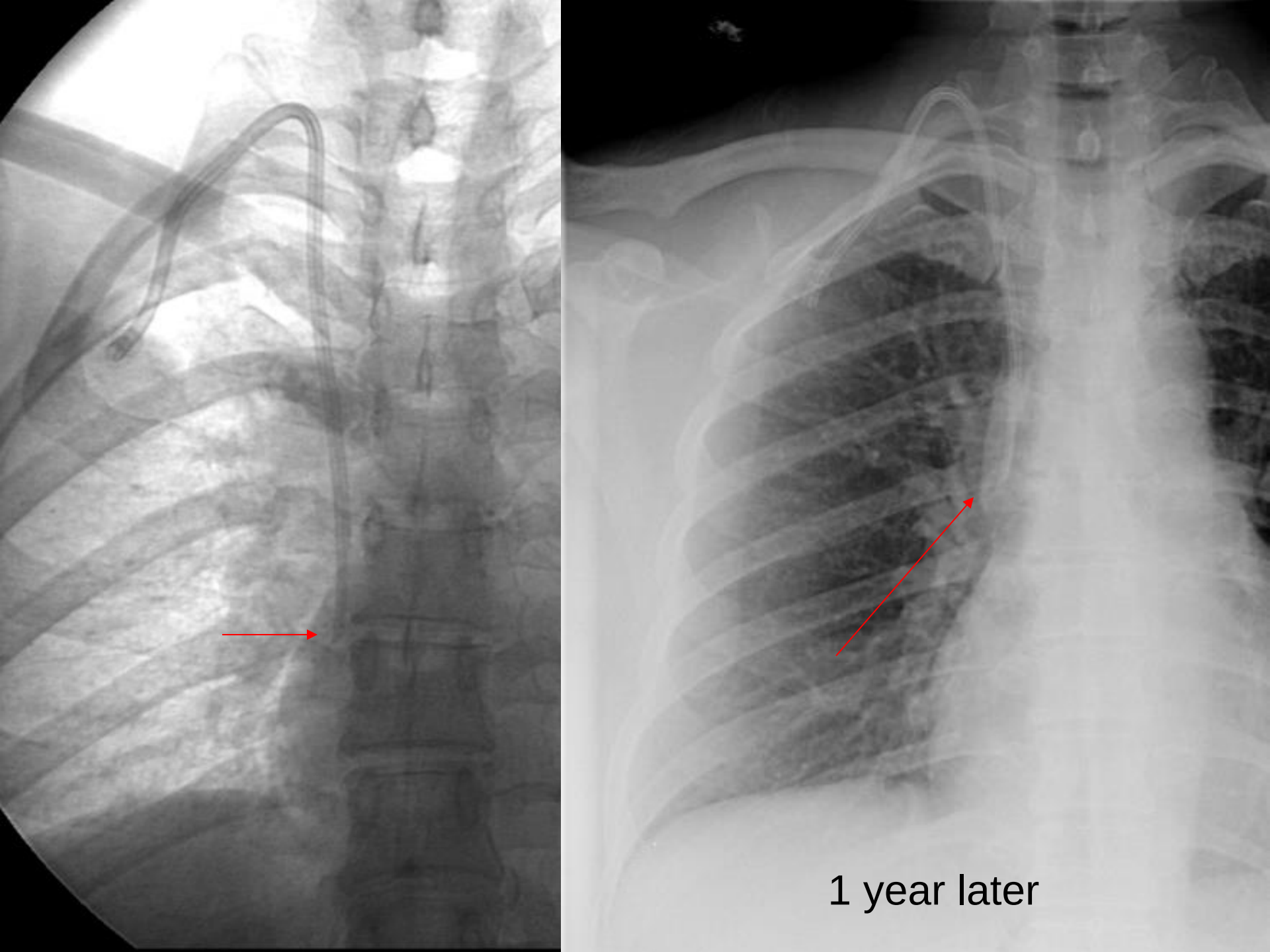
Catheter tip within first 3 cm below right TBA

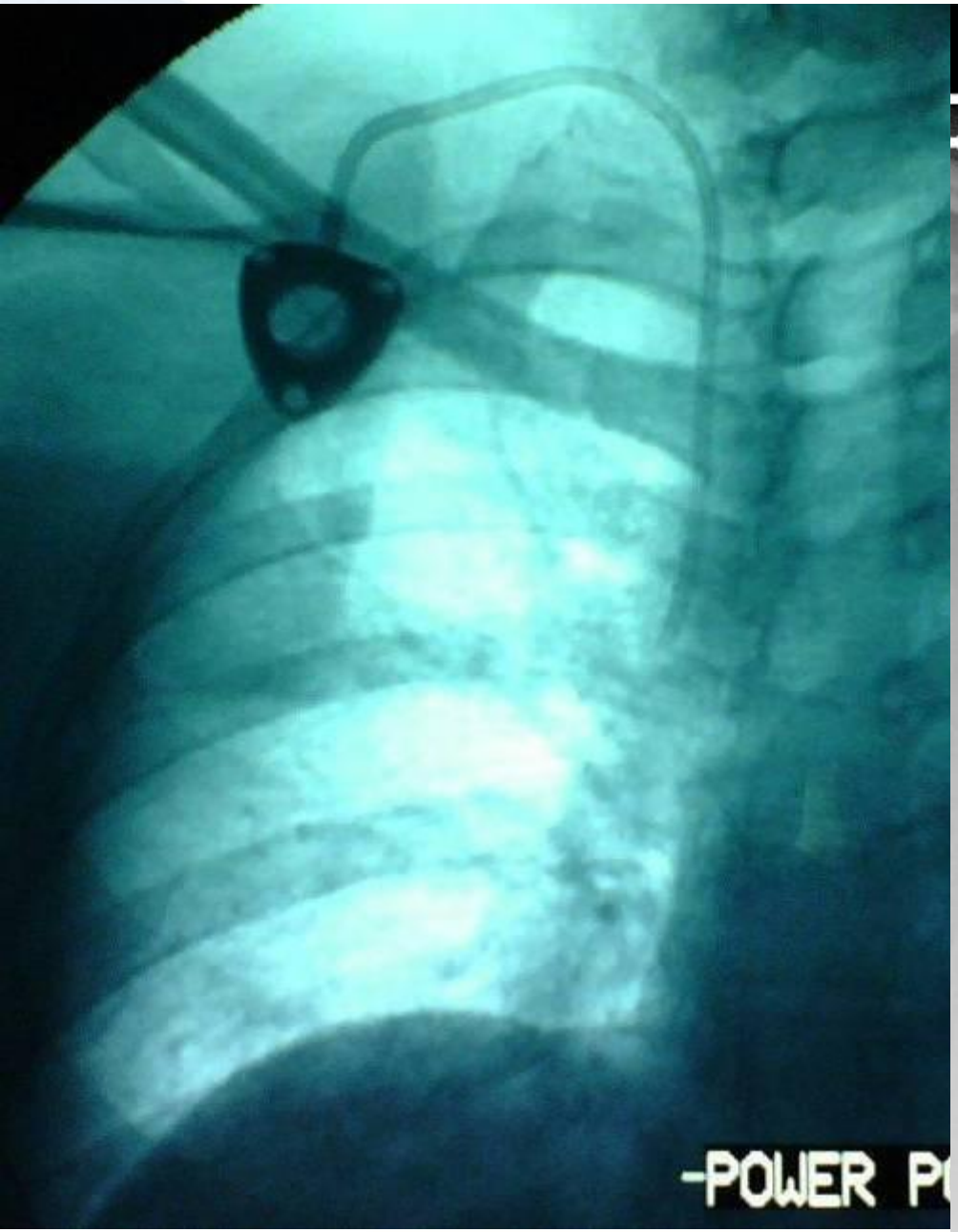
Carina (usually within 1 cm of right tracheobronchial angle)

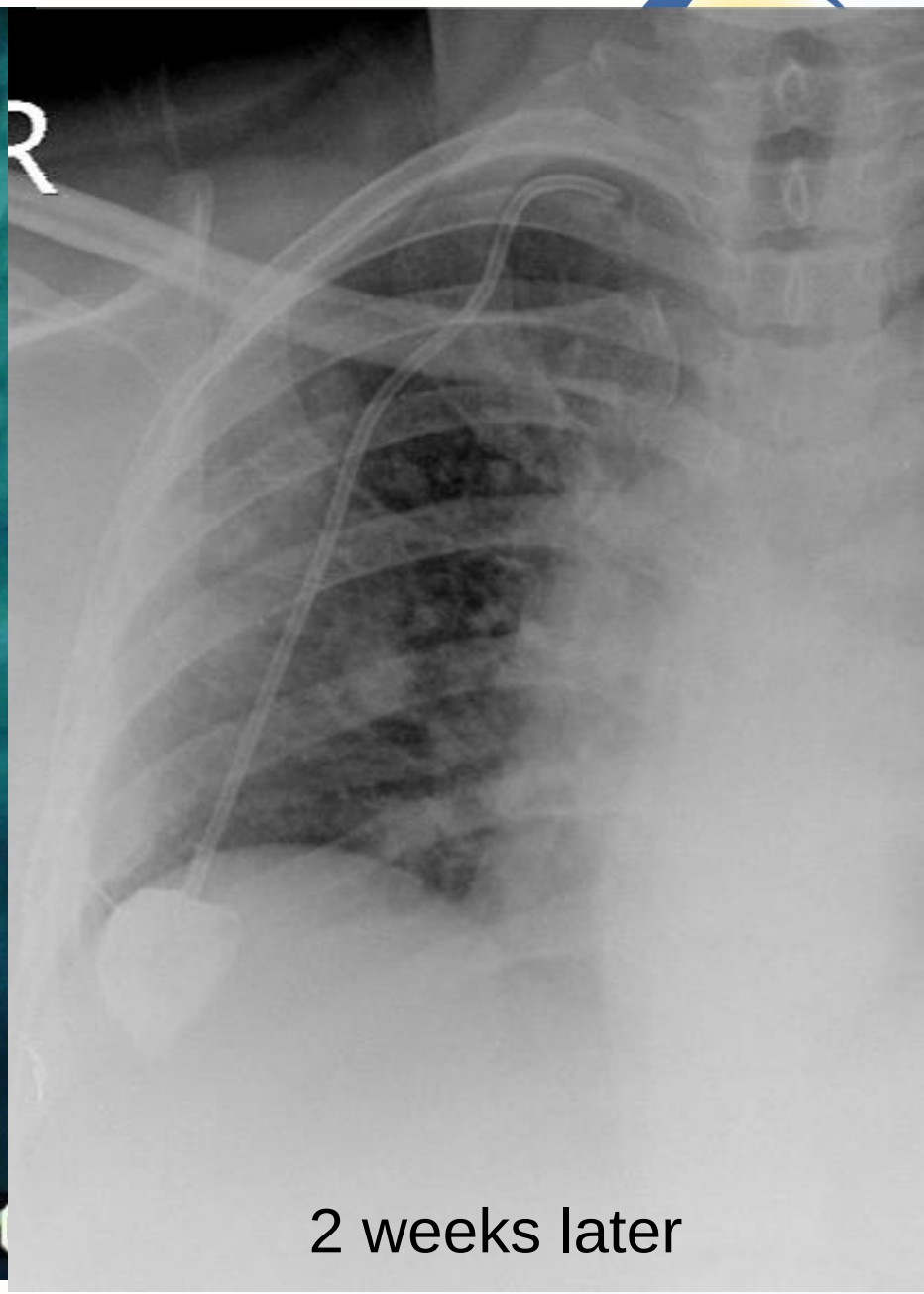
At or below carina = SVC

4 cm below carina = near cavoatrial junction

2 “vertebral body units” below carina


1 year later

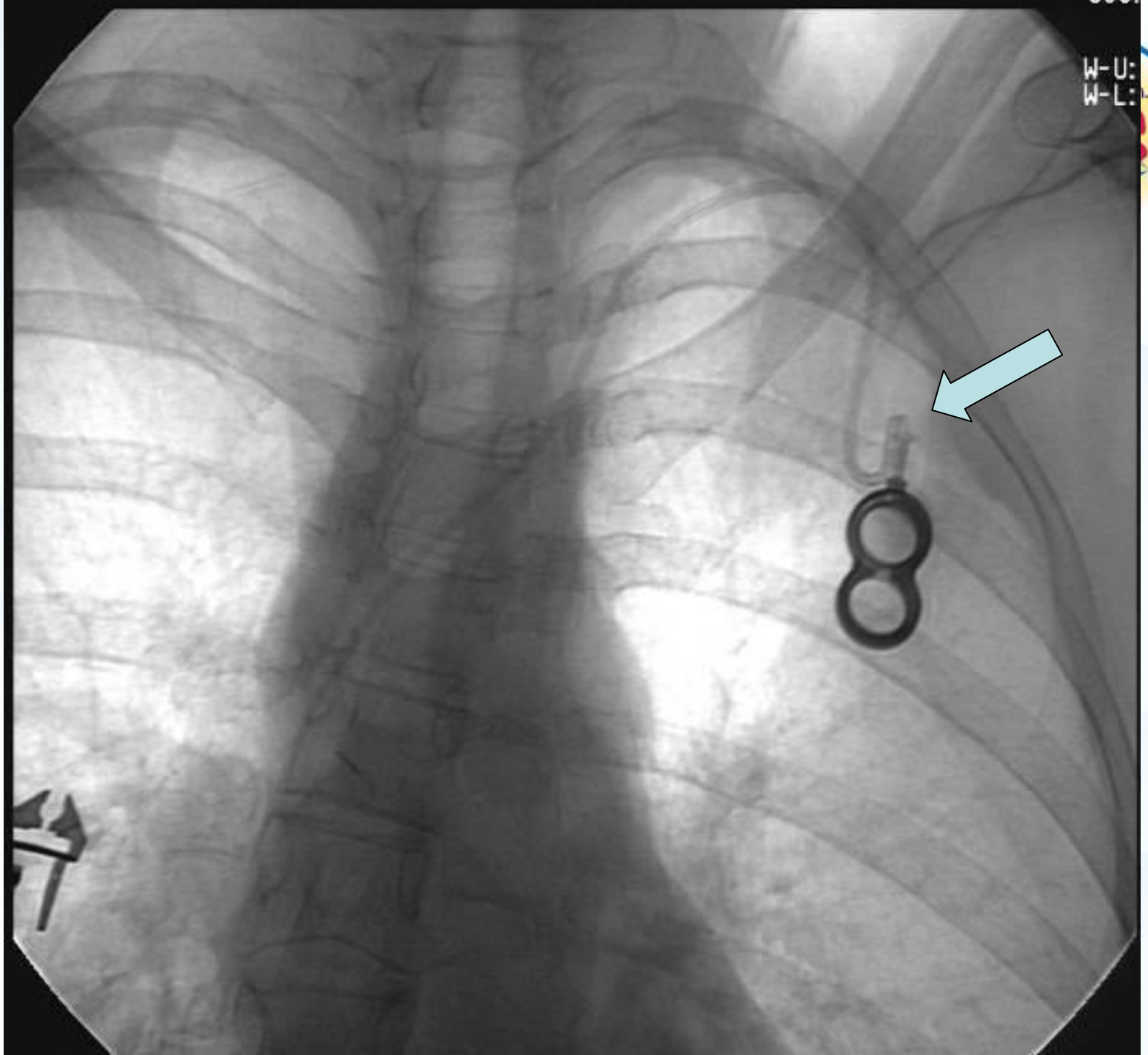




2 weeks later


PORT
RIGHT
RAO:


Murphy’s Law

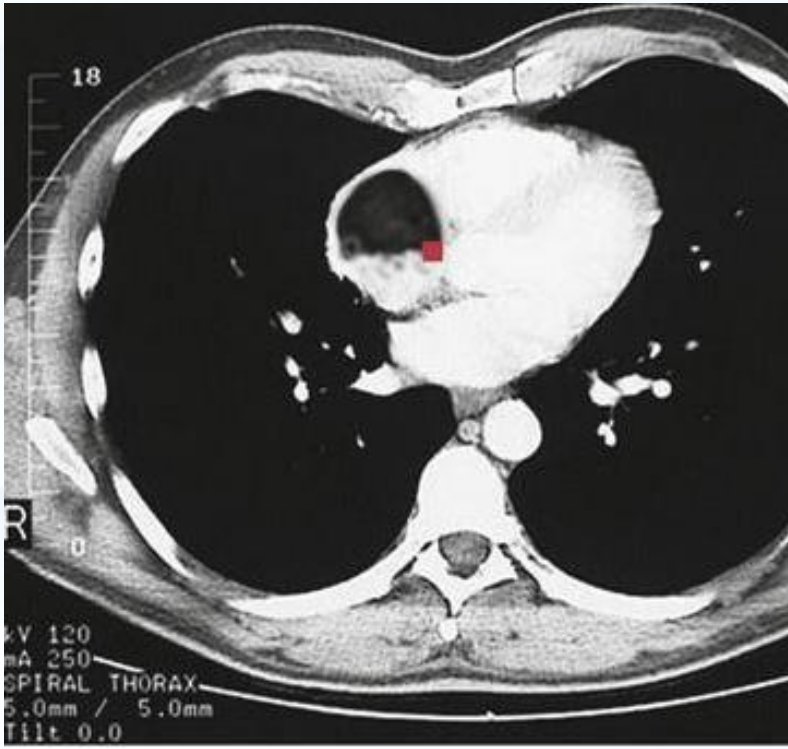


Pneumothorax

- Up to 10% surgical series
- 1-2% IR series (mainly subclavian)
- Operator dependent
- More frequent in emergent placements
- Incidence decreased with imaging guidance

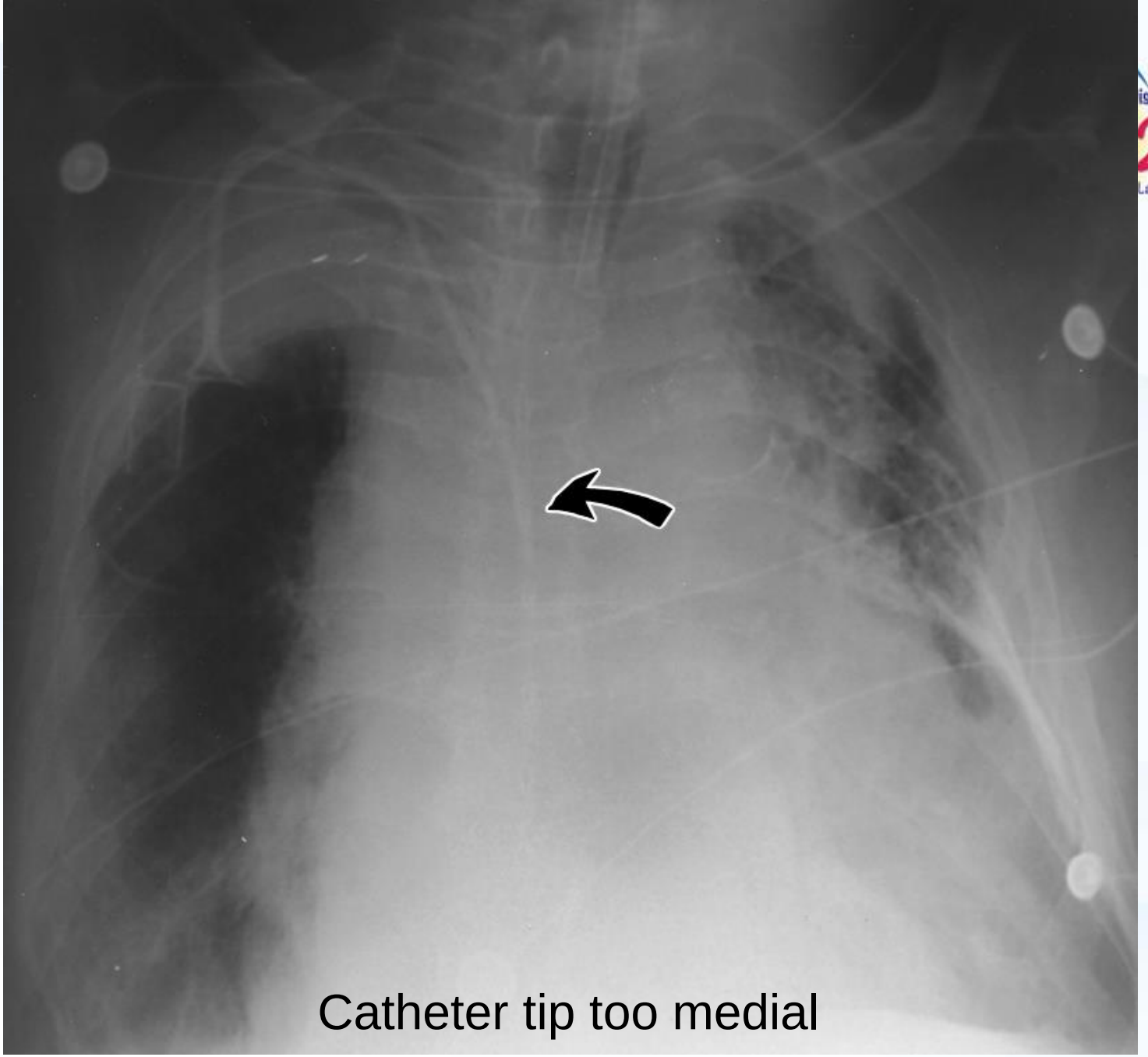
Air Embolism

- If symptomatic, can be fatal (rare)
- Fatal amount est. at 300-500cc
- Occurs during insertion thru peel-away, sucking sound, air in RA on fluoro
- Air lock: inc right heart and PA pressures, hypoT due to decreased LV preload
- Rx: turn on left side (Durant's position), O2, aspiration under fluoro

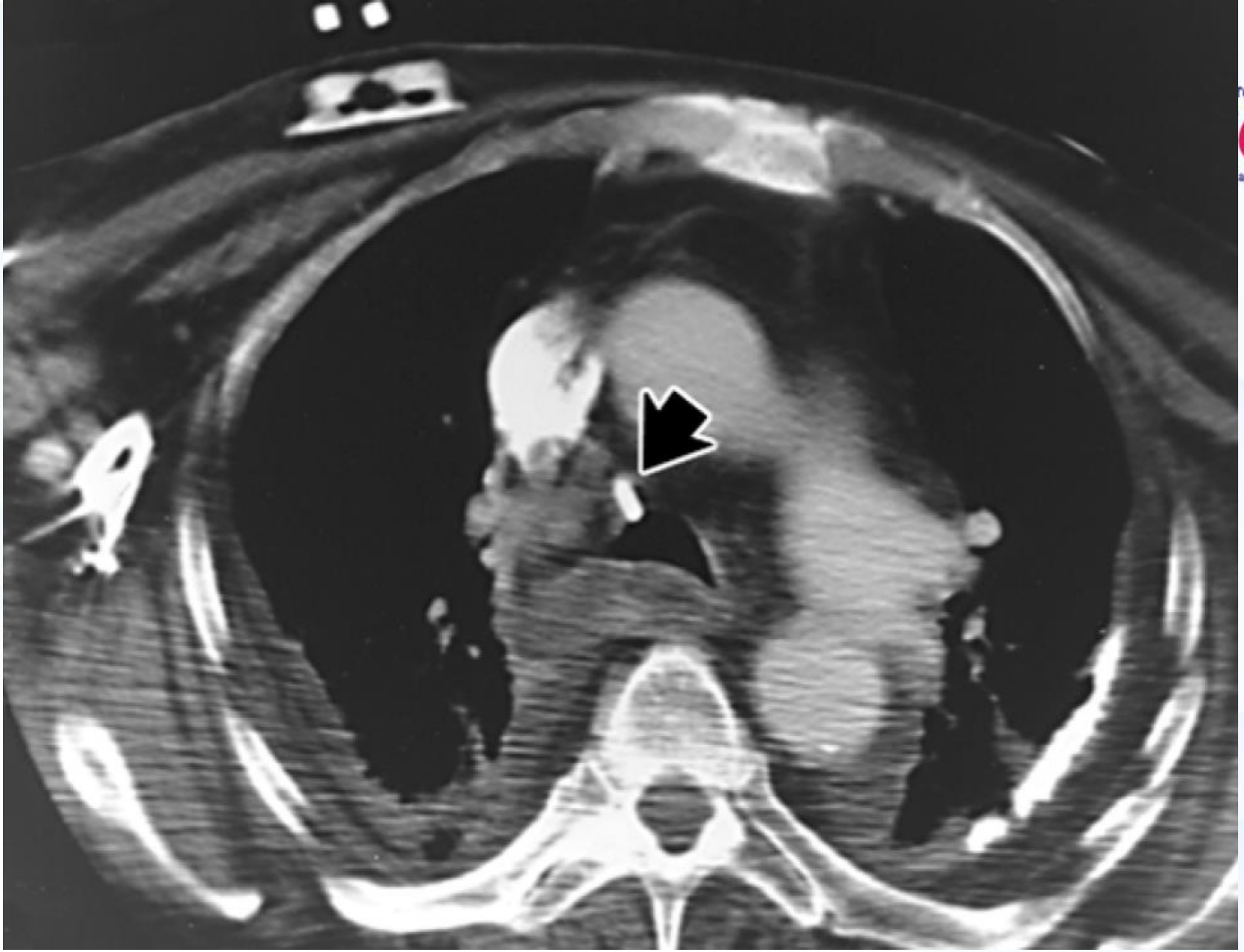


Great Vessel Perforation

- Fortunately these events are rare, avoided with careful imaging guidance
- Venous: rarely life threatening unless large French diameters
- Arterial: usually of no consequence if recognized early, skinny needle
  - Manual compression
  - Rarely, balloon tamponade/covered stent



Catheter tip too medial



Fibrin sheath

Proteinaceous coat composed of eosinophilic material and inflammatory cells

May have associated thrombus, acts as one way valve

"infuses but won't aspirate"

tPA/Cathflo

2mg tPA/lumen

Dwell 30 minutes and recheck

Dwell 120 minutes and recheck

May repeat if needed

tPA infusion

2.5 mg/lumen over 3 hours

5mg in 100cc saline @ 40cc/hour

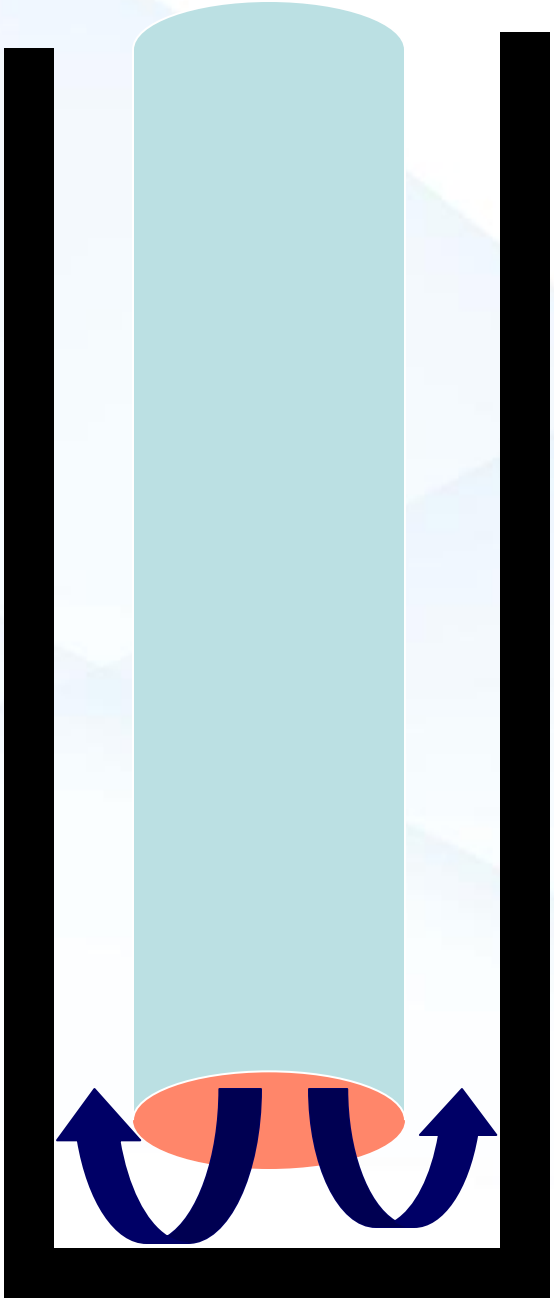
Catheter exchange +/- angioplasty

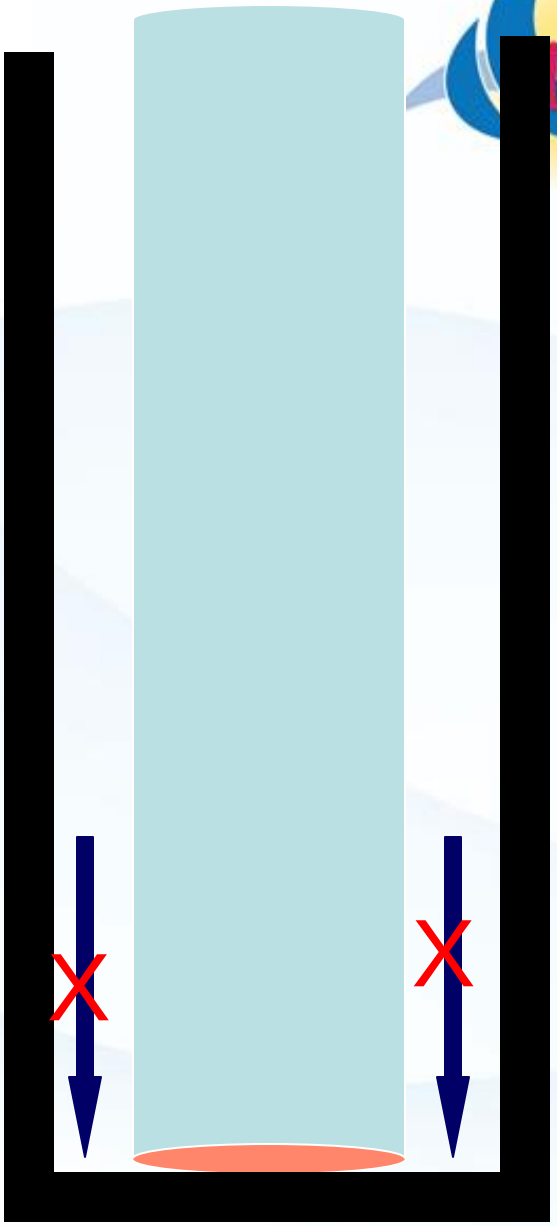
Fibrin sheath stripping

Consider in ports as there are more difficult to exchange compared to tunneled catheter

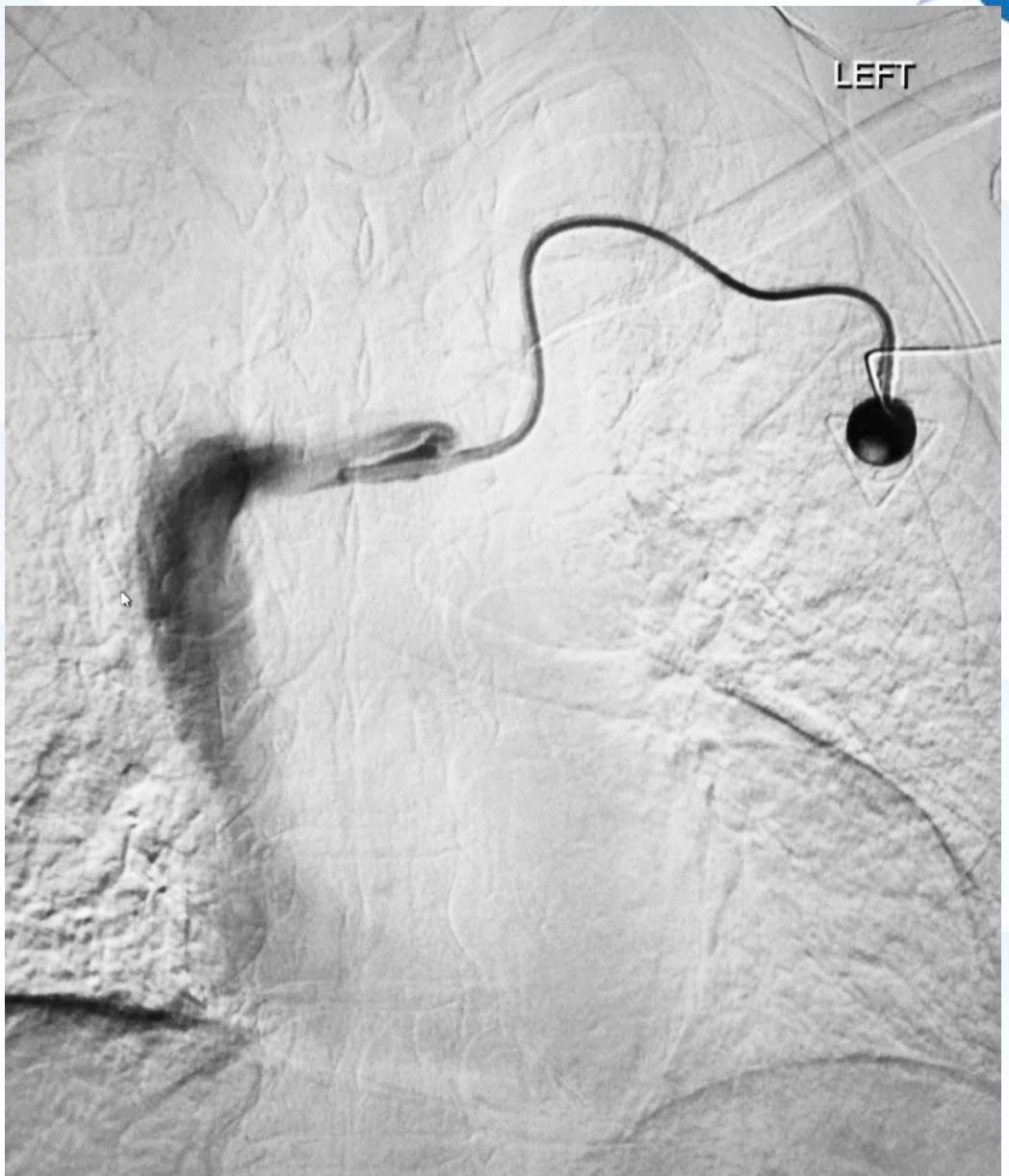
Fibrin Sheath

- Proteinaceous coat of eosinophilic material and inflammatory cells coating catheter
- May be associated with thrombus causing a one way (check) valve effect
- Catheters may infuse but not aspirate

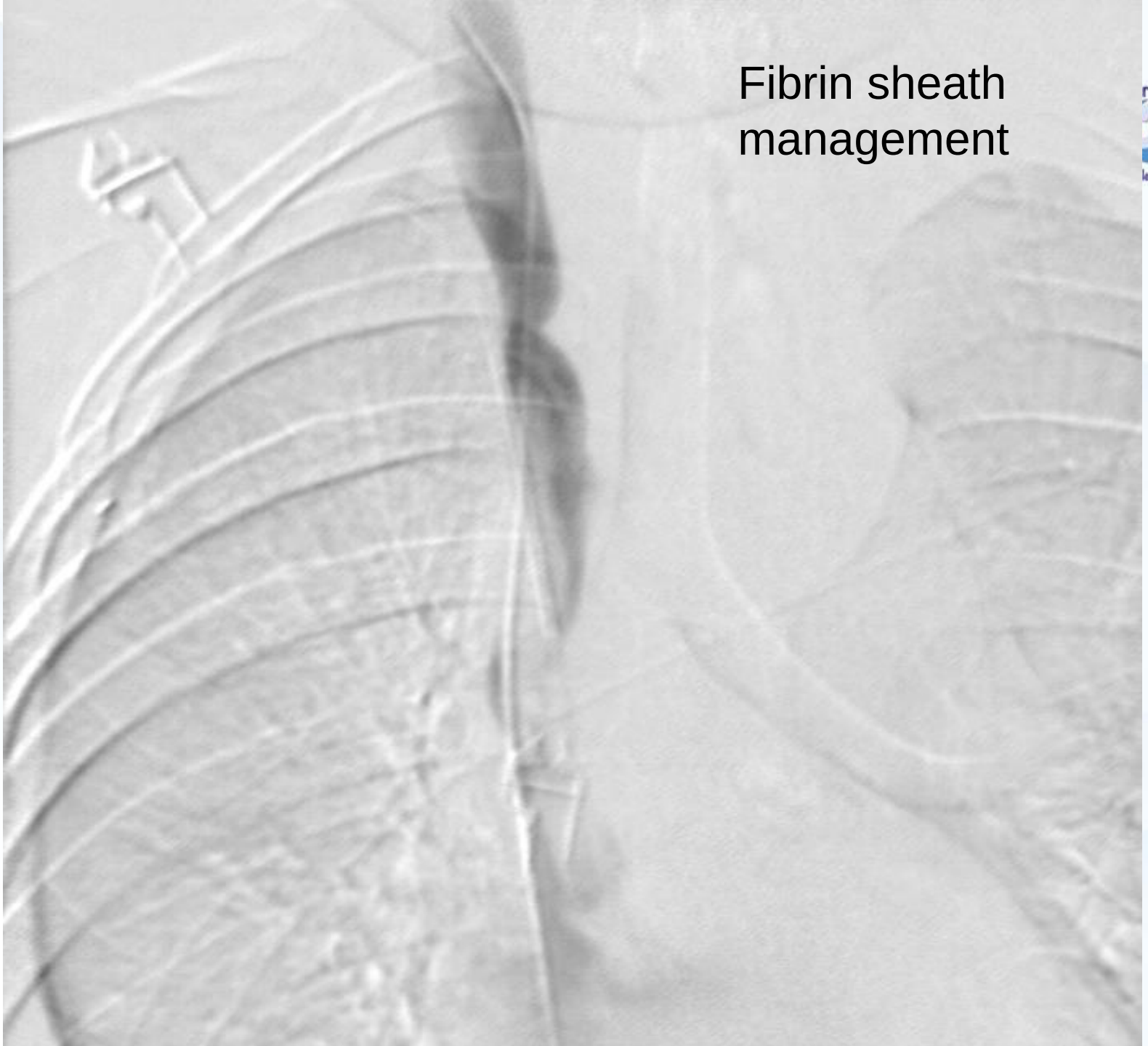


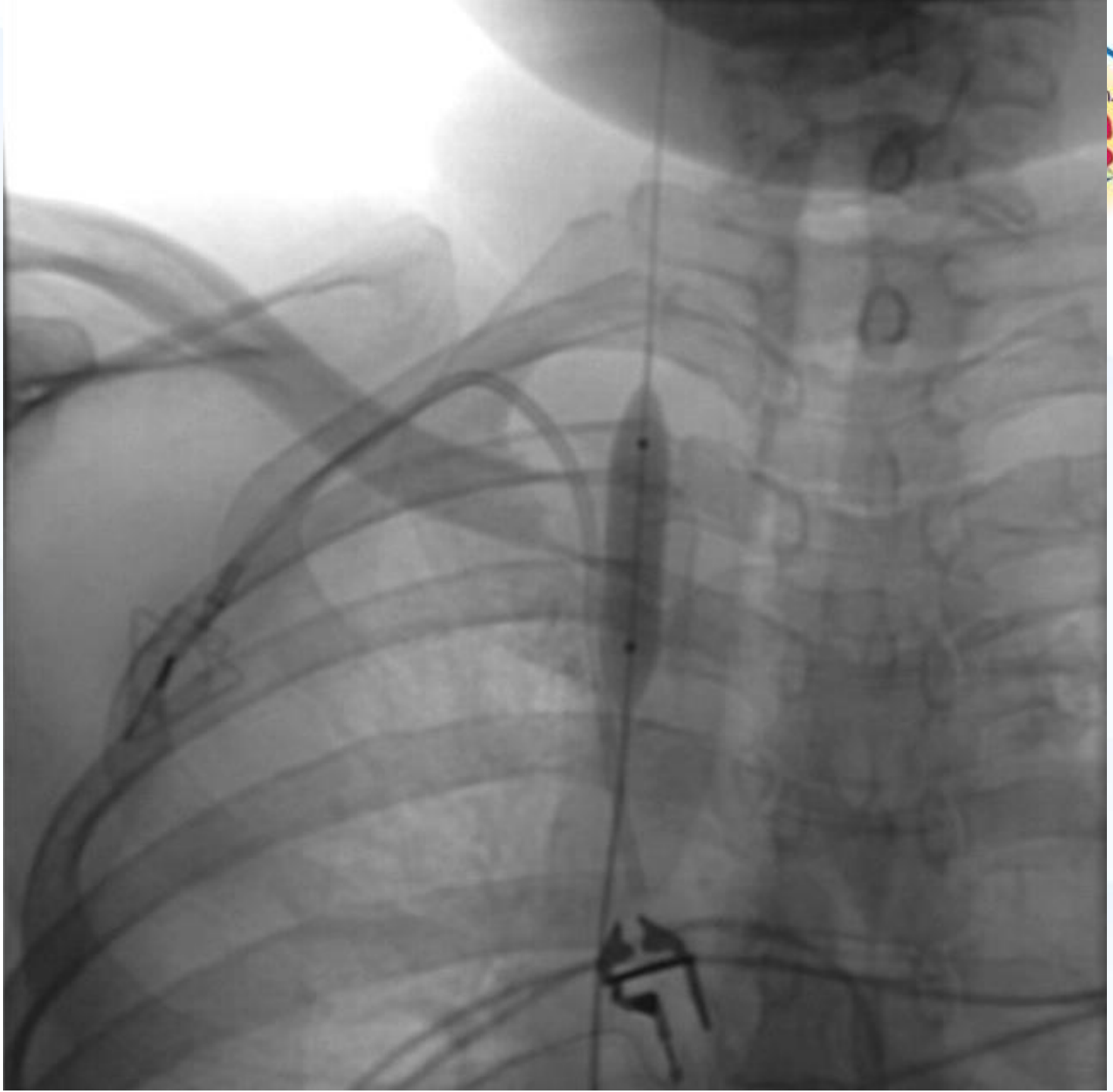


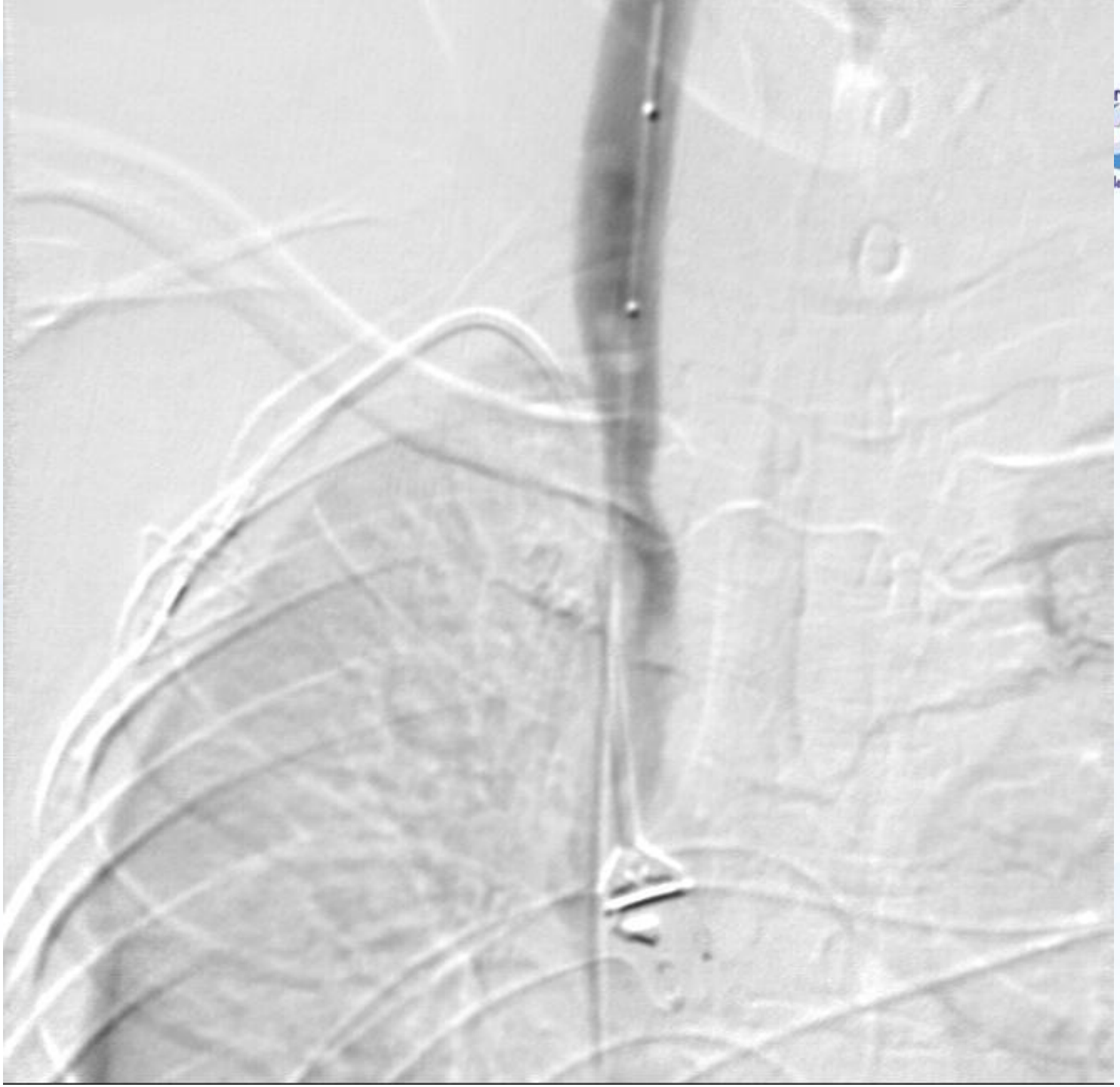
Fibrin Sheath



Fibrin sheath management

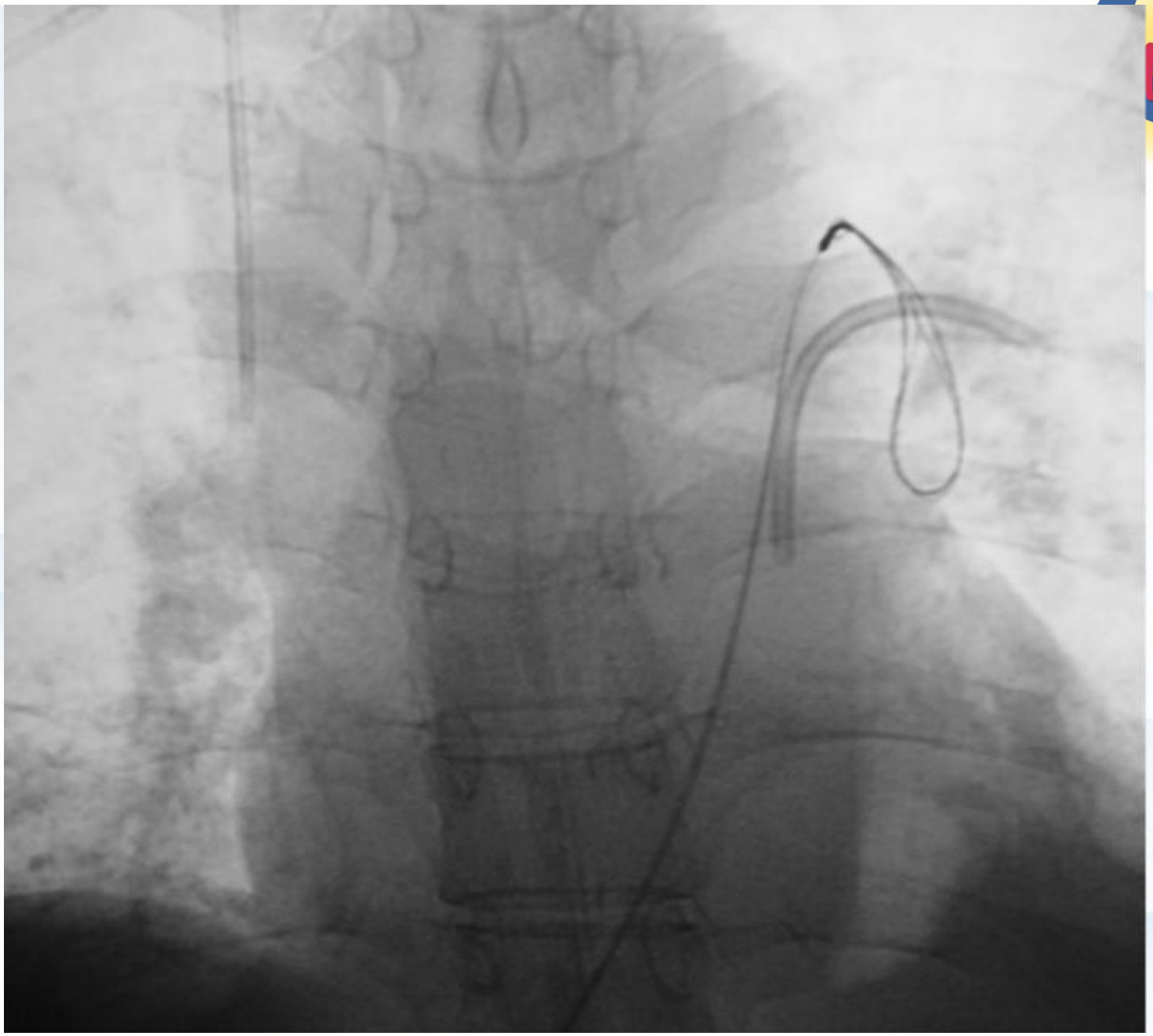


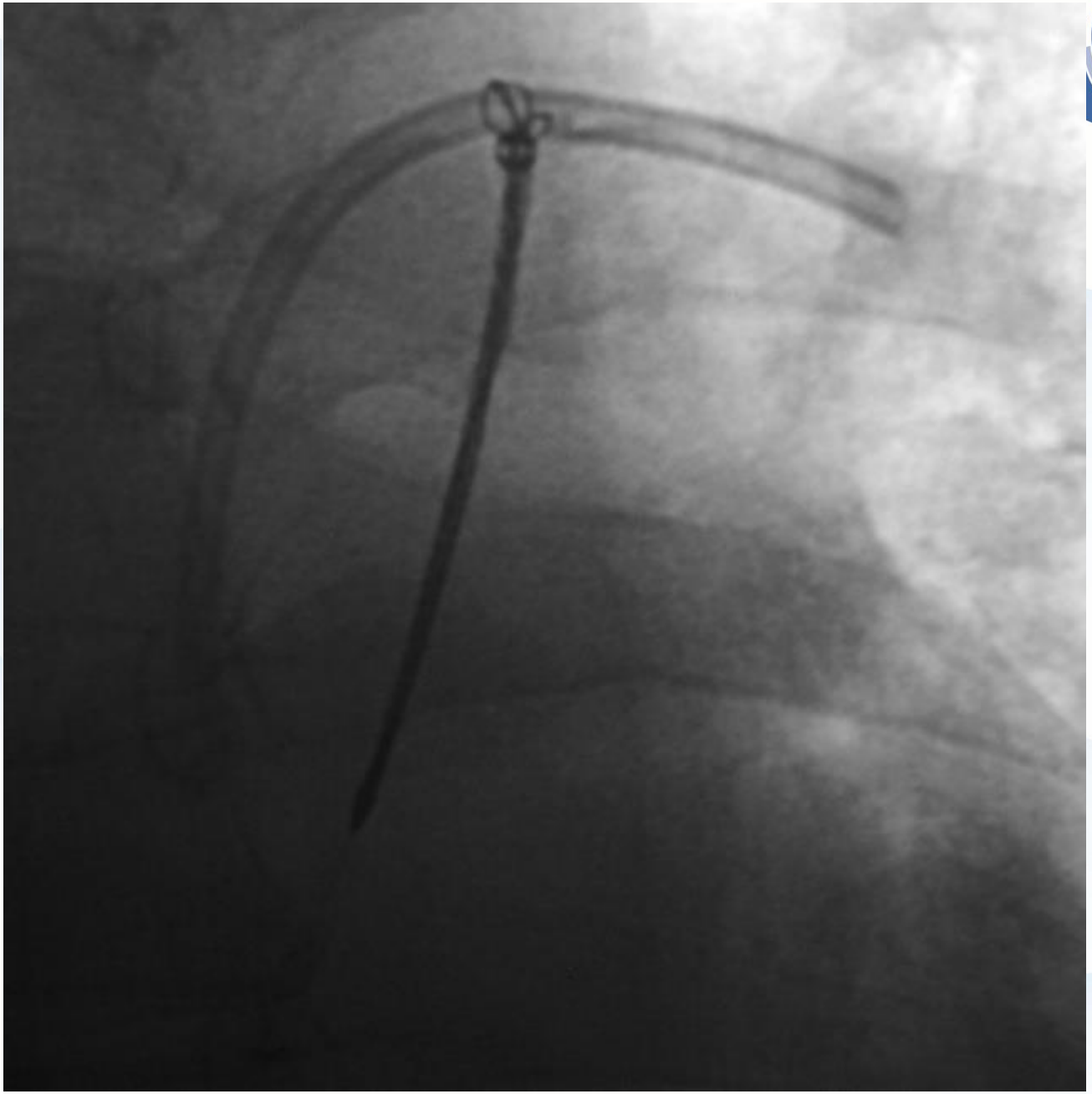


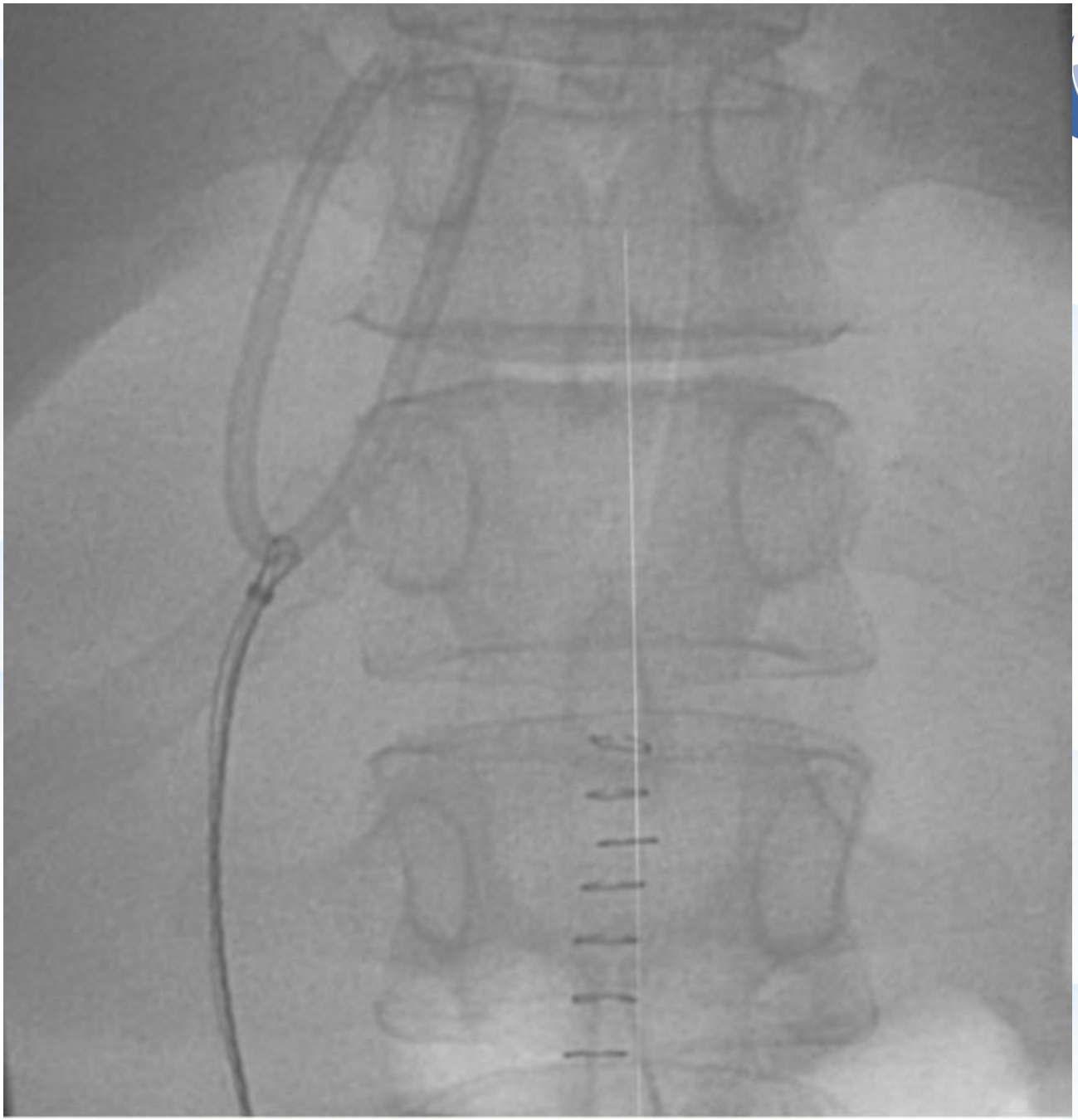


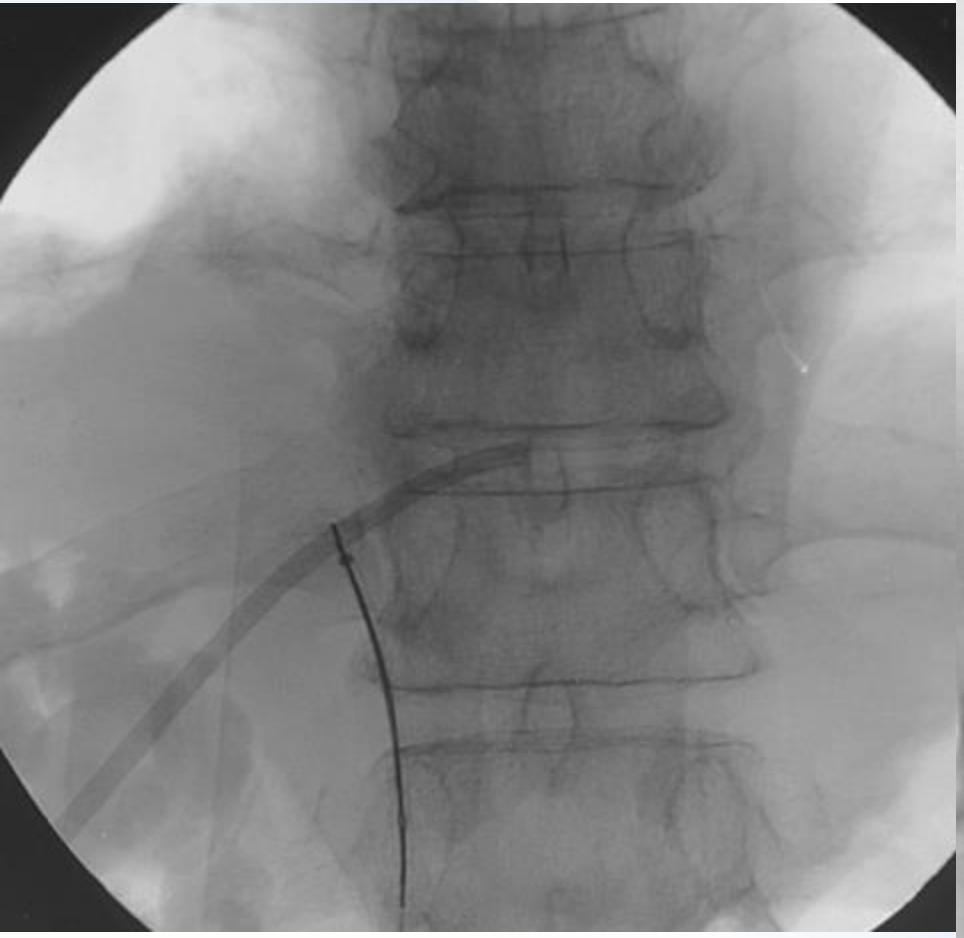
Catheter Pinch Off

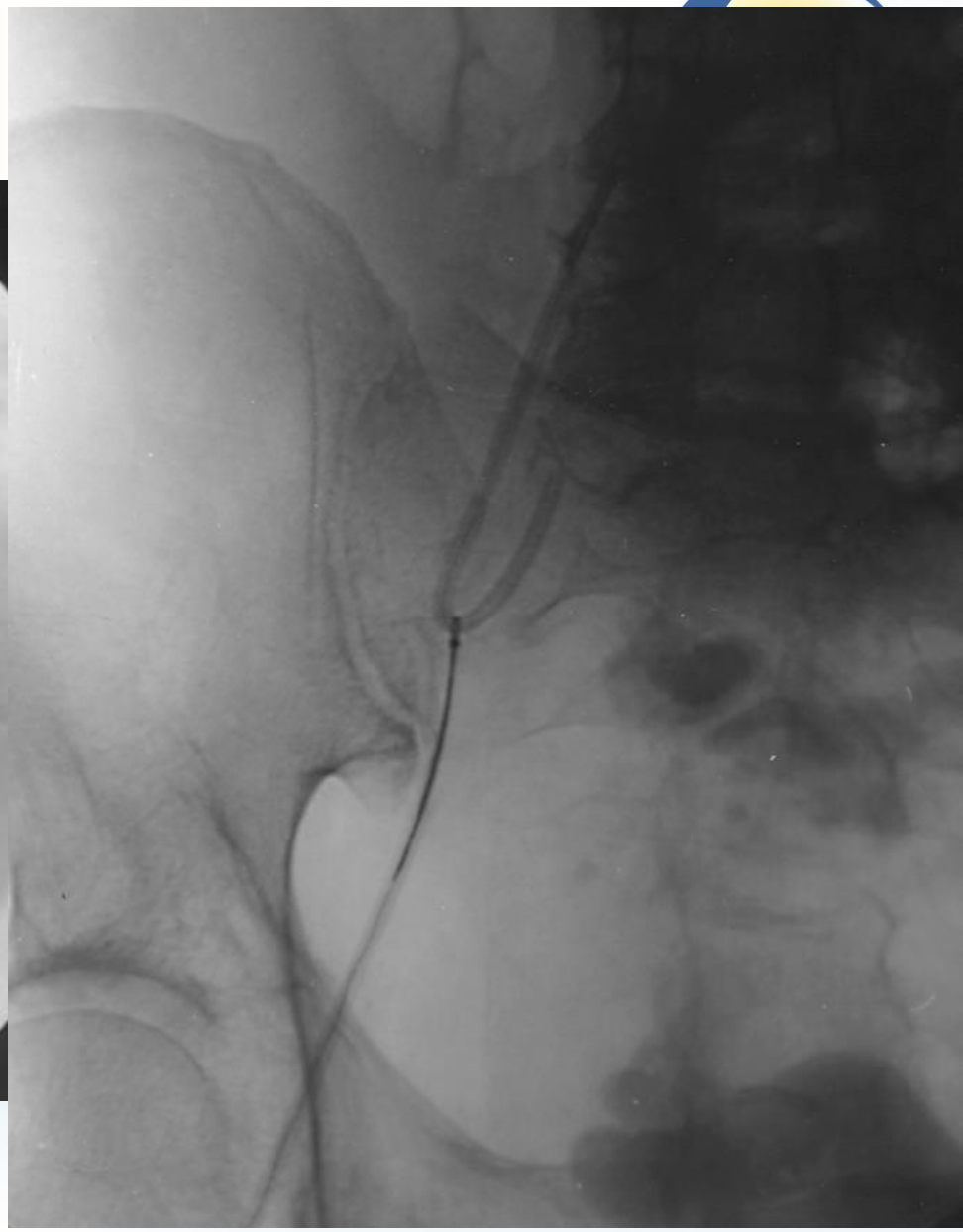
- Mainly with subclavian ports
- Kinking of catheter can progress to fracture
- May need foreign body retrieval

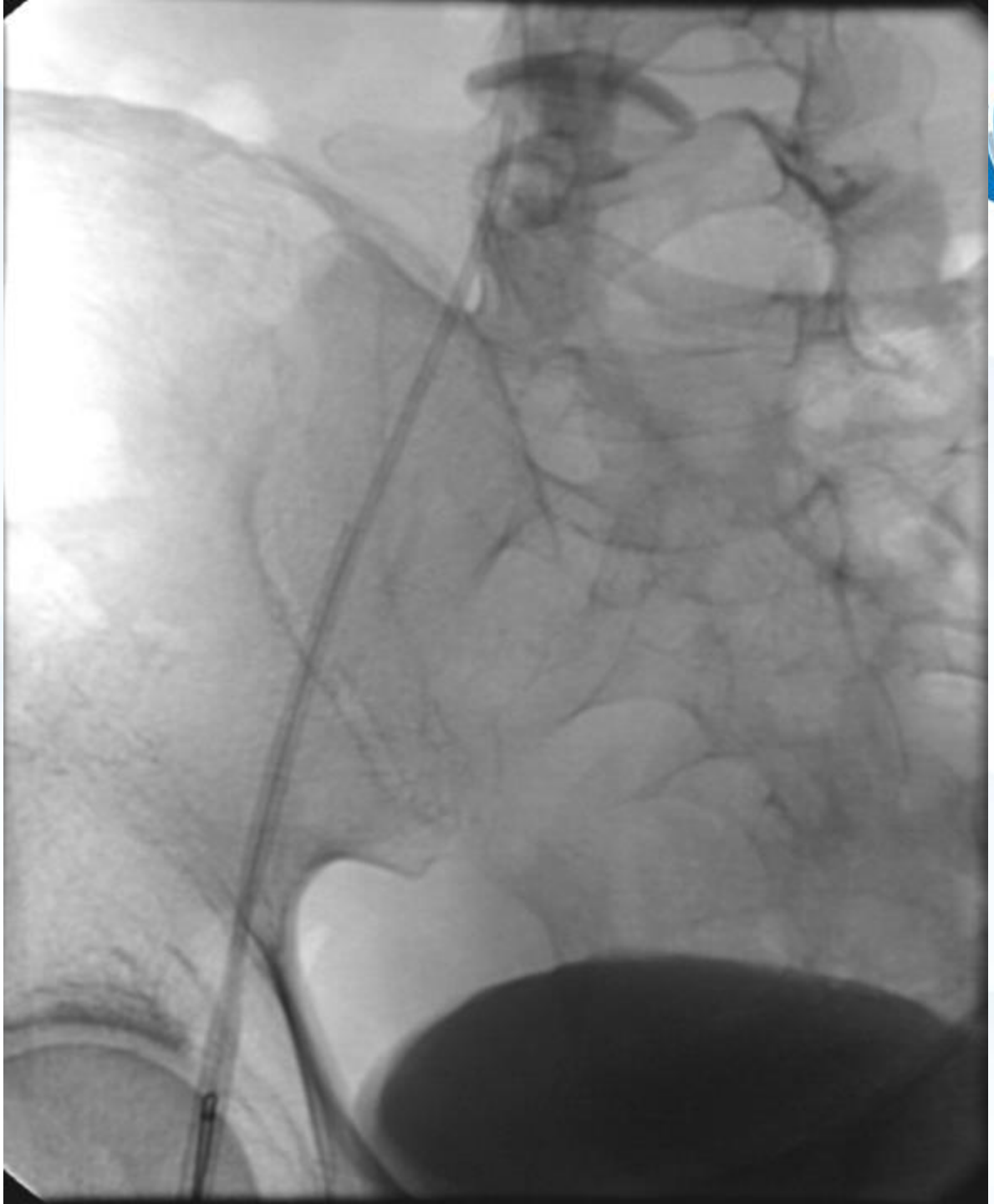






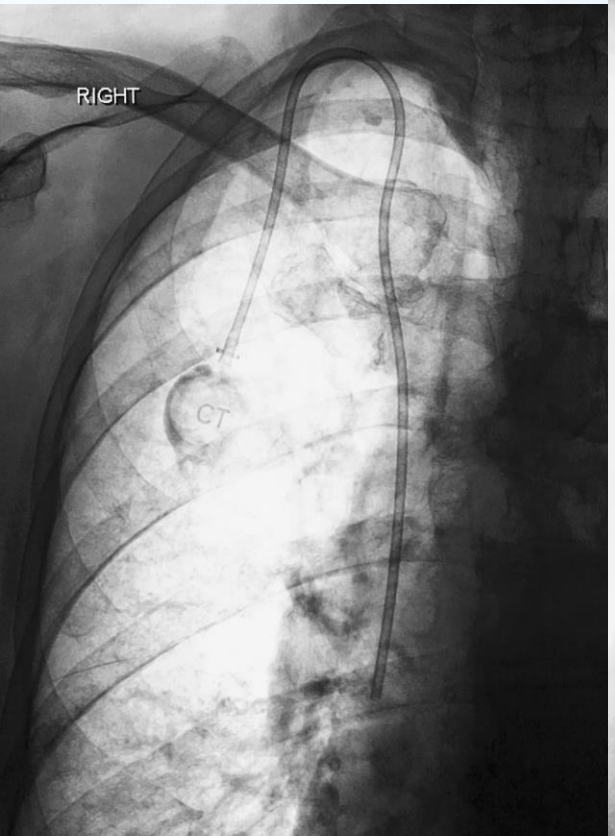


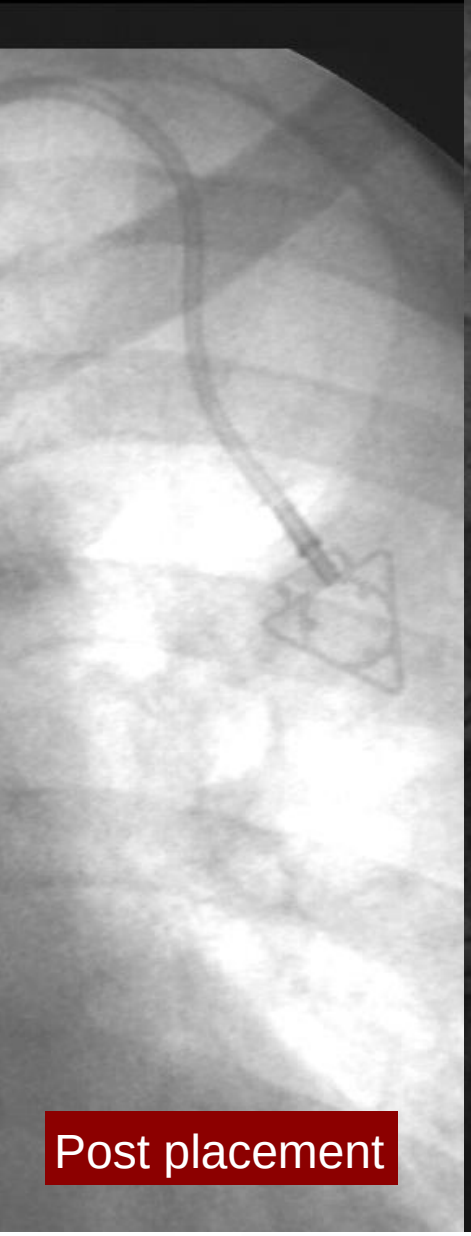




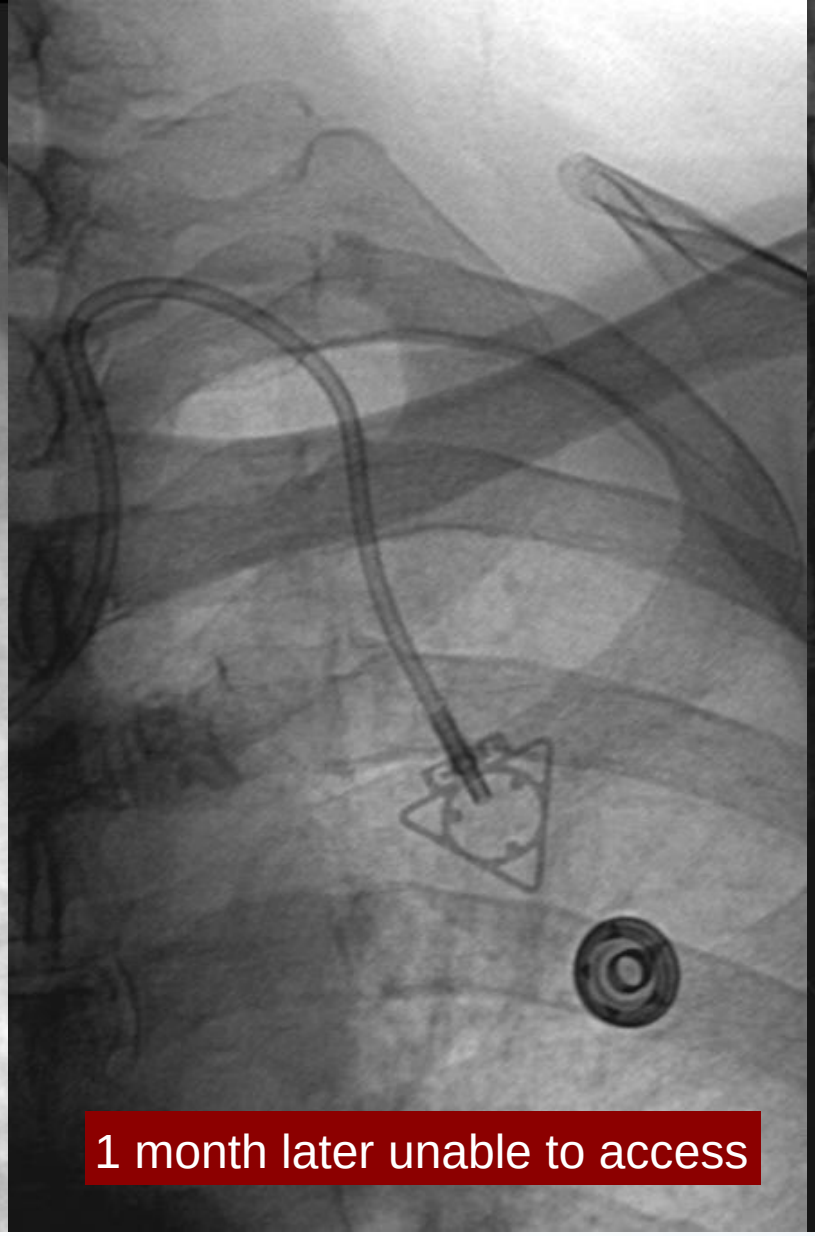
Flipped port

- Presents as inability to access port or extravasation after “access”

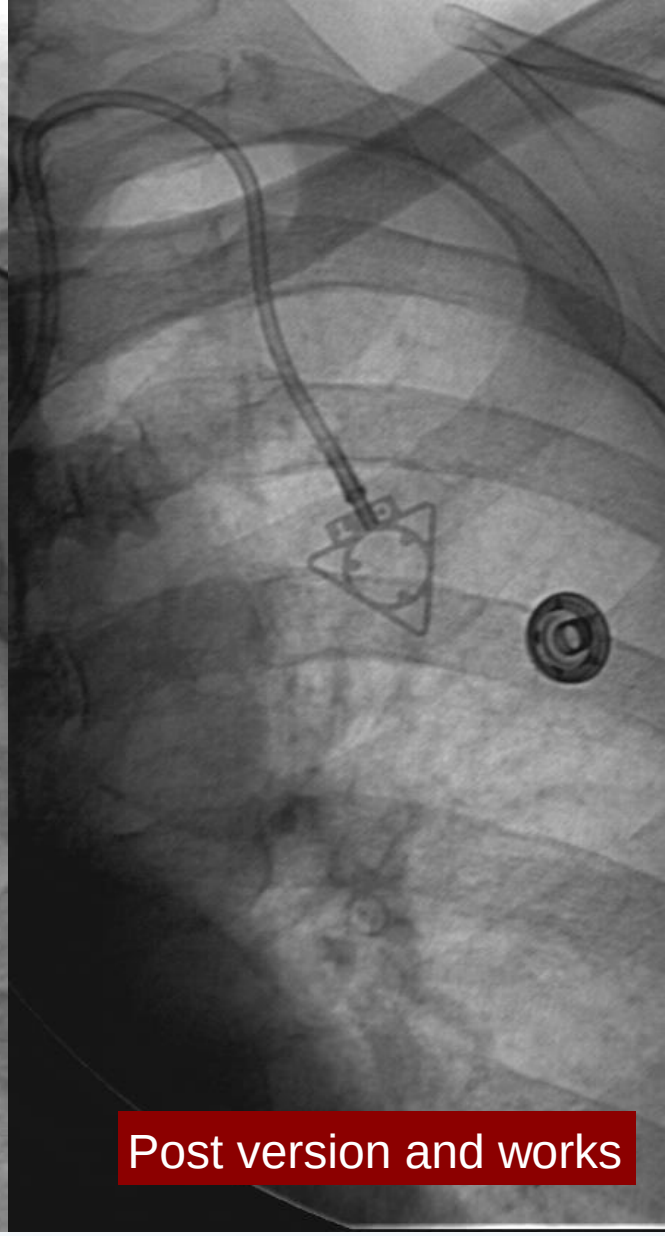




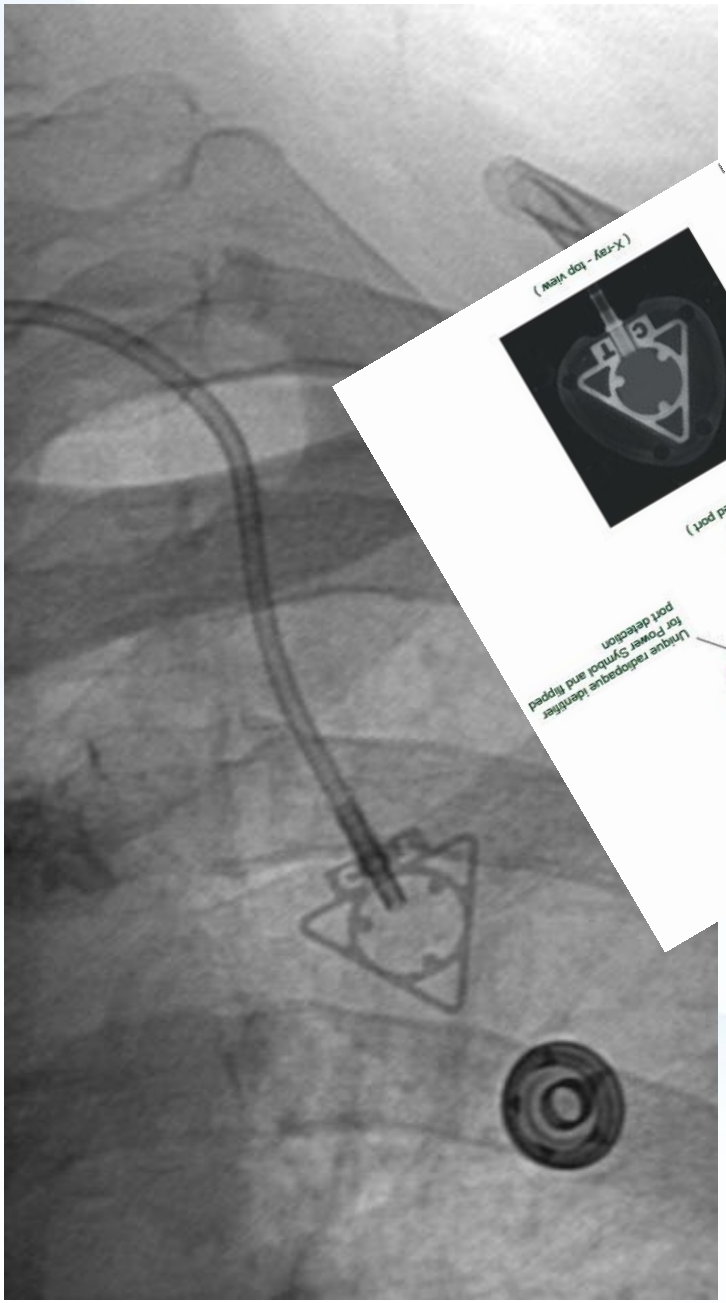
Post placement

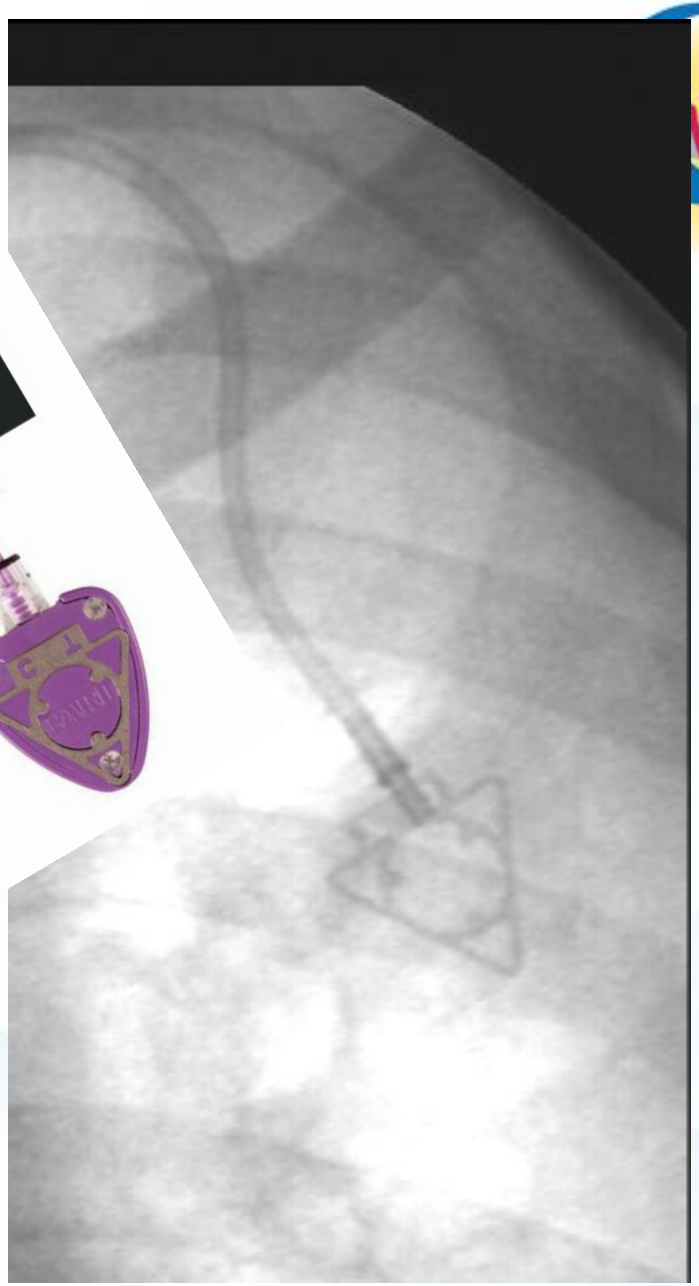


1 month later unable to access



Post version and works





Learn. Discover. Share.
NS 2016
Ft. Lauderdale, FL · May 14-19

INFECTION and THROMBOSIS

- Catheter related infection and venous thrombosis are the two most important complications to recognize and manage, particularly in the oncology patient

- Failure to recognize and treat may result in:
  - Delayed chemotherapy treatment
  - Reduced chemotherapy doses and suboptimal Rx
  - Prolonged hospitalization
  - Higher mortality rate
  - Increased cost of care

Infection

- Most common complication, most common source of inpatient bacteremia
- Defined as either:
  - 1. **Local** (insertion / exit site)
  - 2. **Tunnel or port pocket**
  - 3. **Bloodstream** (CRBSI): positive blood cultures
  - In U.S. CRBSI rate is 1.5 per 1000 CVC-days
  - 12-25% mortality

European Society for Medical Oncology Clinical Practice Guidelines, 2015.

Infection

- Historically, most common bloodstream pathogen was gram negative bacteria
- With recent prevalence of indwelling catheters, now most common is gram positive (>60%)
  - S. aureus
  - Candida (fungal)
- Successful treatment dependent both on early detection and the type of organism(s) responsible

Infection - Prevention

- Skin prep: chlorhexidine-based preparations decreased infection rates 40-50% compared to povidone-iodine solutions
- Chlorhexidine-impregnated dressings also reduce colonization at exit site: 14.8% vs 26.9% for standard dressings
- Antibiotic ointment at entrance site actually associated with increase in infection rates
- Antimicrobial/antiseptic catheters: mixed data, cost considerations

American Society of Clinical Oncology, Clinical Practice Guidelines, 2013

Infection - Treatment

- Heterogeneous patient population
- Cultures, begin empiric antibiotic therapy
- Most frequent pathogens are coagulase-negative staphylococcus and MRSA → Vancomycin

- And then the catheter: Take it out or leave it in?

Antibiotic Lock Therapy

- Not a lot of data regarding efficacy of this
- Uncomplicated infections, stable patient
- Overall success rates <50%
- Abx concentrations of 1-5mg/ml with 50-100 IU heparin to fill lumen
- Used in conjunction with systemic Abx
- Mainly for Staph, GNB infections; NOT effective against fungal infections

K Hall et al. JVIR 2004; 15:327-334.

Indications for catheter removal

- Sepsis
- Septic thrombophlebitis
- Endocarditis
- Tunnel infection
- Port pocket abscess
- Positive blood cultures despite 48-72 hrs treatment
- BSI with S. aureus, fungi or mycobacteria

European Society for Medical Oncology Clinical Practice Guidelines, 2015.

Chest Ports

- Outpatient placement reduces infection rate as compared to inpatient placement
  - Inpatients had a significantly higher infection rate per 1,000 catheter-days versus outpatients (0.72 vs 0.5; *P* = .01). Pandey N et al. JVIR 2013.

- Bevacizumab (Avastin) and wound healing
  - Dehiscence most significant within first 7days of Rx and port implantation, NO significant relative risk for removal beyond 14 days. Erinjeri JP et al. Cancer, Mar 2011.

3 days port port insertion

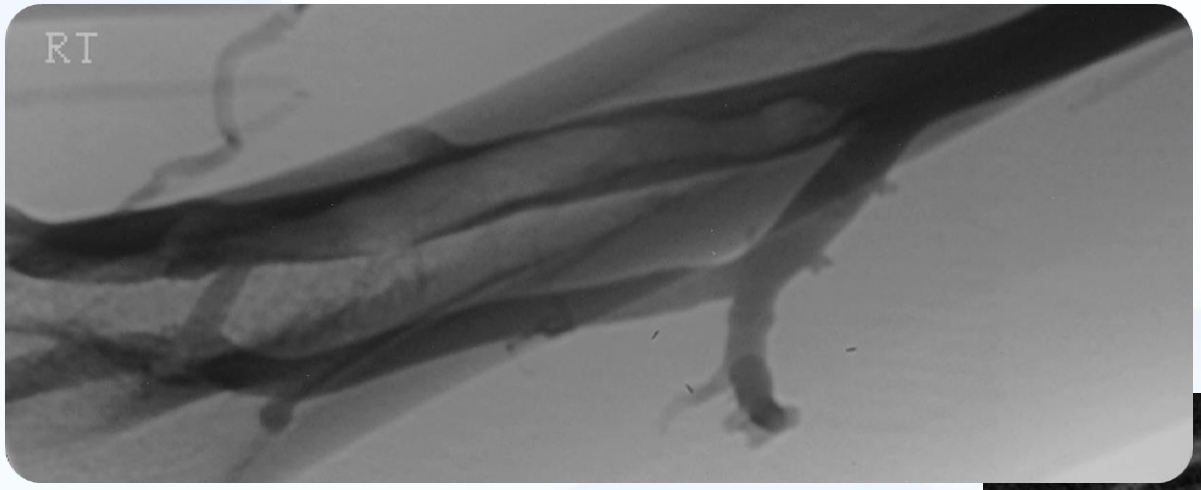
Port infection

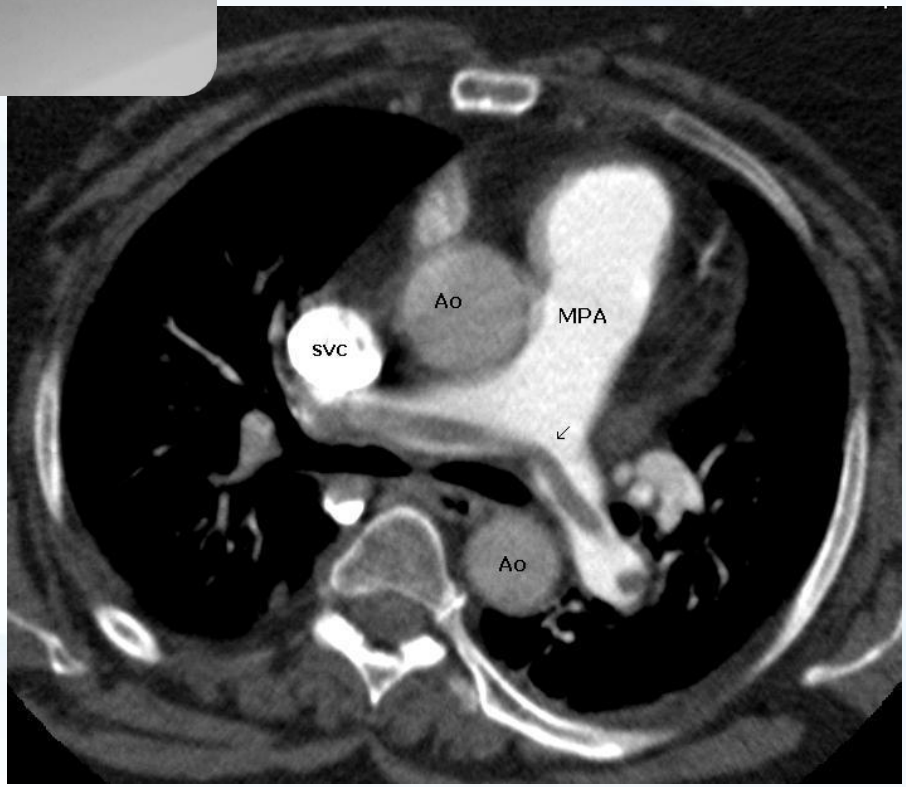
Removal

Port Pocket Infection Management

- Mild infection (cellulitis, skin intact):
  - Oral antibiotic therapy

- Purulent discharge, skin breakdown, signs of bactermia:
  - 5% incidence of port removal due to infection
  - Removal of port, cultures from pocket
  - Irrigation of port pocket with saline
  - Close wound primarily: if no purulence, healthy edges
  - Secondary Intention: Packing of wound with wet to dry dressings, wound clinic if available





Thrombus

Catheter Related Venous Thrombosis

- Second most common complication
- Recent placement of a central venous catheter increases the risk for upper-extremity deep vein thrombosis (DVT) by 5 – 7x in the cancer pt
  - Arch Intern Med 2000; 160:809-815
- Mechanisms:
  - Inc. plasma thrombin, coagulation cascade
  - Impaired fibrinolysis
  - Dec. levels of coagulation inhibitors
  - Enhanced platetlet aggregation

Deep Venous Thrombosis

- 130,000 – 550,000 cases in the U.S. per year
- DVT (lower extremity)= 0.1% incidence, increasing with age to 1% in elderly
- UEDVT= 1-4% all episodes of DVT

Anderson FA Jr, Wheeler HB, Goldberg RJ, et al. A population-based perspective of the hospital incidence and case-fatality rates of deep vein thrombosis and pulmonary embolism. The Worcester DVT Study. Arch Intern Med. 1991;151:933-938

Upper Extremity DVT

- 1-4% of all causes of venous thrombosis
- ***30%*** Primary DVT includes: thoracic outlet syndrome, effort thrombosis, and idiopathic venous thrombosis
- ***70%*** Secondary DVT includes: central venous catheters, transvenous pacemakers, or cancer (thrombophilia)

Incidence of Catheter Related UEDVT

- Asymptomatic upper extremity venous thrombosis has been reported to occur in 20% – 60% of patients with a central venous catheter

- Symptomatic DVT has been reported to occur in 0%-30% of patients with a central venous catheter

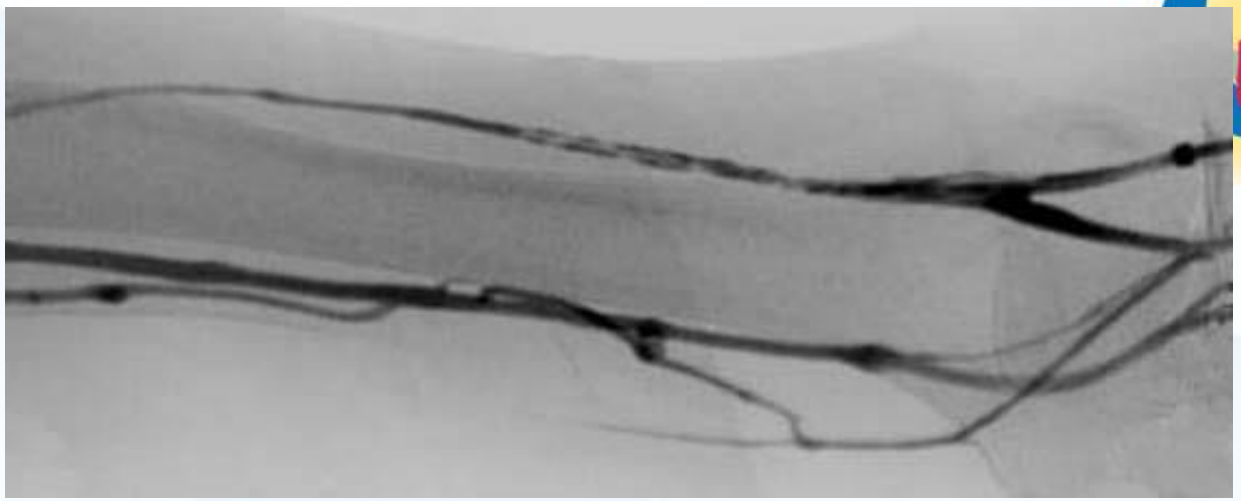
Allen A et al. **JVIR 2000;** 11:1309–1314

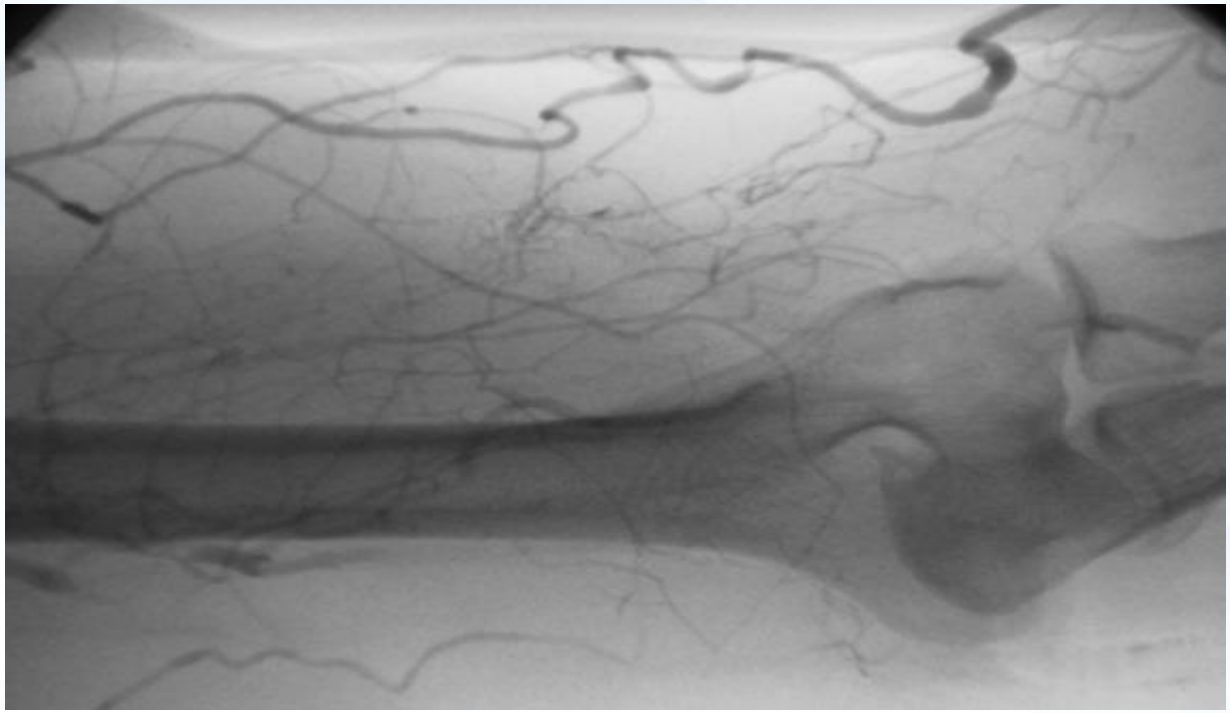
Table 2—*Characteristics of Patients With PICC-Associated DVT at Intermountain Medical Center During 2008*

Characteristic	No.
Total PICC insertions with DVT (%)	60 (3.0)
Total distinct patients with DVT	57
Patients with two DVTs during same hospitalization	2
Patients with two DVTs during different hospitalizations	1
Mean duration from PICC insertion to DVT diagnosis, d (range)	9.5 (1-64)
Veins affected by DVT[a]	
Axillary	49
Subclavian	26
Basilic	10
Brachial	3
Cephalic	3

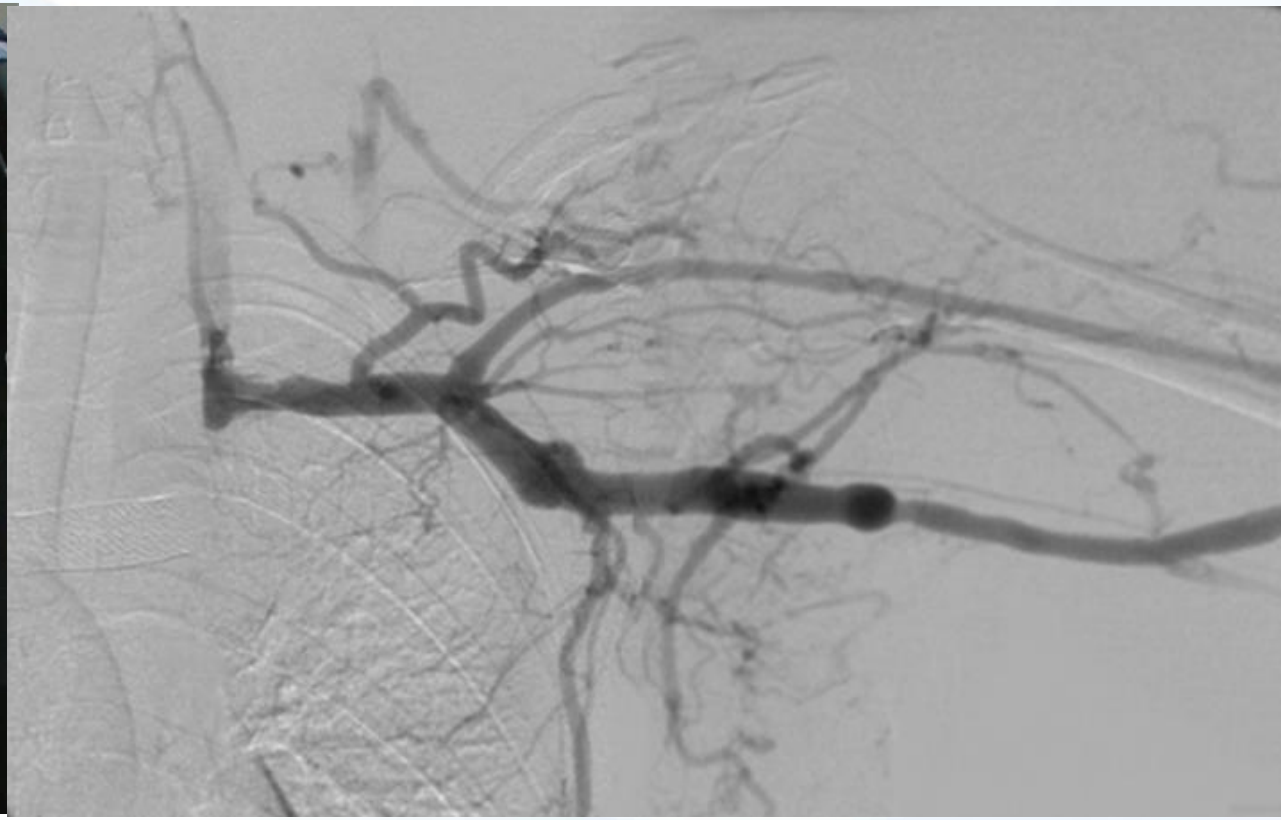
See Table 1 legend for expansion of abbreviation.

[a]Multiple veins could be involved during the same incidence of DVT.





Catheter Related Chronic Central Occlusion



Technical Risk Factors for UEDVT

- Larger catheter diameter (5F or less for UE veins*)
- More catheter lumens
- Catheter tip malposition
- Two or more insertion attempts
- Left sided placement
- Subclavian insertion site

* Trerotola SO et al. *Radiology* 2010: 256(1)

Catheter Removal + Anticoagulation

- Catheters were removed from 77% of 101 patients with upper extremity DVT
- Anticoagulation was used in 62%
- Both catheter removal and anticoagulation were used in 49%.
- In multivariate analysis, only catheter removal predicted likelihood of thrombus resolution (*P=0.025).*

Guidelines for Prevention of Thrombus

- Systemic anticoagulation:
  - NO: Not been shown to decrease incidence of CR-DVT
  - Yes, to flushing catheter with heparinized saline
- Routine use of thrombolytics:
  - NO: No advantage over heparin flush
- Use of tPA or Urokinase to restore catheter patency:
  - YES: (4 RCTs)

American Society of Clinical Oncology, Clinical Practice Guidelines, 2013

Relationship of Thrombus and Infection

- Heparin impregnated catheters or catheters with anti-thrombogenic engineering:
  - Increased intraluminal fibrin deposition may contribute to increased colonization and infection
  - One RCT in cancer patients: catheter related BSI 2.5% in heparin-coated catheters vs. 9.1% in non-coated, flushed with heparin

(Marin MG et al. *Prevention of nosocomial bloodstream infections: Effectiveness of antimicrobial-impregnated and heparin-bonded central venous catheters. Crit Care Med, 2000.* ***28****:3332–3338)*

UEDVT and PE

- Owens CA et al. JVIR 2010; 21: 779-787
  - Review of literature: 28 publications, 3747 cases of UEDVT
  - Rate of PE: 5.6%
  - Mortality from PE: 0.7%

Summary of Treatment for CR Thrombosis

- Comparison of recommendations from:
  - National Comprehensive Cancer Network (NCCN)
  - American Society of Clinical Oncology (ASCO)
  - American College of Chest Physicians (ACCP)

- *Initial Treatment:*
  - Low molecular weight heparin (consensus)
  - Alternatively, PTT adjusted heparin gtt (NCCN)
  - 2mg tPA to restore catheter patency (ASCO)

Summary of Treatment for CR Thrombosis

- Long term treatment:
  - NCCN: LMWH for 6mo without warfarin for proximal DVT or PE; alternatively with warfarin initially (INR 2-3)
  - ASCO: 3-6 months followed by warfarin (INR 2-3) if patient symptomatic
  - LMWH preferable over warfarin (consensus) although warfarin acceptable if LMWH not available (ASCO)

What About the Catheter?

- NCCN: Anticoagulate as long as catheter in place and 1-3 mo after catheter removal
- ASCO: Treat beyond 6mo if active cancer (metastatic disease, receiving chemo, recurrent thrombosis)
- Remove if catheter not needed, symptoms persist (consensus)

Thrombolytic Therapy

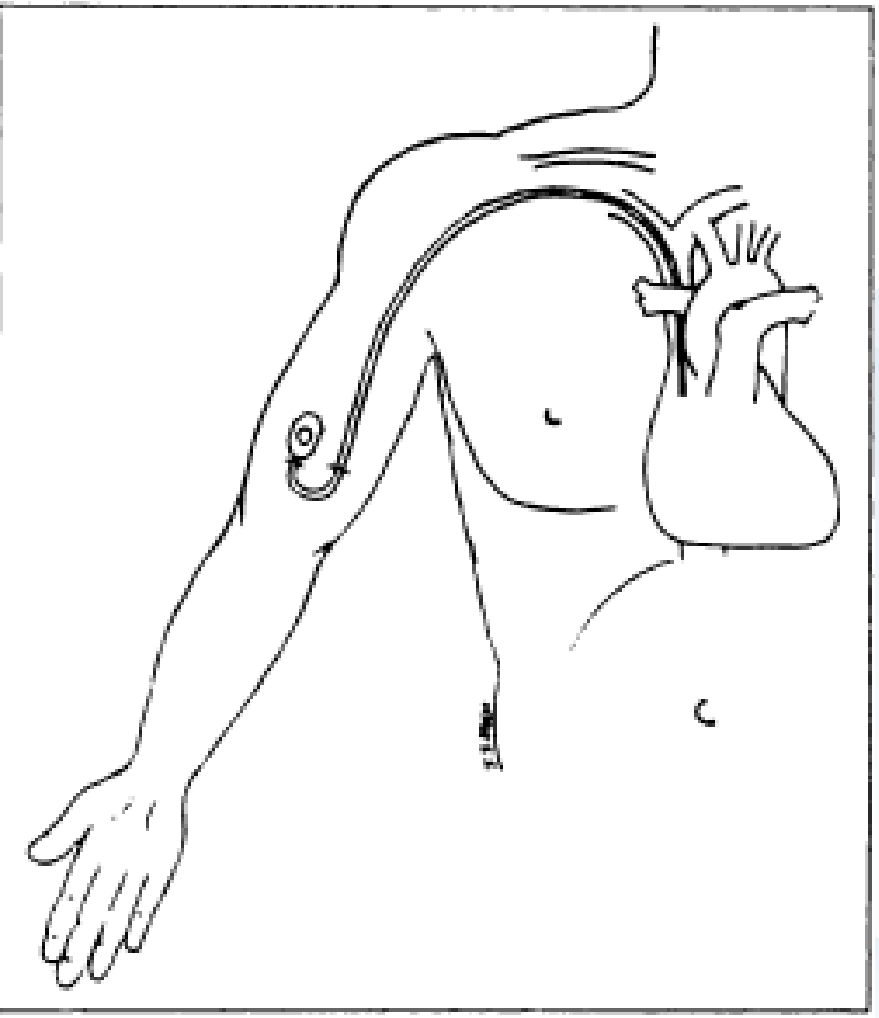
- Role for Catheter directed Rx IF:

- massive DVT
- Symptomatic
- Low bleeding risk

Does type of catheter matter?

- Consider patient's present and future needs, duration of therapy, co-morbidities, etc.
- Literature review (American Society of Clinical Oncology, Clinical Practice Guidelines, 2013):
  - 10 RCTs
  - 3 meta-analyses
  - Insufficient evidence to recommend one CVC
    - Ports better for long term chemotherapy (specifically for solid tumors)
    - Ports/tunneled lines have higher immediate infection risk
    - PICCs have higher infection risk when inpatients

Arm ports



- Well tolerated
- Higher risk of DVT when compared to IJ
  - (11.4% vs. 4.8%)
- Higher malfunction rate
  - (29% vs. 1.7%)
  - (.05/1000 days vs. .95/1000 days)

Yip et al. Subcutaneous chest ports via the IJ ve
Acta Radiologica, 2002; 43:371-375.

Kaufman et al. Long-term outcomes of Radiologically Placed Arm Ports. Radiology 1996; 201:725-
Kuriakose P et al. Risk of deep venous thrombosis associated with chest versus arm central venous subcutaneous port catheters: a 5-year single-institution retrospective study. J Vasc Interv Radiol. 2002 Feb;13(2 Pt 1):179-84

Does access site matter?

- ASCO 2013 Guidelines:
  - 6 RCTs
  - 1 meta-analysis
  - Insufficient evidence, right or left, internal jugular vs subclavian vs cephalic
  - Avoid femoral access except in emergencies
    - Higher infection, thrombosis risk

Summary

- Infection, thrombosis and mechanical complications comprise the 3 major categories of CVC related complications
- Clinical examination and CXR are essential tools for diagnosis
- Anticoagulation for DVT with LMWH should be at least 3-6 months
- In the setting of thrombus, the catheter should remain in place unless no longer needed or if no improvement despite therapy


Thank
You
Gracias
Merci
Arigato
Biyan
Grazie
Juspaxar
Shukria
Mehrbani
Dankscheen
Efcharisto
Yaqhanyelay
suksama
bolzïn
Tashakkur
Shukuria
Paldies
Komapsumnida
Tingki
atu
gozaimashita
Maake
Ekhmet
Spassibo
Merastawhy
Dhanyabaad
Maketai
Wabeeja
Medawagse
Mersi
Denkauja
Fakaaue
Baiika
Yuspagaraktam
Minmonchar
Atto
Gaejtho
Maitaka
ekoja
Sanco