

RADIOGRAPHIC ASSESSMENT OF PICCs: *A Review*

***Jamie Bowen Santolucito, RN, CRNI, VA-BC
Director of Clinical Practice & Education
GoldStar Vascular Access, Inc.
Portland, Oregon***

Financial Disclosures

Jamie has the following financial disclosures:

Speaker Bureau:

BD-BARD

Adhezion Biomedical

There is no corporate support for this lecture.

Objectives

- Review vascular anatomy of the right and left mediastinal borders.
- Identify direct and indirect methods for determining optimal CVAD “landing zone.”
- Present select cases demonstrating optimal, suboptimal and malpositioned PICCs.

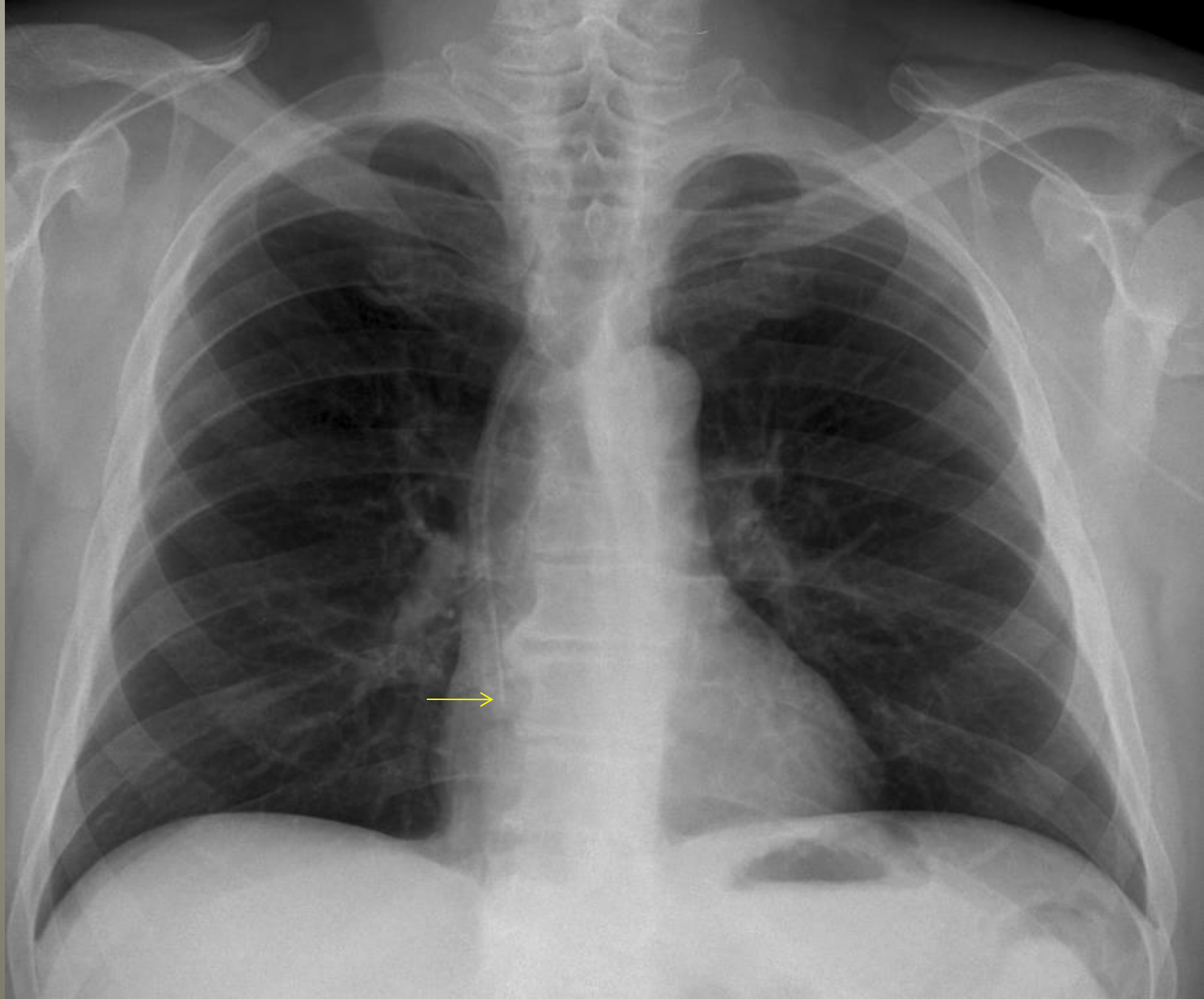
Initial Radiographic Assessment of PICC Tip Position by Qualified Vascular Access Specialist

- INS Standard 23. CVAD Tip Location
 - *“Clinicians with documented competency determine the tip location of a CVAD by using ECG or assessing the post-procedure chest radiograph and initiate therapy based on this assessment.”*
- AVA, 2008 Position Statement
 - “Interpretation of Chest Radiographs by RNs for Verification of PICC Tip Position”
 - *“A nurse who has met the requirements to competently assess the anatomic location of a vascular catheter on a chest radiograph can verify the tip position of a peripherally inserted central catheter (PICC) and authorize use of the device.”*
- INS, 2010 Position Paper
 - “The Role of the Registered Nurse in Determining Distal Tip Placement of PICCs by Chest Radiograph”
 - *“A qualified RN may determine the distal tip location of peripherally inserted central catheters (PICCs) by initial or repeat chest radiograph studies prior to administration of the prescribed therapy.”*

Gorski, L.A., et al (2016) Infusion therapy standards of practice. *JIN*.

AVA Position Statement: Interpretation of chest radiographs by nurses for verification of PICC tip position. (2008) Retrieved from www.avainfo.org.

INS (2010) Position Paper: The role of the registered nurse in determining distal tip placement of PICCs by chest radiograph. *JIN*, 33(1);19-20.



Recommendations for CVAD Tip Position

<i>Standard</i>	INS, 2016 Standards of Practice	Lower segment of SVC at or near the CAJ IVC above level of diaphragm
<i>Guideline</i>	ONS, 2011 Access Device Guidelines	Distal third of SVC
<i>Guideline</i>	NKF, 2006 Dialysis Quality Initiative Guidelines	SVC or RA
<i>Statement</i>	AVA, 1998 Position Statement	Distal SVC close to CAJ
<i>Guideline</i>	ASPEN, 2004 Safe Practices for Parenteral Nutrition	Lower SVC adjacent to RA
<i>Guideline</i>	SIR, 2010 Quality Improvement Guidelines for CVCs	Cavoatrial region or RA <i>CAJ defined as two vertebral body units below carina</i>

Quality Improvement Guidelines for Central Venous Access



Sean R. Dariushnia, MD, Michael J. Wallace, MD, Nasir H. Siddiqi, MD, Richard B. Towbin, MD,
Joan C. Wojak, MD, Sanjoy Kundu, MD, FRCPC, and John F. Cardella, MD

J Vasc Interv Radiol 2010; 21:976–981

PREAMBLE

THE membership of the Society of Interventional Radiology (SIR) Standards of Practice Committee represents experts in a broad spectrum of interventional procedures from both the private and academic sectors of medicine. Generally Standards of Practice Committee members dedicate the vast majority of their professional time to performing interventional procedures; as such they represent a valid broad expert constituency of the subject matter under consideration for standards production.

Technical documents specifying the exact consensus and literature review methodologies as well as the institu-

tional affiliations and professional credentials of the authors of this document are available upon request from SIR, 3975 Fair Ridge Dr., Suite 400 North, Fairfax, VA 22033.

METHODOLOGY

SIR produces its Standards of Practice documents using the following process. Standards documents of relevance and timeliness are conceptualized by the Standards of Practice Committee members. A recognized expert is identified to serve as the principal author for the standard. Additional authors may be assigned dependent upon the magnitude of the project.

An in-depth literature search is performed using electronic medical literature databases. Then a critical review of peer-reviewed articles is performed with regards to the study methodology, results, and conclusions. The qualitative weight of these articles is assembled into an evidence table, which is used to write the document such that it contains evidence-based data with respect to content, rates, and thresholds.

When the evidence of literature is weak, conflicting, or contradictory, consensus for the parameter is reached by a minimum of 12 Standards of Practice Committee members using a Modified Delphi Consensus Method (Appendix A). For purposes of these documents, consensus is defined as 80% Delphi participant agreement on a value or parameter.

The draft document is critically reviewed by the Revisions Subcommittee members of the Standards of Practice Committee, either by telephone conference calling or face-to-face meeting. The

finalized draft from the Committee is sent to the SIR membership for further input/criticism during a 30-day comment period. These comments are discussed by the Subcommittee, and appropriate revisions made to create the finished standards document. Prior to its publication the document is endorsed by the SIR Executive Council.

INTRODUCTION

This guideline was revised from a quality improvement document initially developed by SIR for central venous access (1).

These guidelines are written to be used in quality improvement programs to assess central venous access procedures. The most important processes of care are (i) patient selection, (ii) performing the procedure, and (iii) monitoring the patient. The outcome measures or indicators for these processes are indications, success rates, and complication rates. Outcome measures are assigned threshold levels.

DEFINITIONS

Image-guided percutaneous central venous access is defined as the placement of a catheter with its tip in the cavoatrial region or right atrium with the assistance of real-time imaging. The cavoatrial junction has been defined as two vertebral body units below the carina (2). The most commonly used imaging techniques during placement are fluoroscopy and ultrasonography (US).

Tunneled catheters are defined as catheters that travel through a subcutaneous tract before exiting the body through a small incision in the skin. Im-

SIR DEFINITIONS

“central venous access is defined as the placement of a catheter with its tip in the cavoatrial region or right atrium”

“the cavoatrial junction has been defined as two vertebral body units below the carina”

From the Department of Interventional Radiology and Image-Guided Medicine (S.R.D.), Emory University, Atlanta, Georgia; Department of Interventional Radiology (M.J.W.), The University of Texas M. D. Anderson Cancer Center, Houston, Texas; Mallinckrodt Institute of Radiology (N.H.S.), Saint Louis University School of Medicine, St. Louis, Missouri; Department of Radiology (R.B.T.), Phoenix Children's Hospital, Phoenix, Arizona; Department of Radiology (J.C.W.), Our Lady of Lourdes Medical Center, Lafayette, Louisiana; Department of Medical Imaging (S.K.), Scarborough General Hospital, Toronto, Ontario, Canada; and Department of Radiology (J.F.C.), Geisinger Health System, Danville, Pennsylvania. Received January 14, 2010; final revision received February 27, 2010; accepted March 3, 2010. Address correspondence to S.R.D., c/o Debbie Katsarelis, SIR, 3975 Fair Ridge Dr., Suite 400 N., Fairfax, VA 22033; E-mail: sdariush@emory.edu

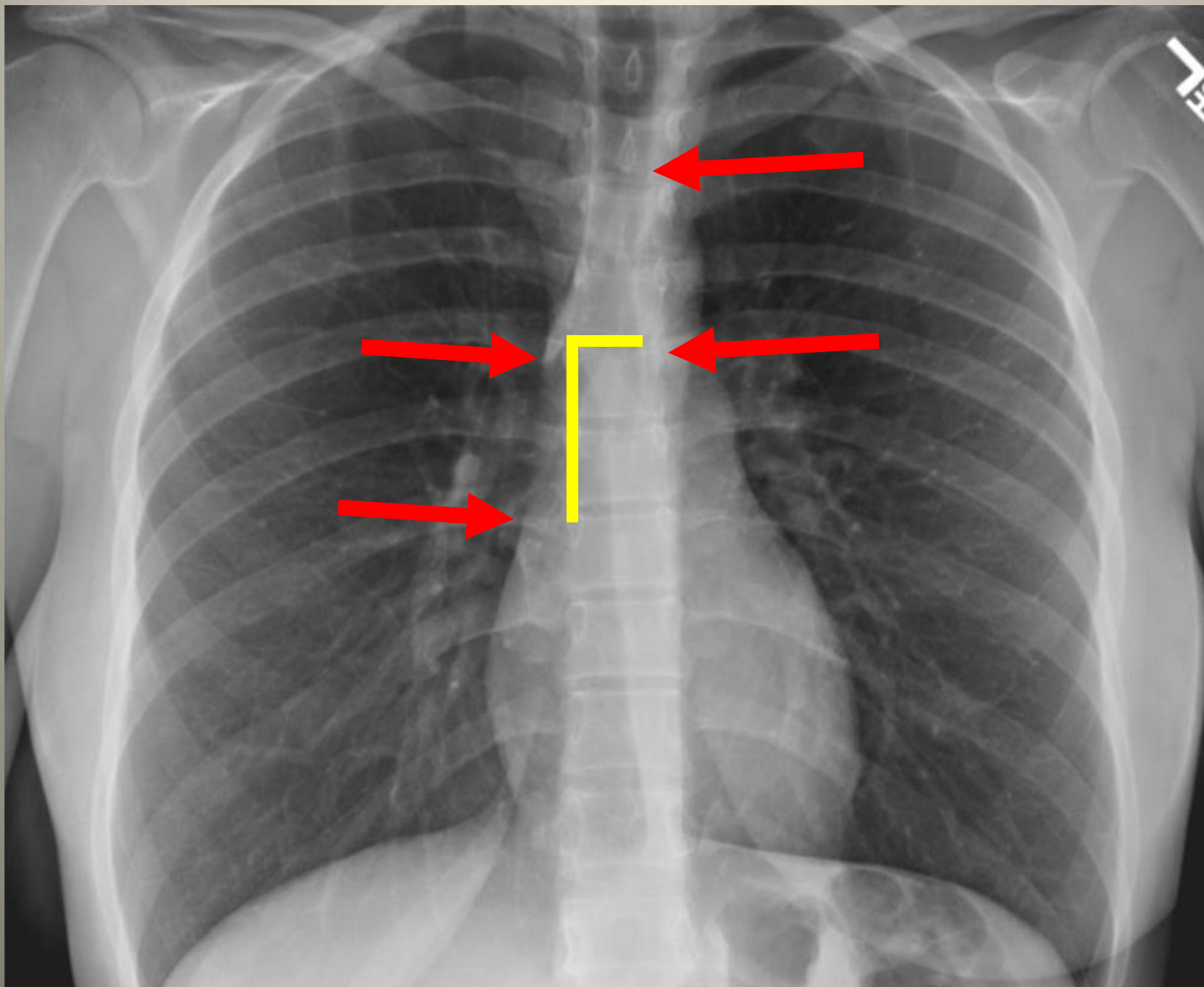
M.J.W. has research funded by Siemens Medical Solutions (Erlangen, Germany). None of the other authors have identified a conflict of interest.

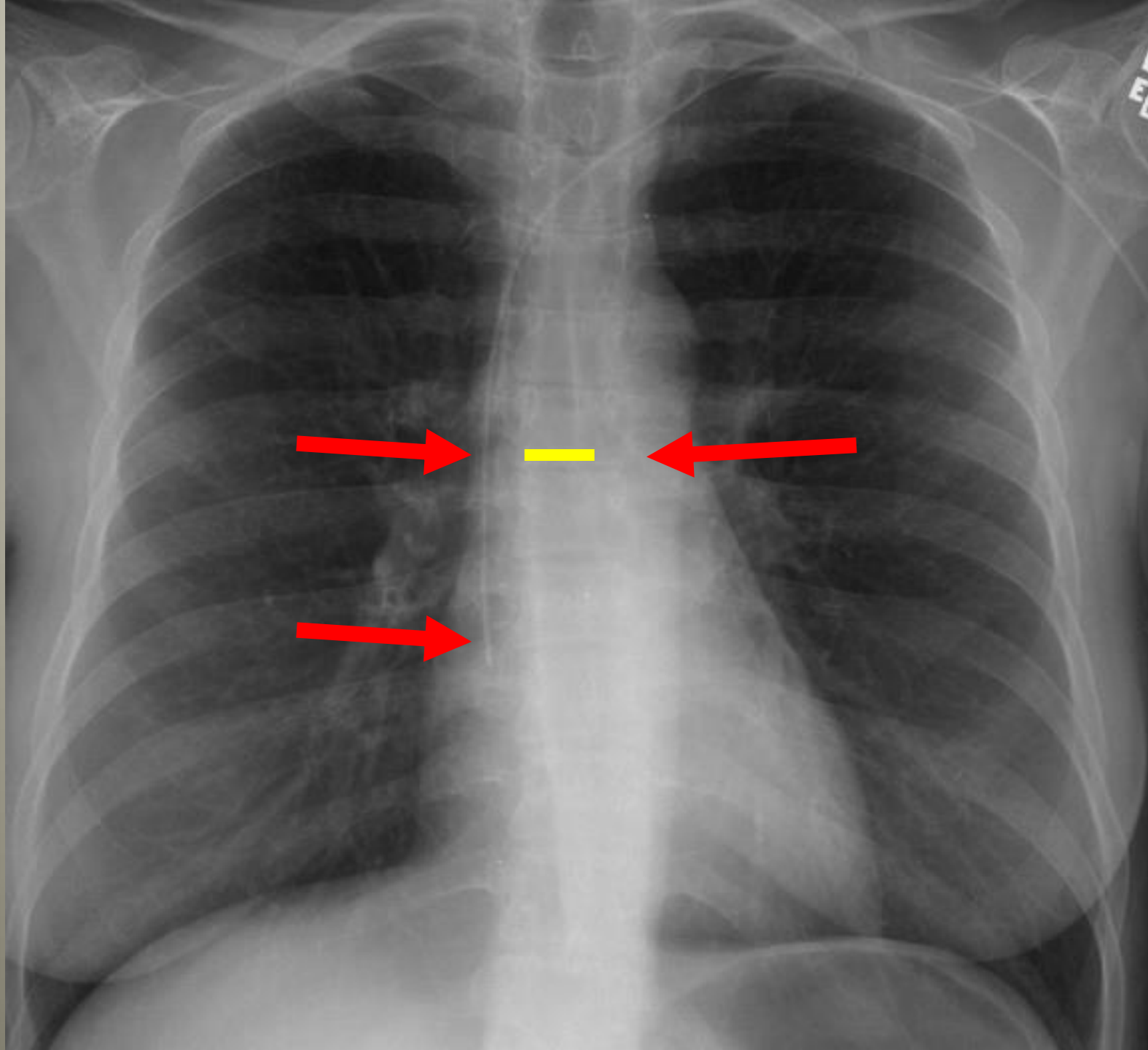
This article first appeared in J Vasc Interv Radiol 1997; 8:475–479; 2003; 14:S231–S235.

© SIR, 2010

DOI: 10.1016/j.jvir.2010.03.006

Dariushnia, S.R., et al. (2010) *Jour Vasc and Interven Radio*.





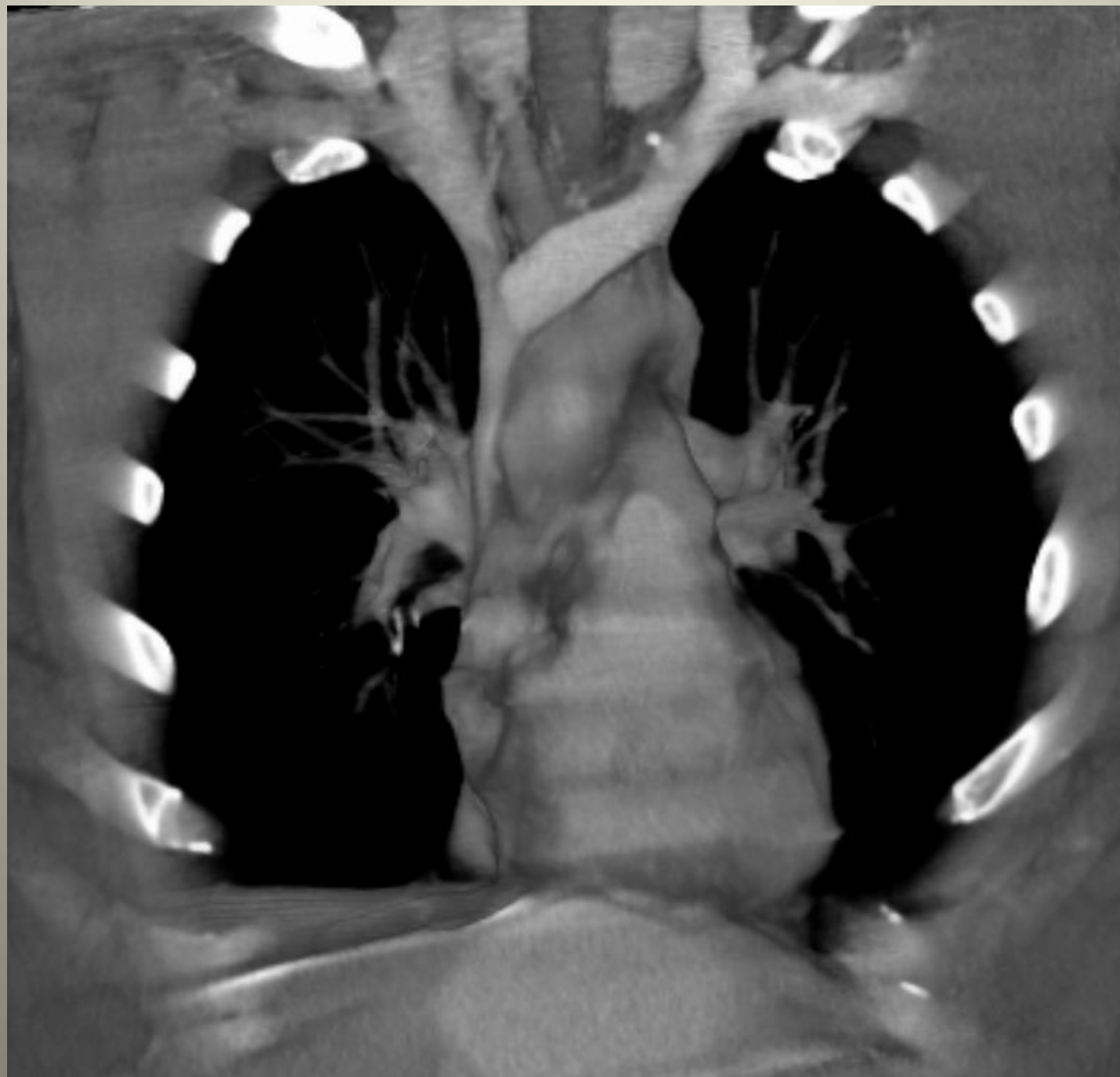
Defining Optimal PICC “Landing Zone”

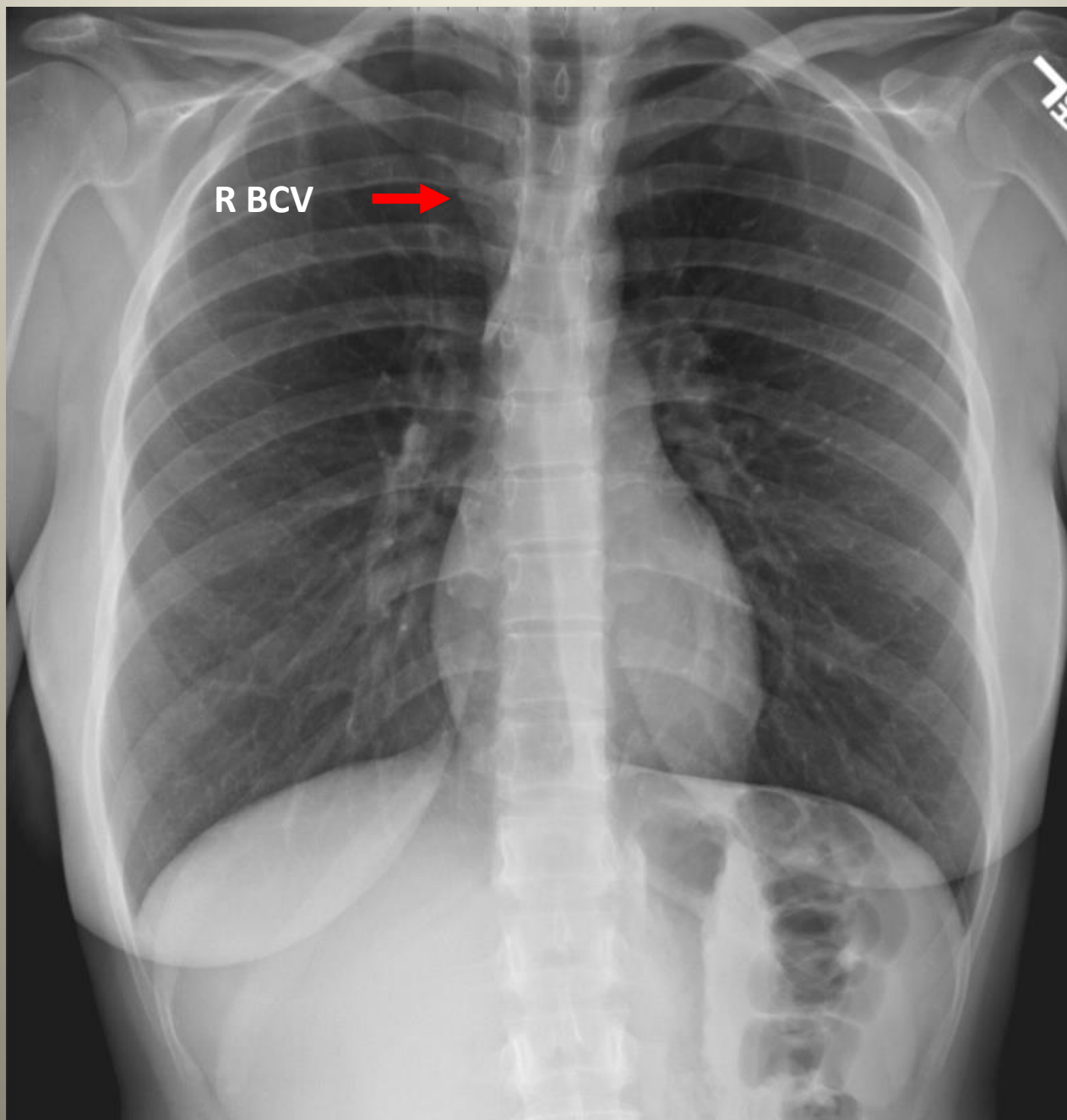
- ***Direct method***
 - ***Utilizes vascular structures***
 - ***Most reliable***

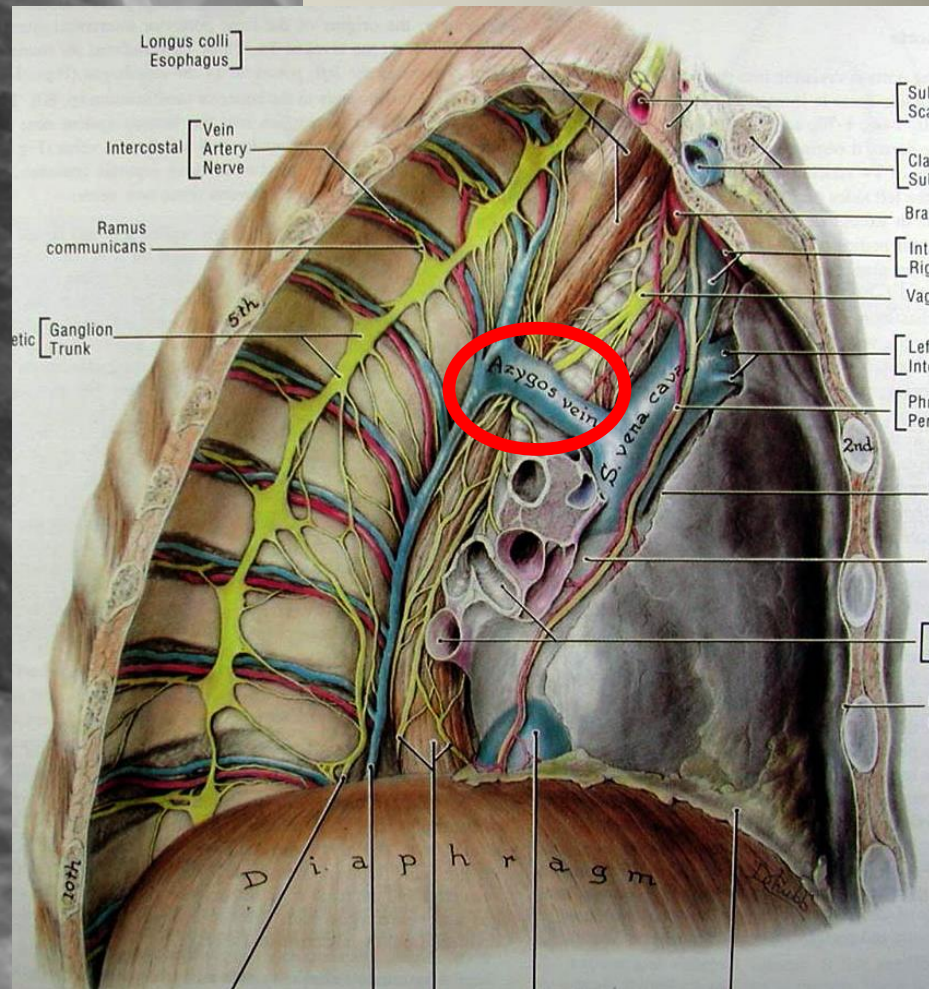
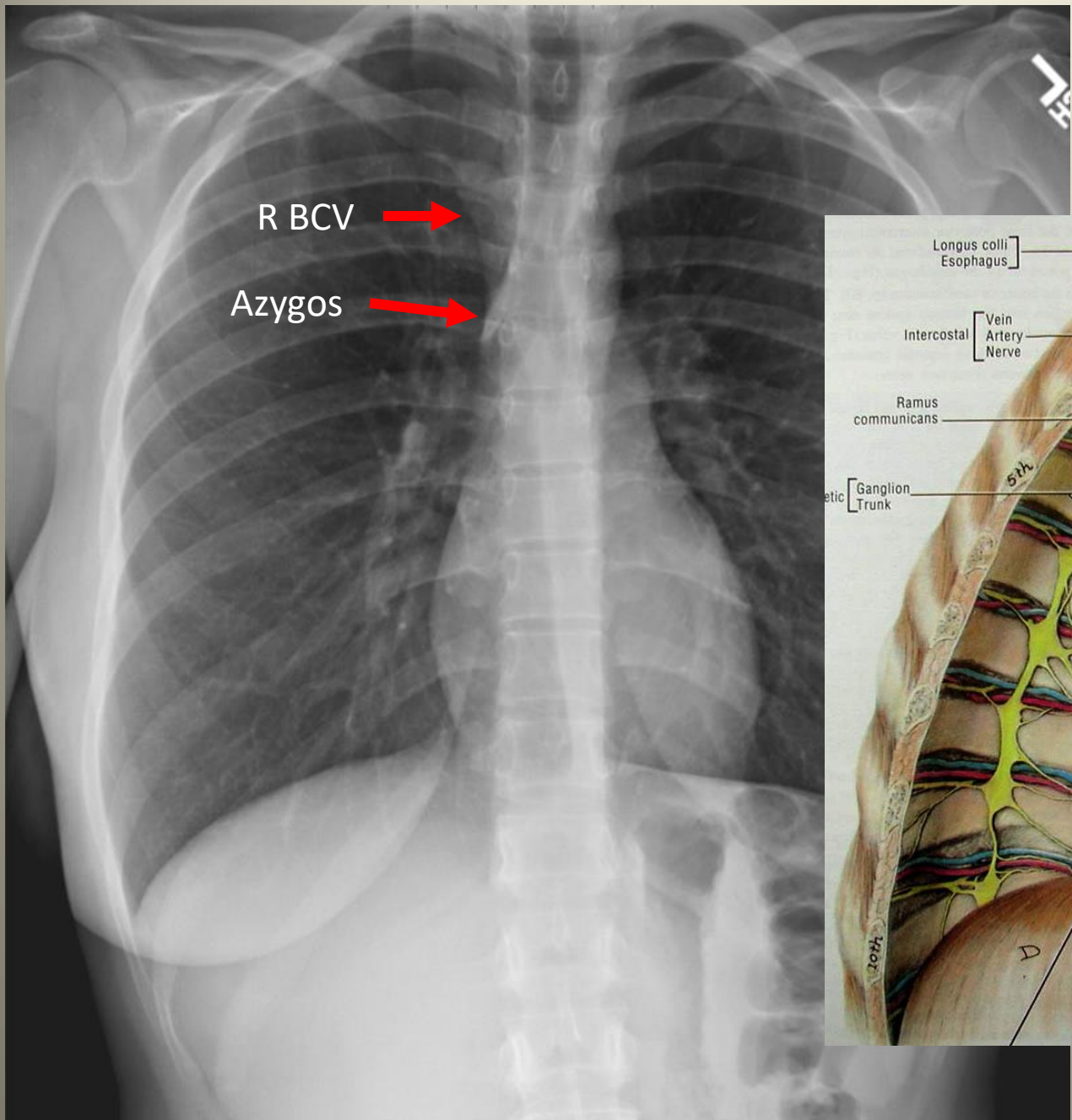
Right Mediastinal Border

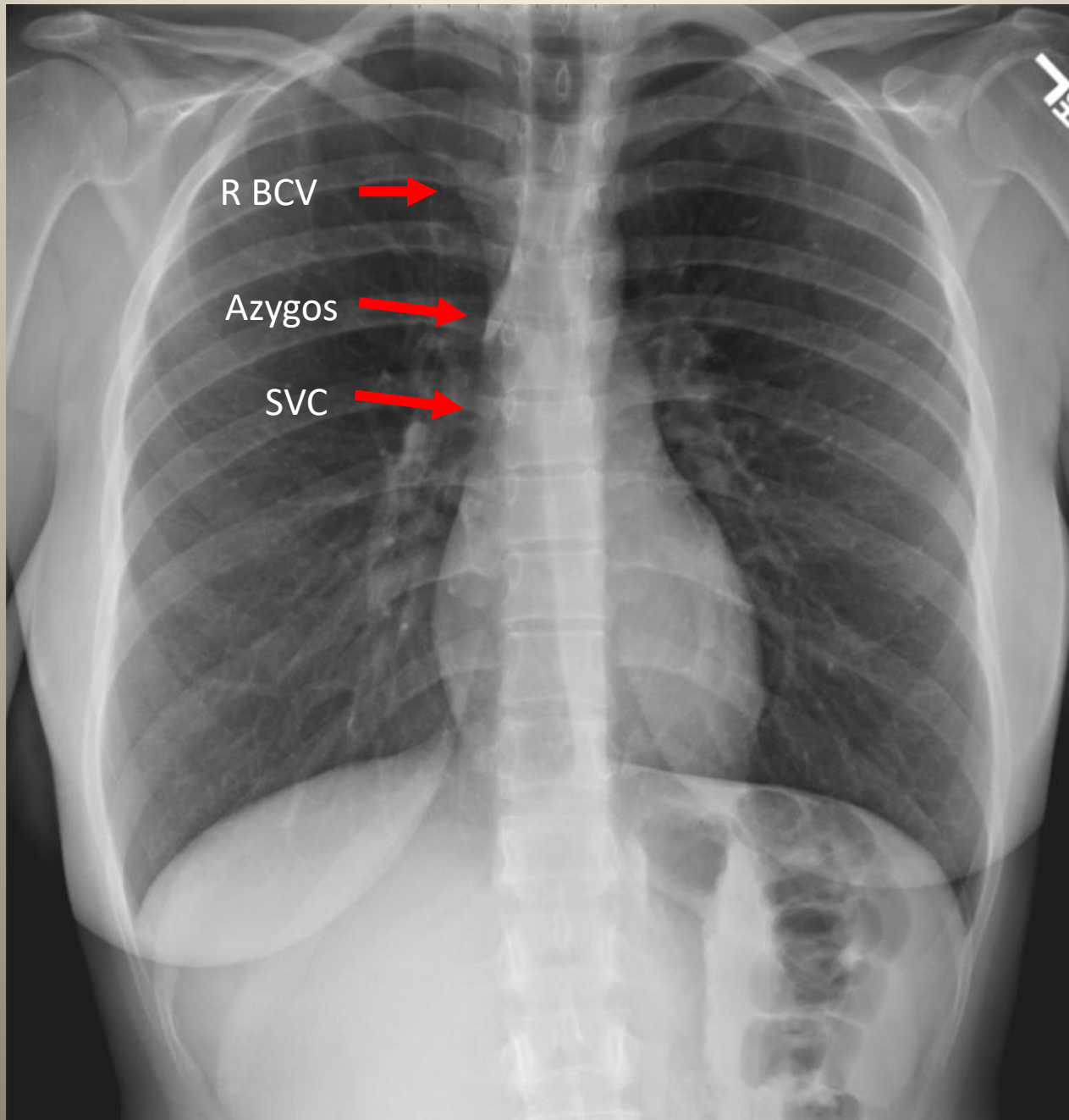
Superior to Inferior

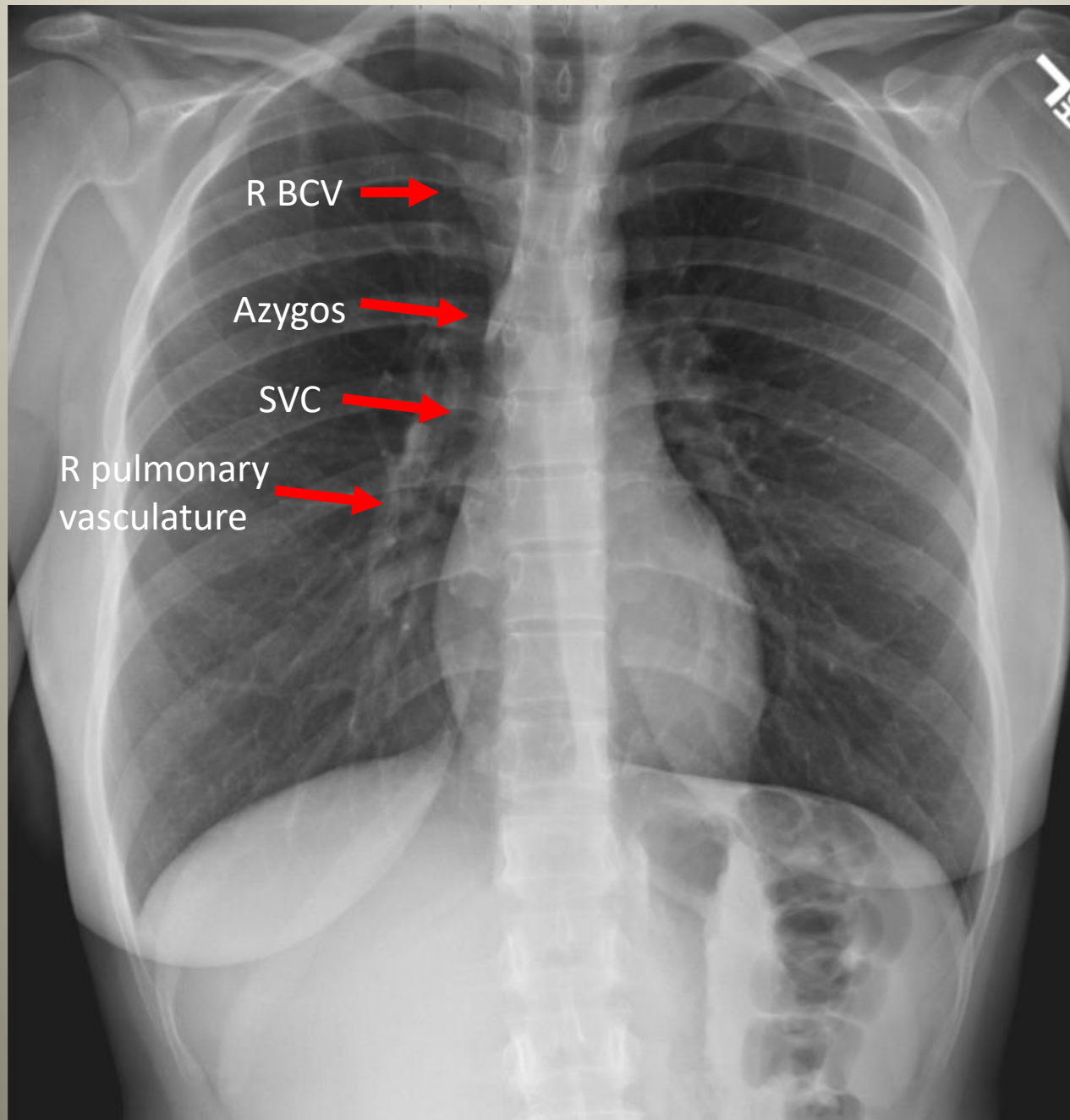
- R Brachiocephalic v.
- SVC
- Azygos v.
- R pulmonary vasculature
- RAA
- CAJ
- RA

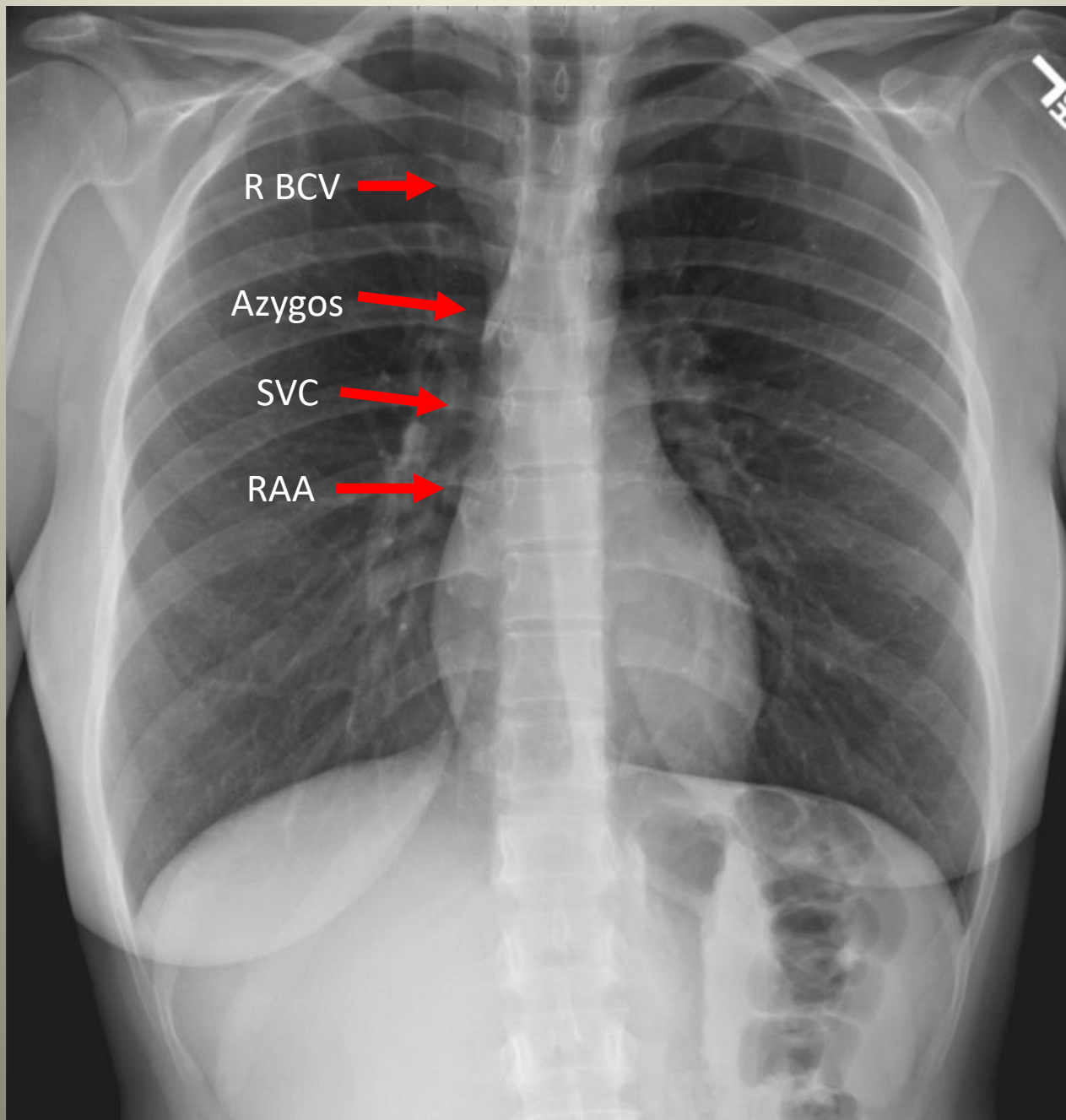






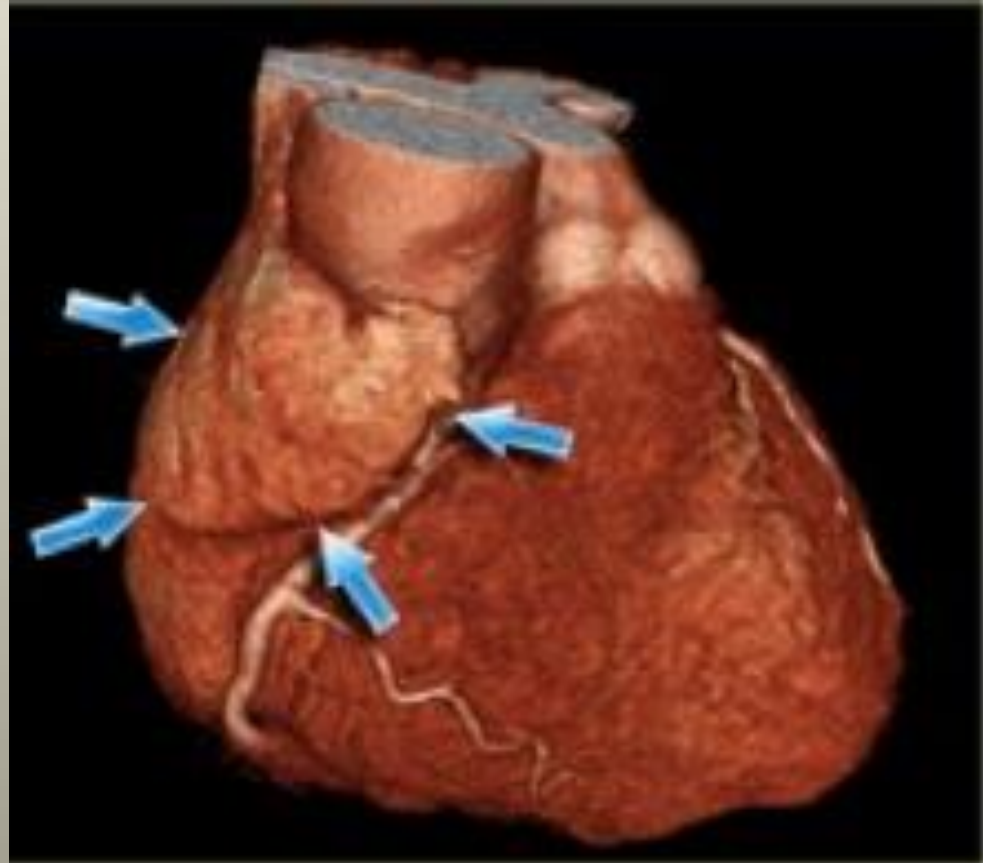


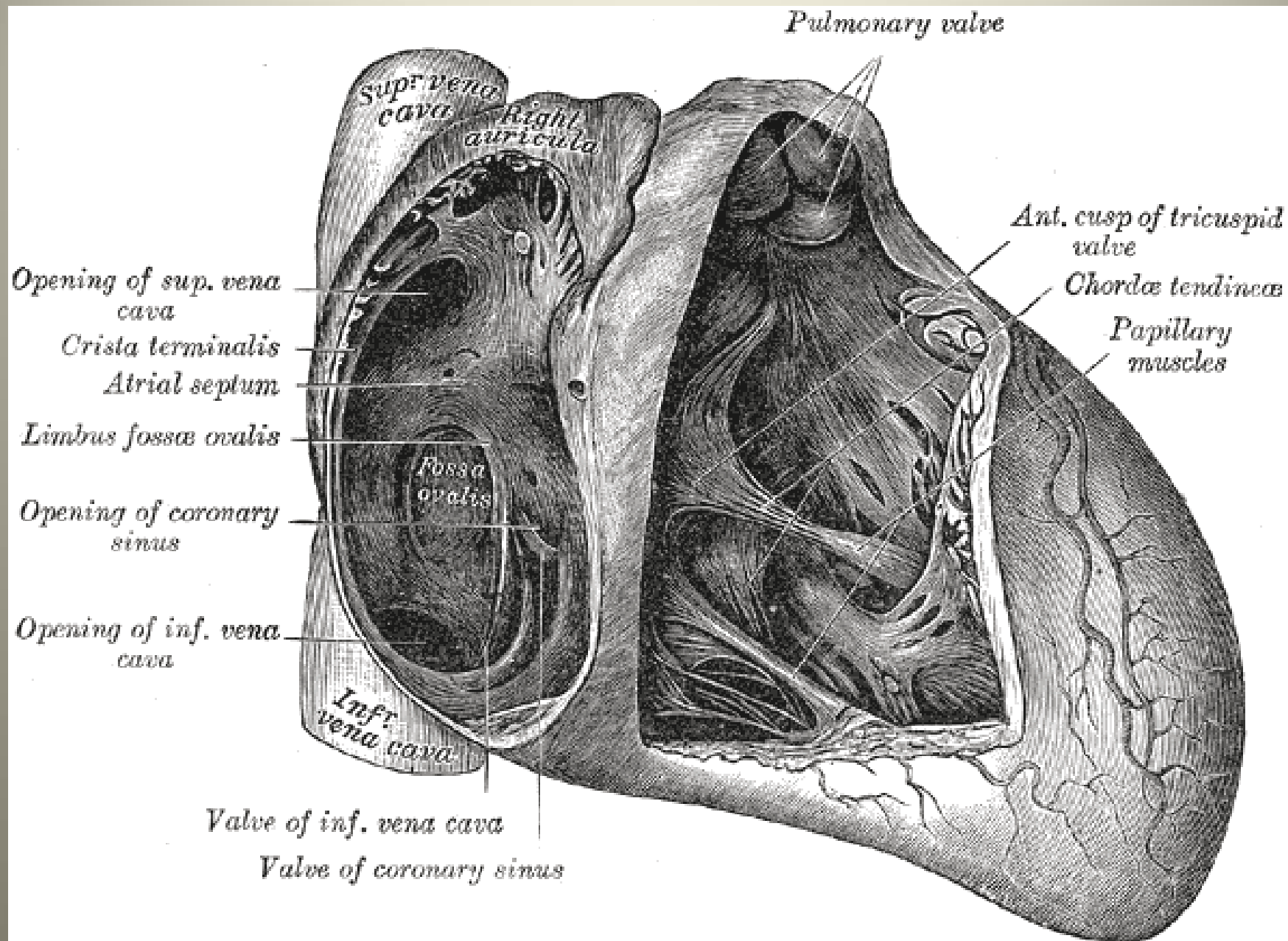




Right Atrial Appendage (RAA)

- Small muscular pouch attached to RA
- Embryonic remnant
- Creates confusion; has little function
- Provides interface on CXR to define CAJ







Where is the CAJ on CXR?

- 99 patients with contrast-enhanced CTs and correlating scout CXR
- Most superior right heart border-forming structure was the RAA in 100% of patients
- CAJ located on average
 - 1.88 cm (2 cm) inferior to RAA
 - 5 cm inferior to carina



SCHOLARLY AND RESEARCH

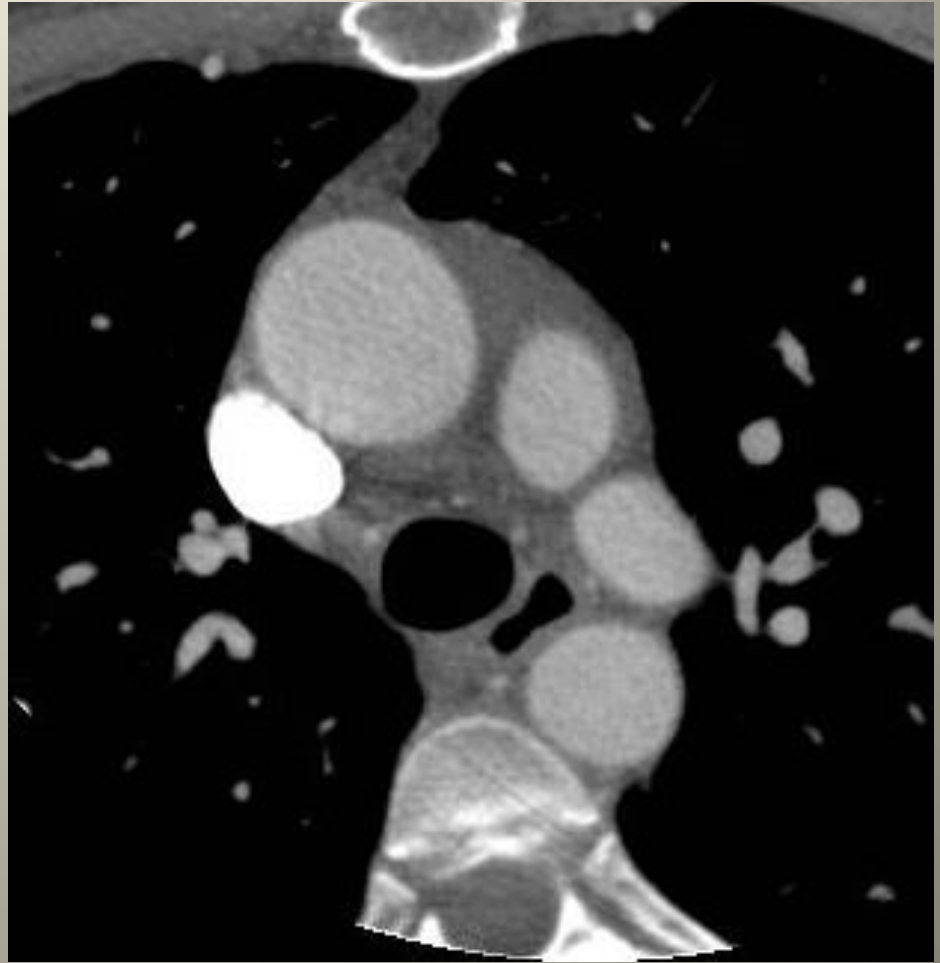
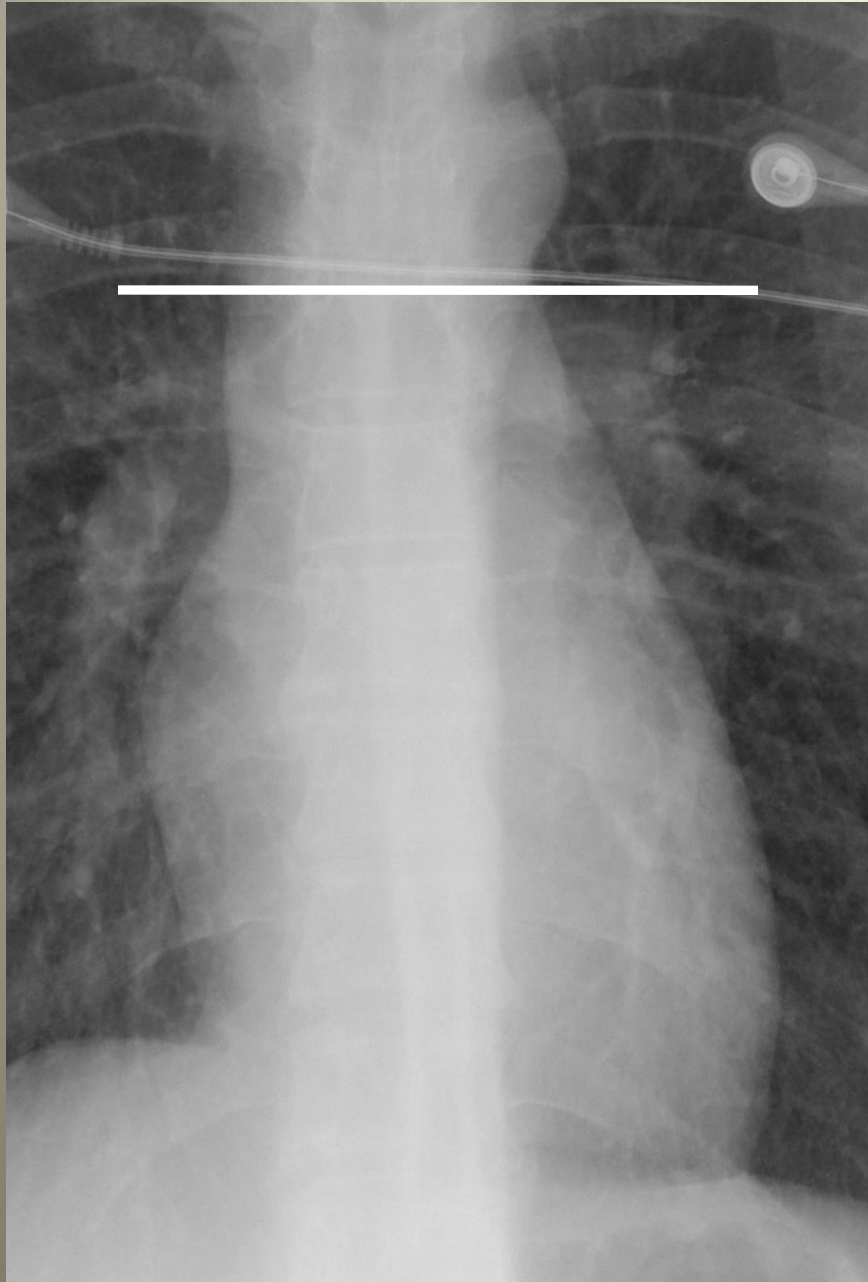
The Right Mediastinal Border and Central Venous Anatomy on Frontal Chest Radiograph—Direct CT Correlation

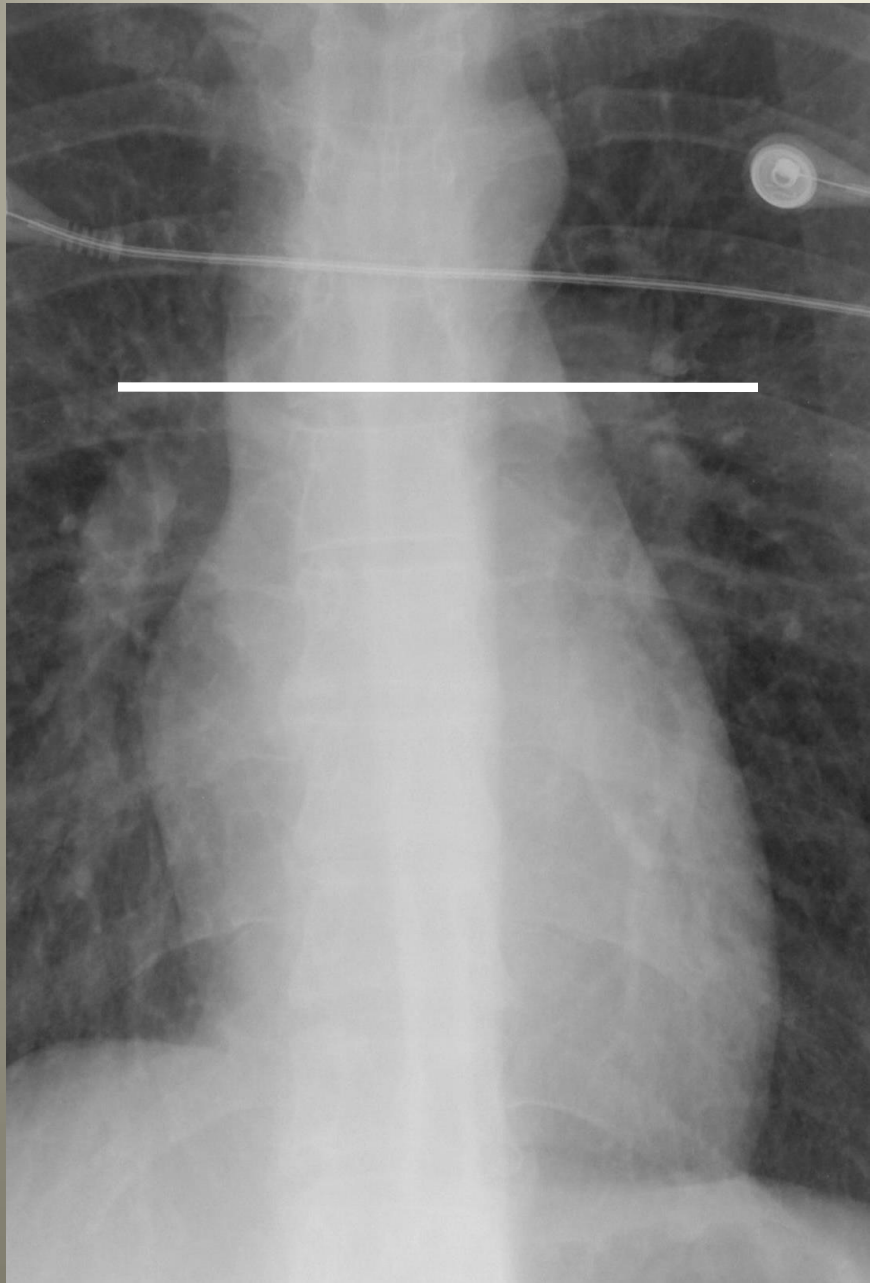
Peter T. Verhey, M.D., M.S., Marc V. Gosselin, M.D., Steven L. Primack, M.D., Paul L. Blackburn, R.N., M.N.A., Alexander C. Kraemer, B.S., M.E.

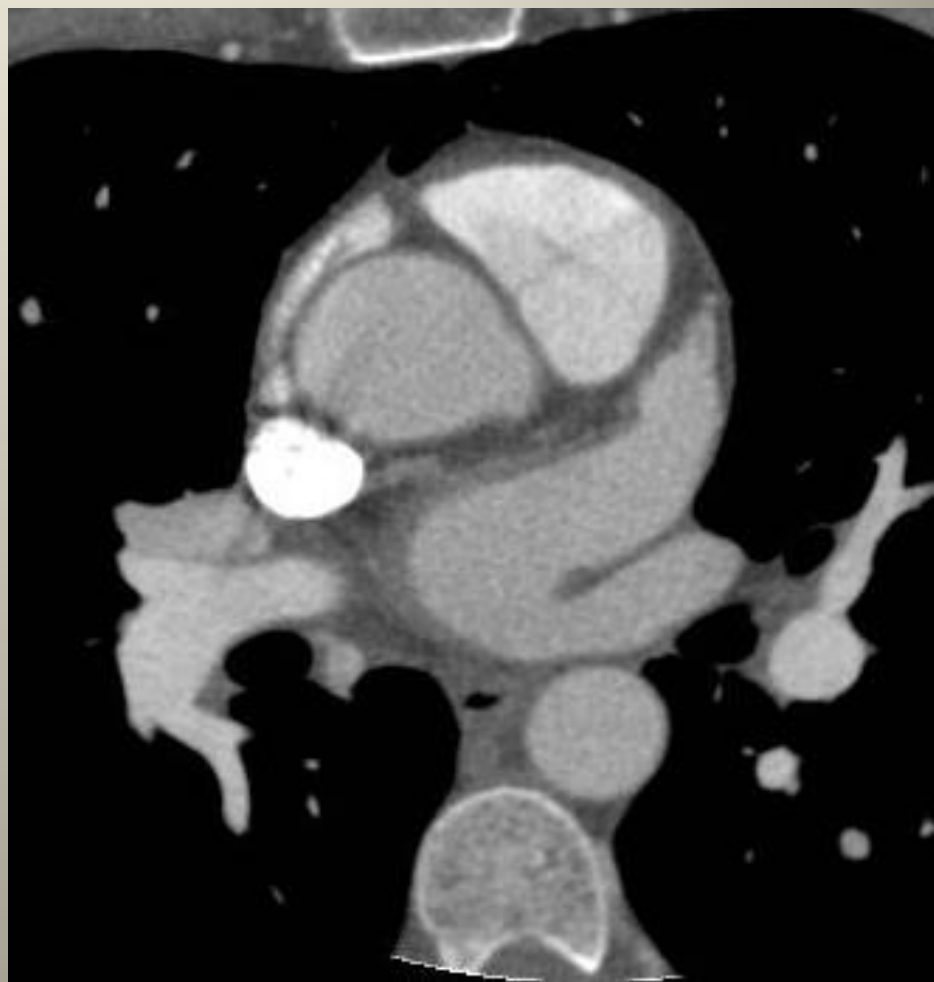
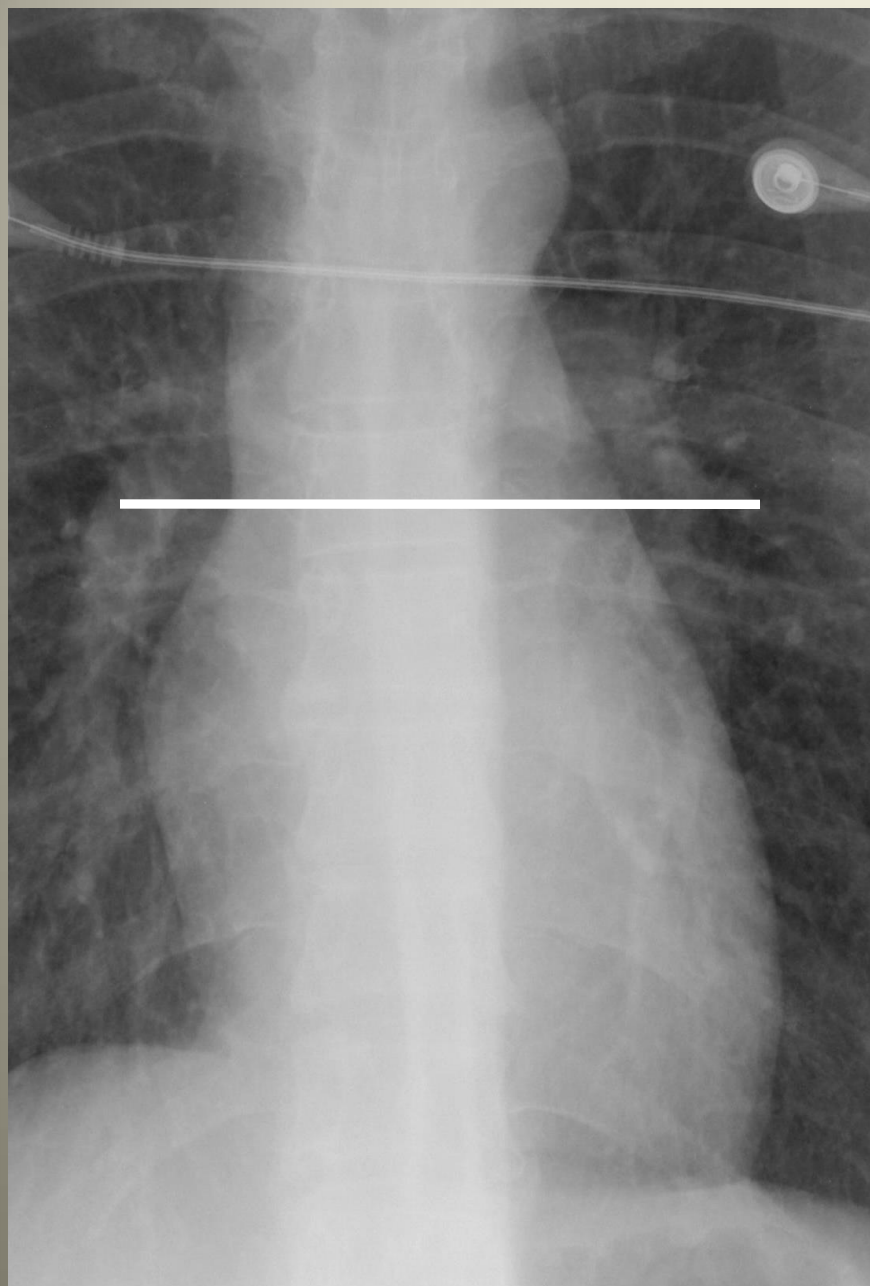
JAVA

Vol 13 No 1

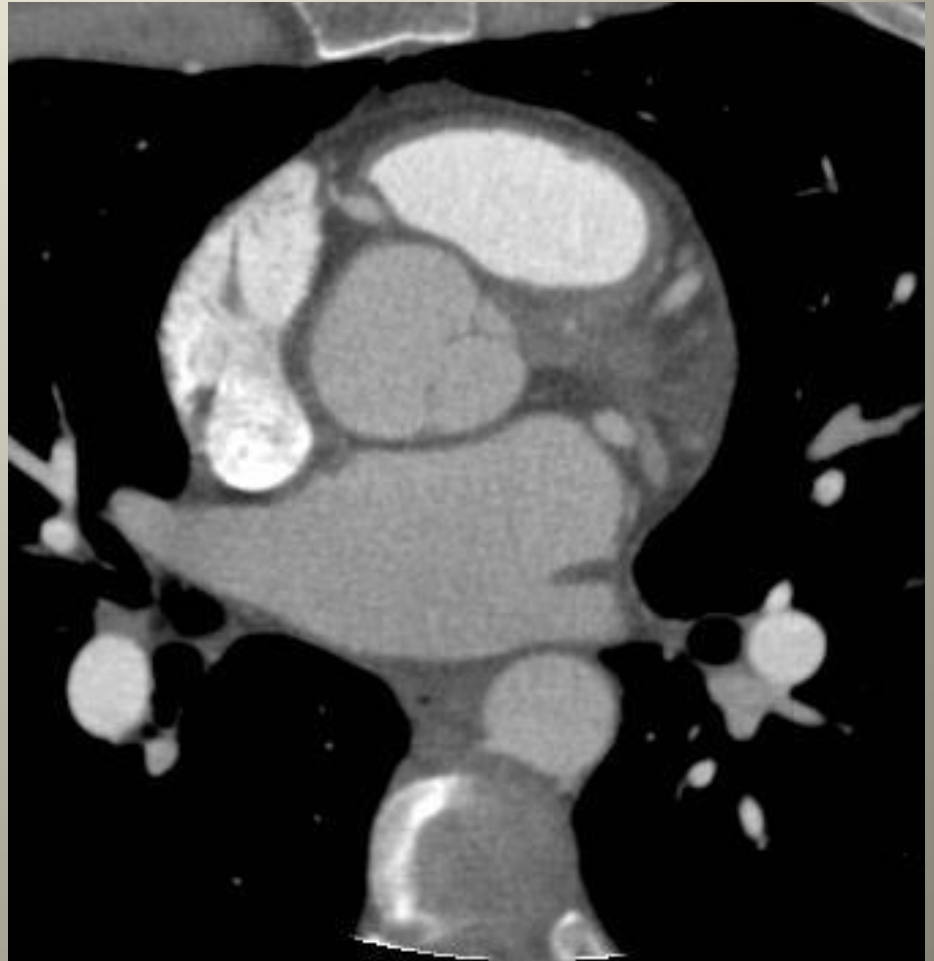
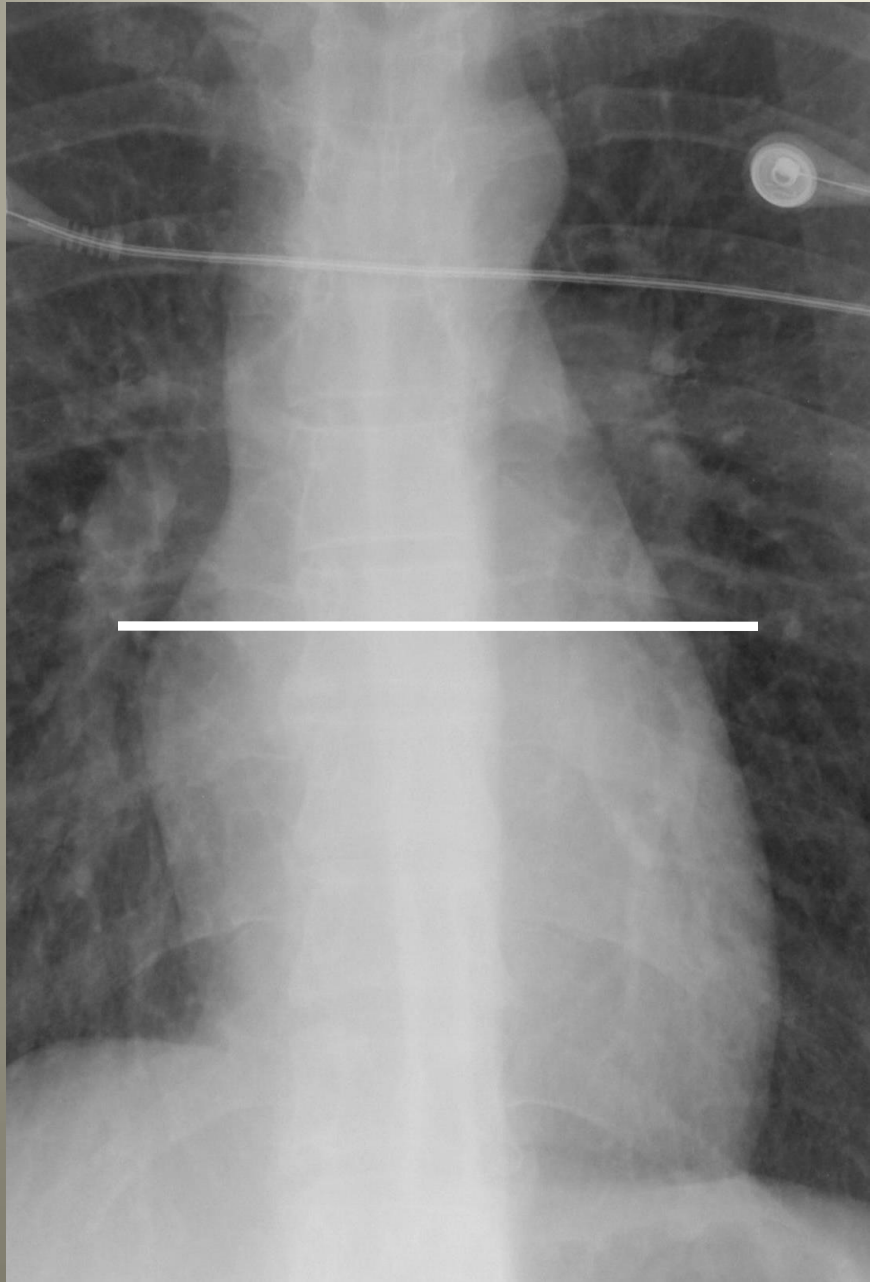
2008

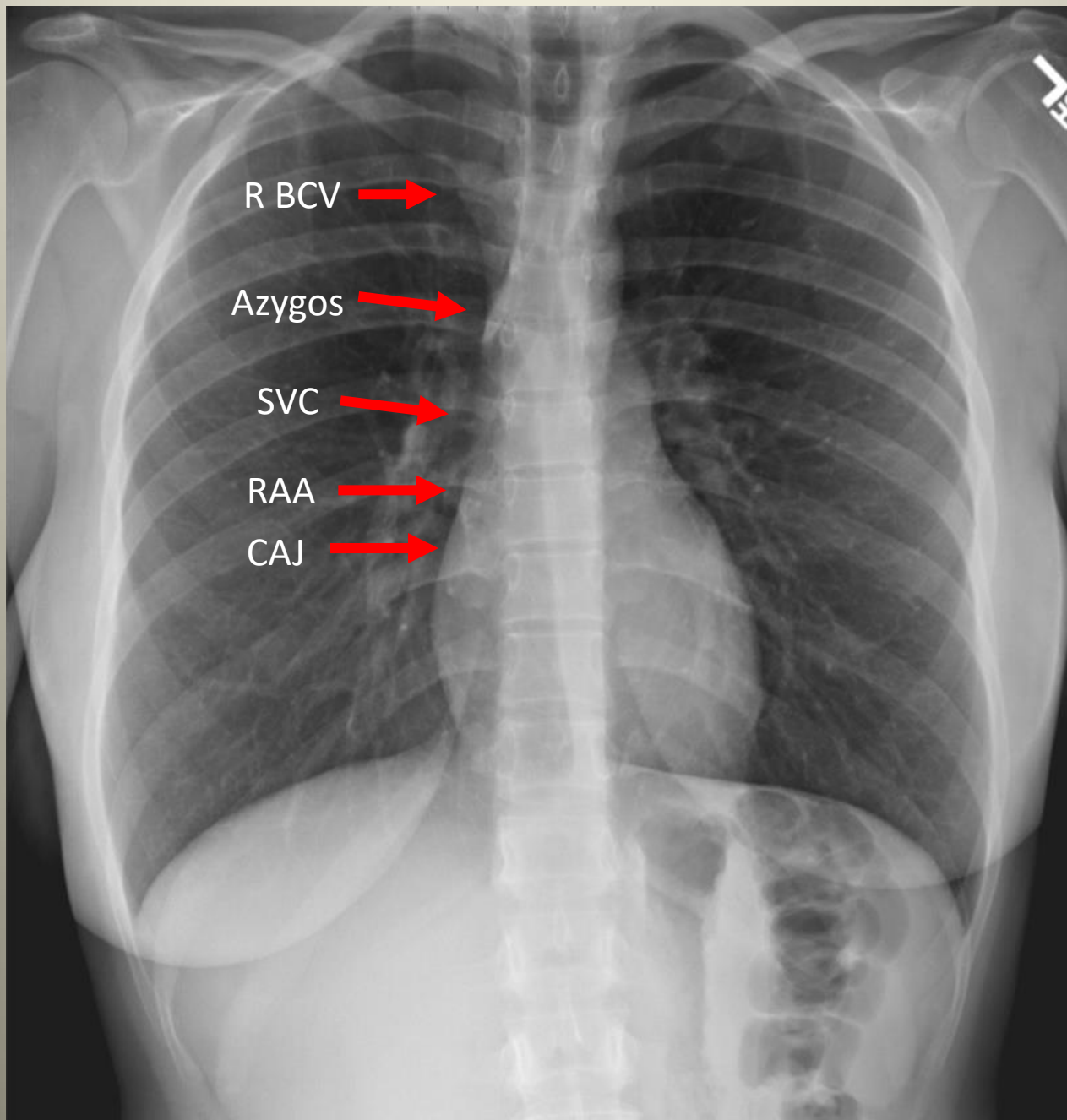


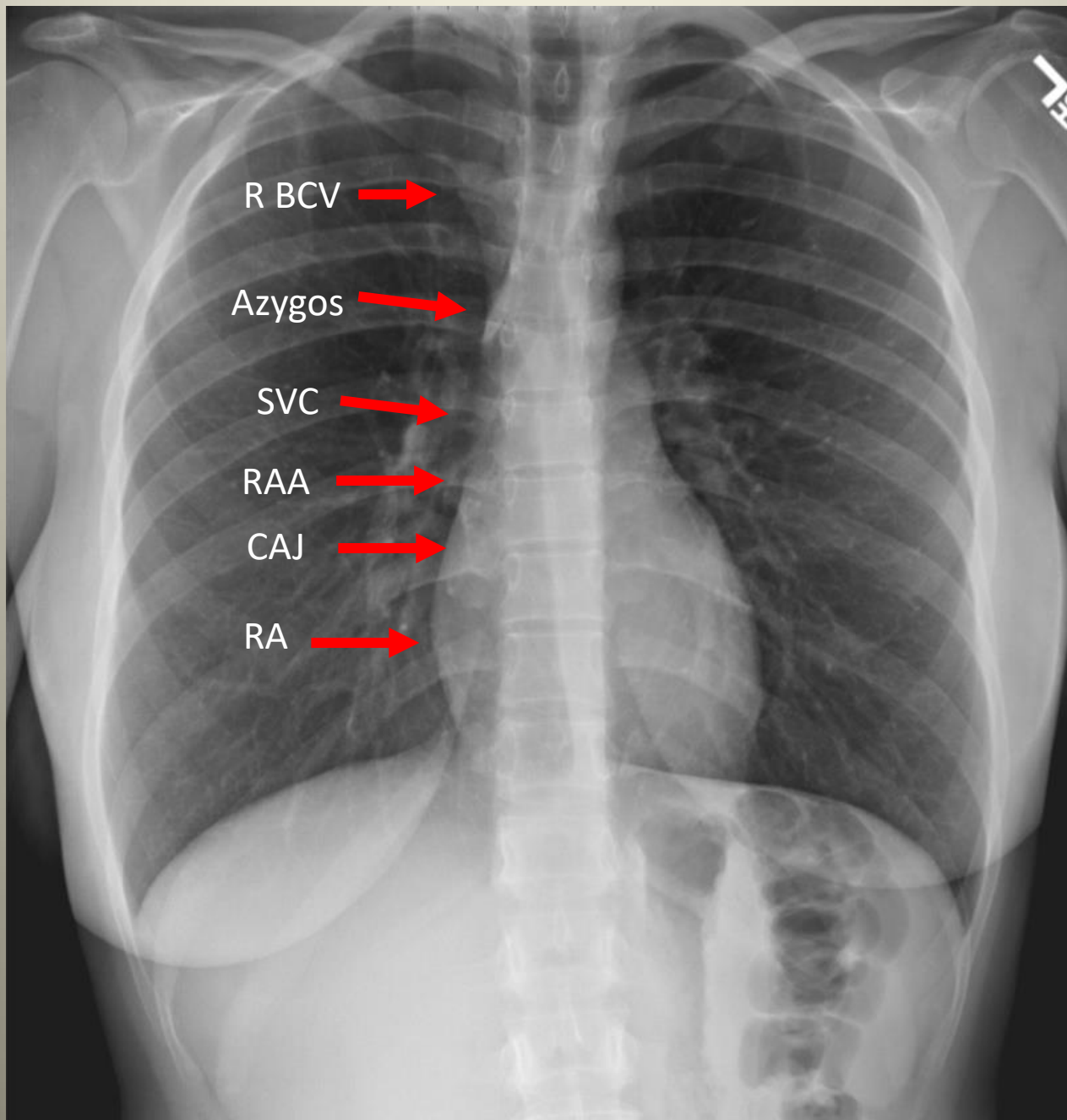


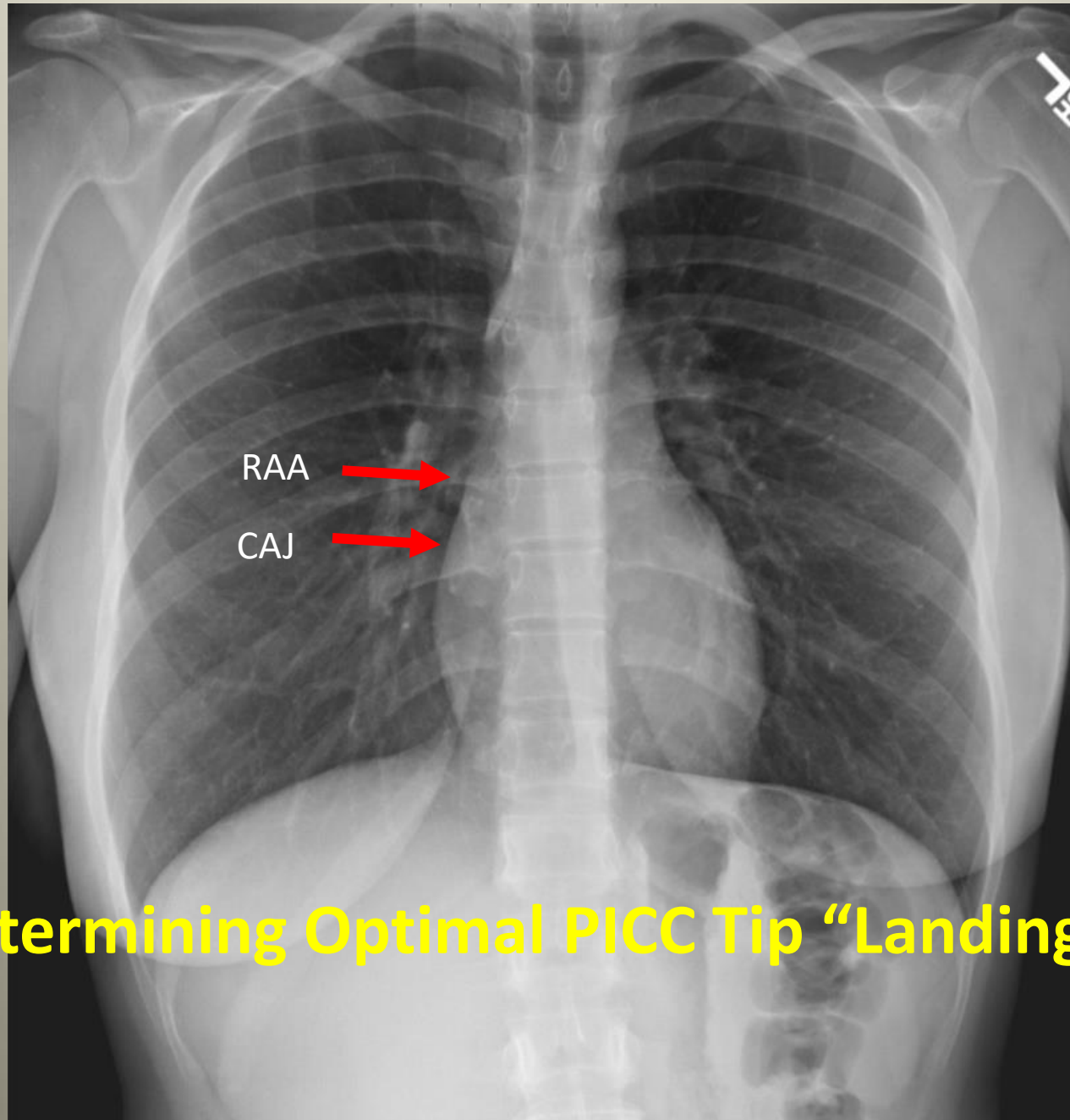




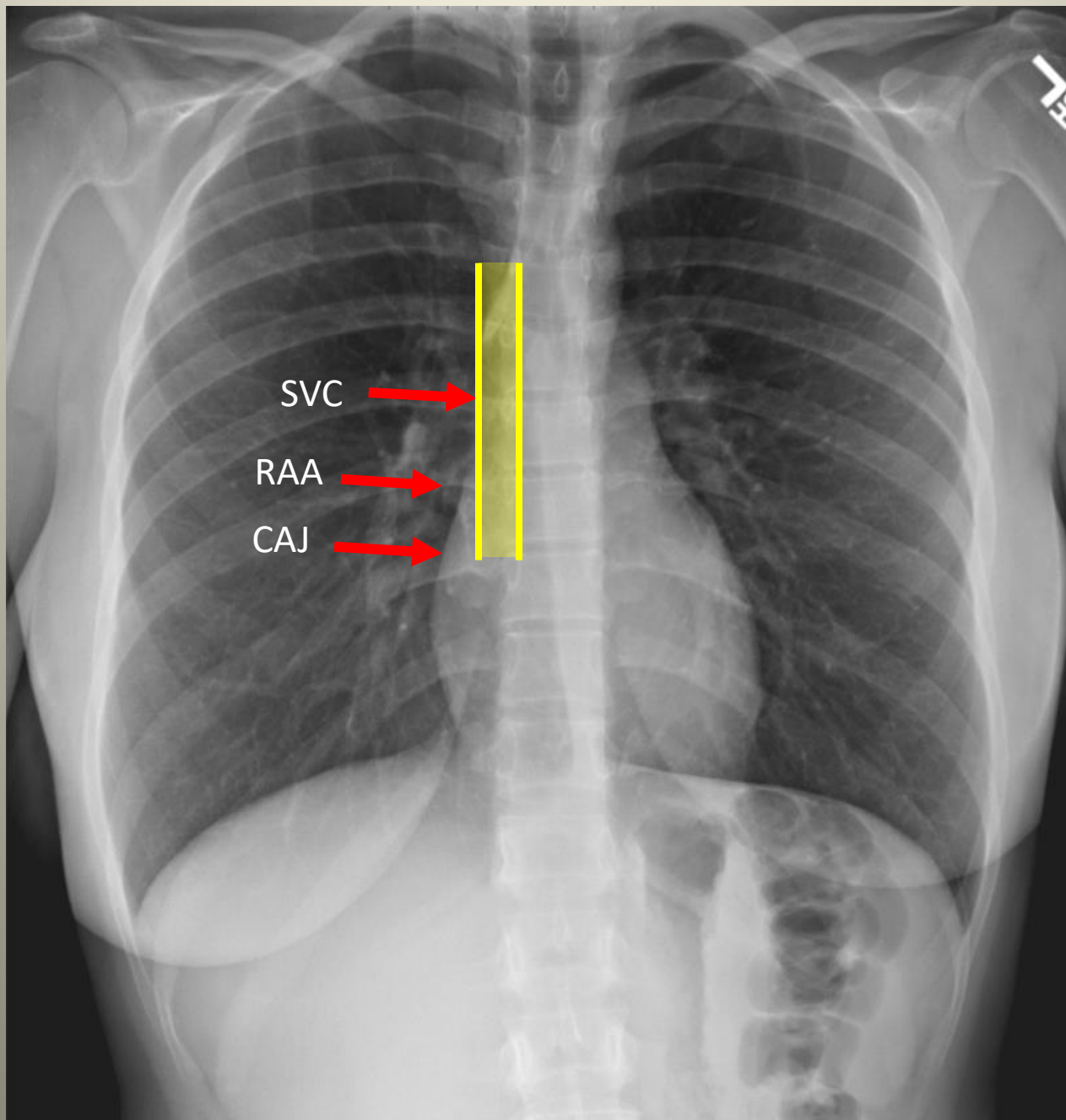


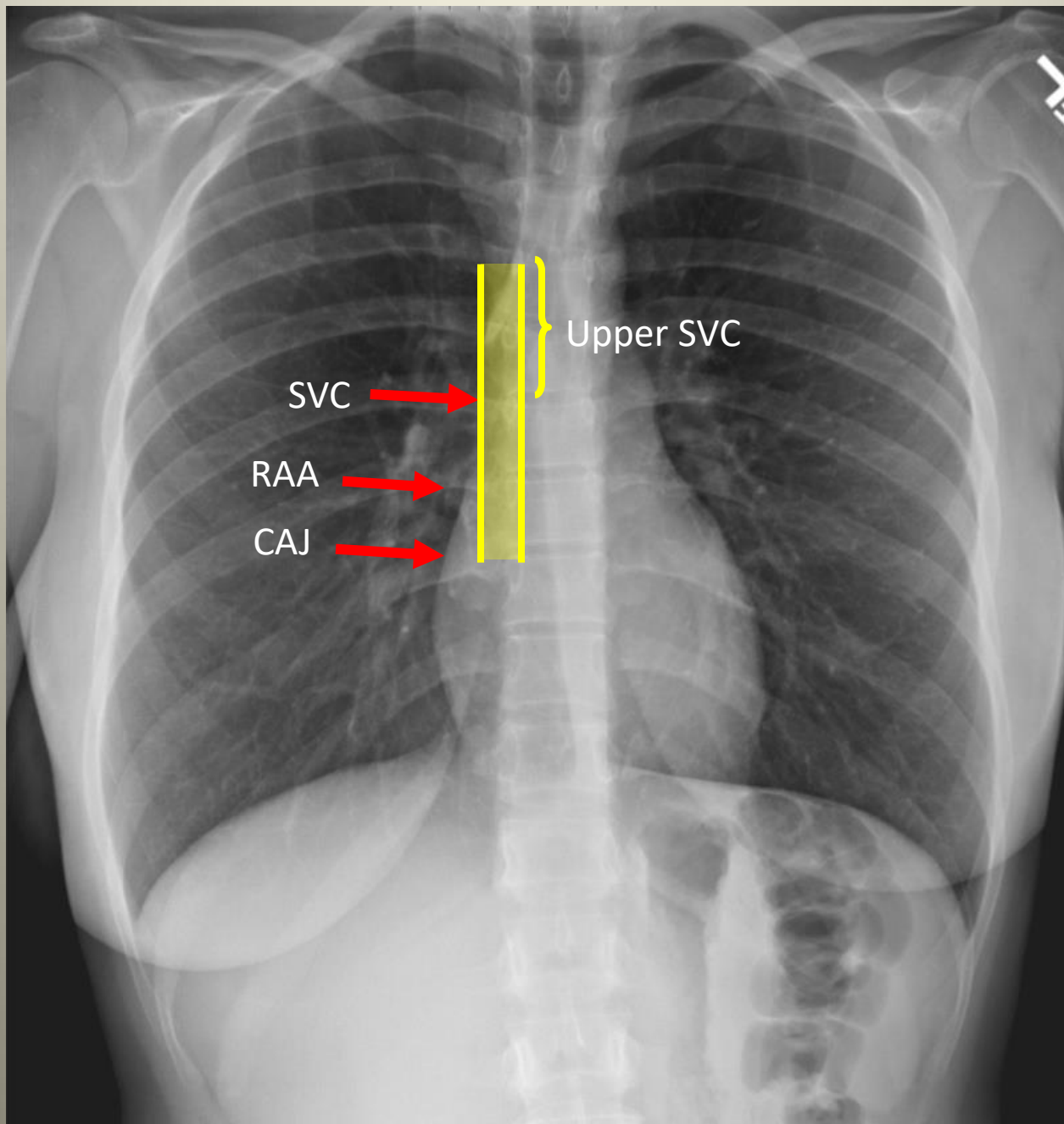


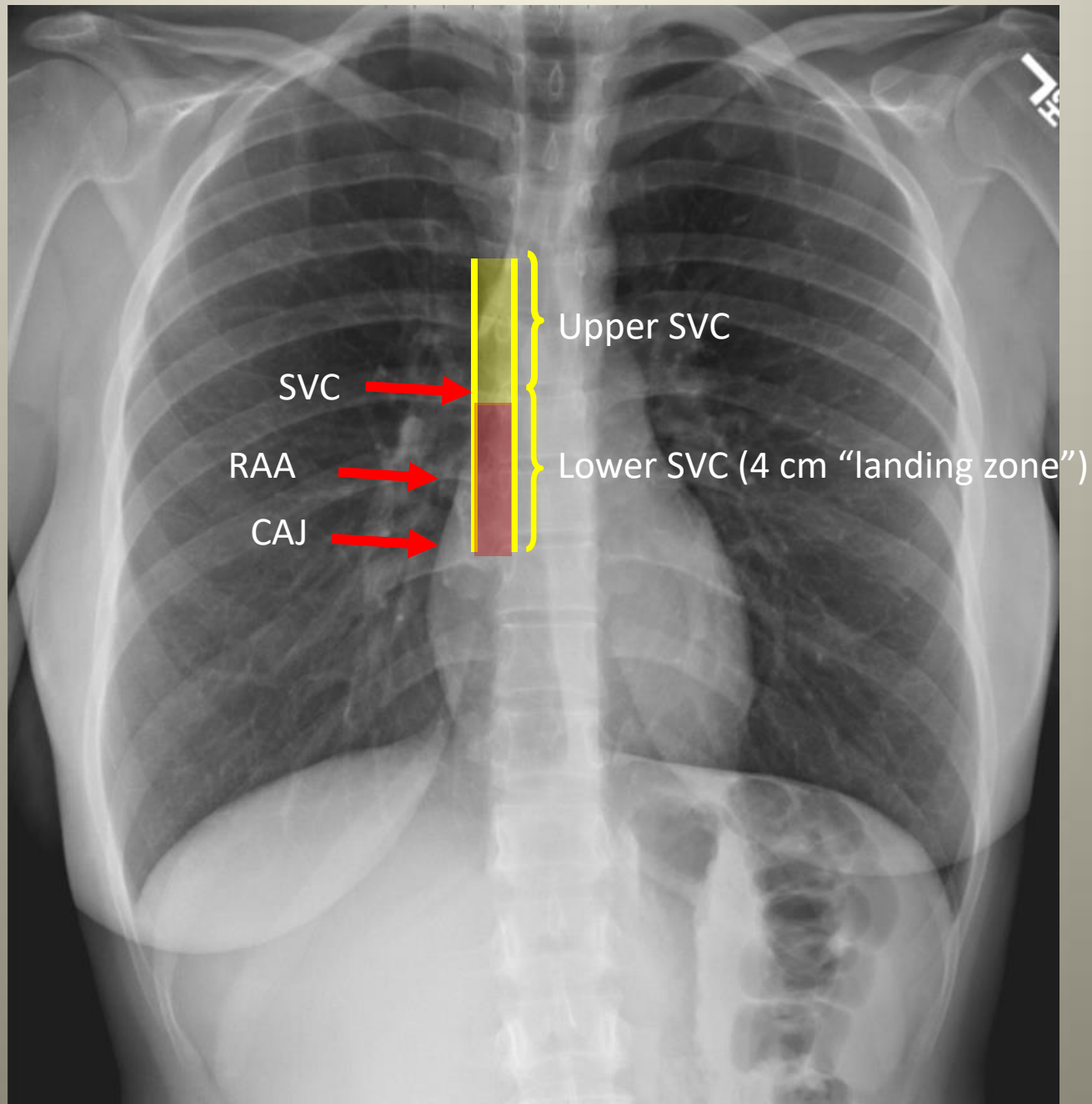


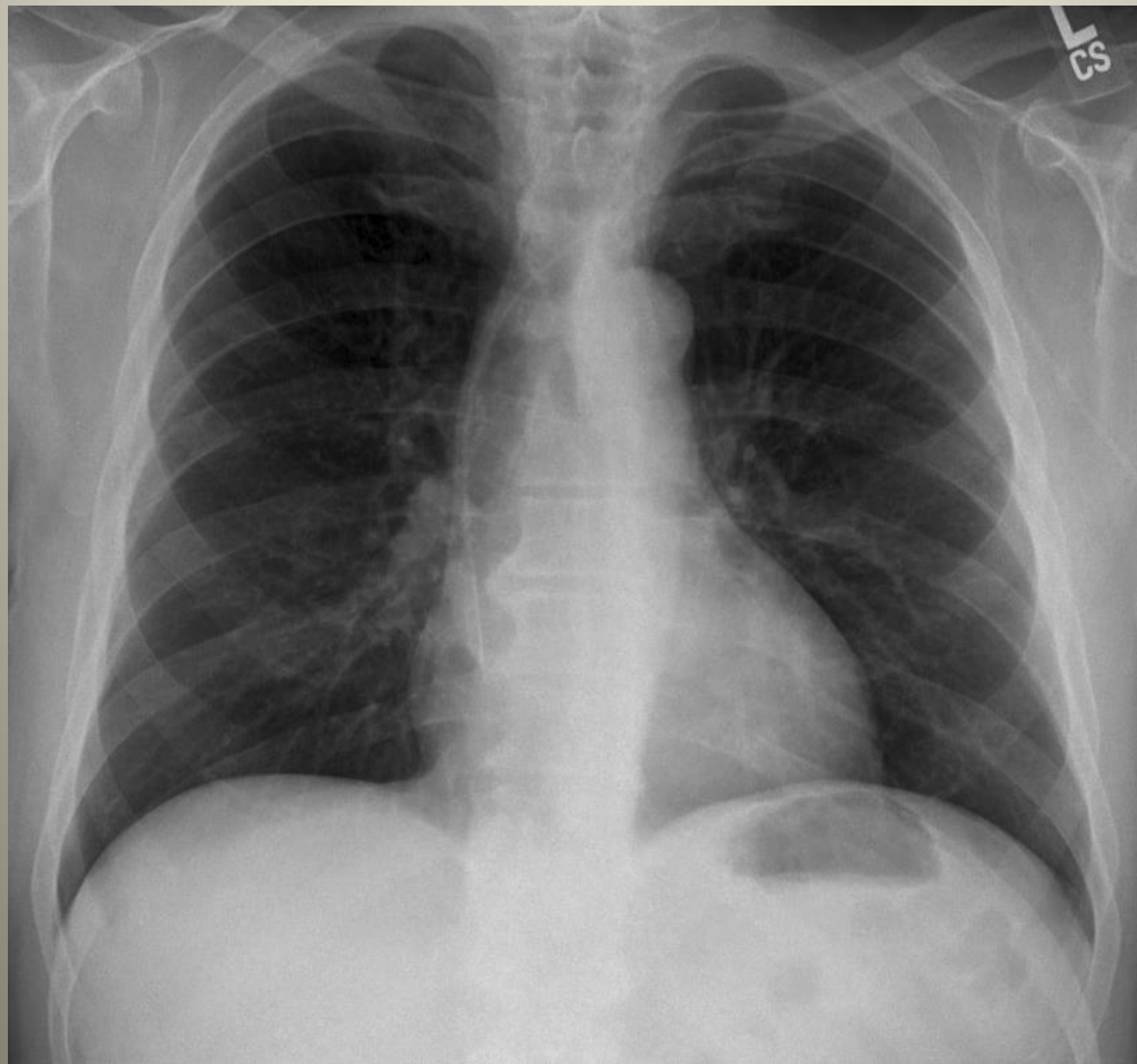


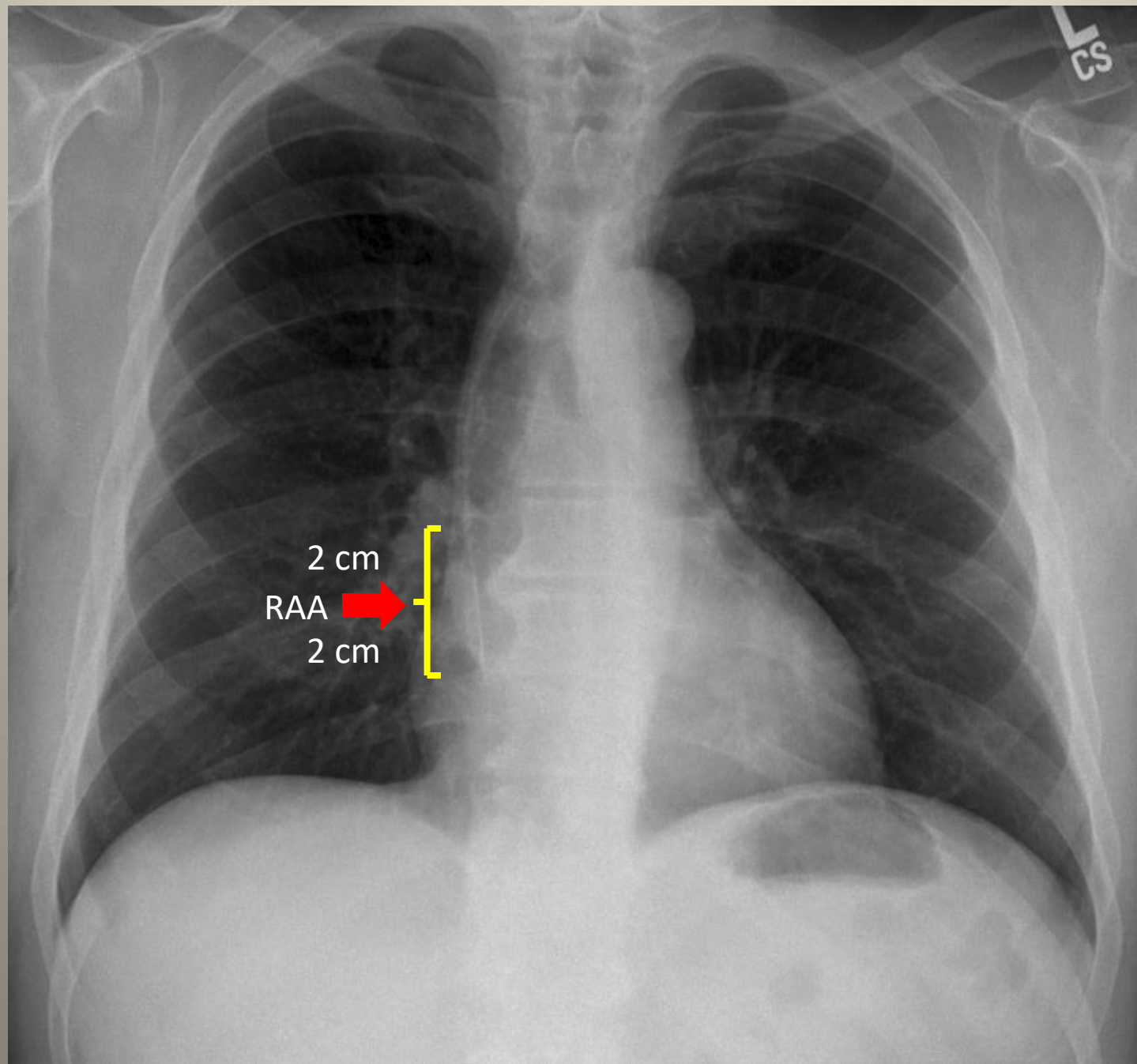
Determining Optimal PICC Tip “Landing Zone”

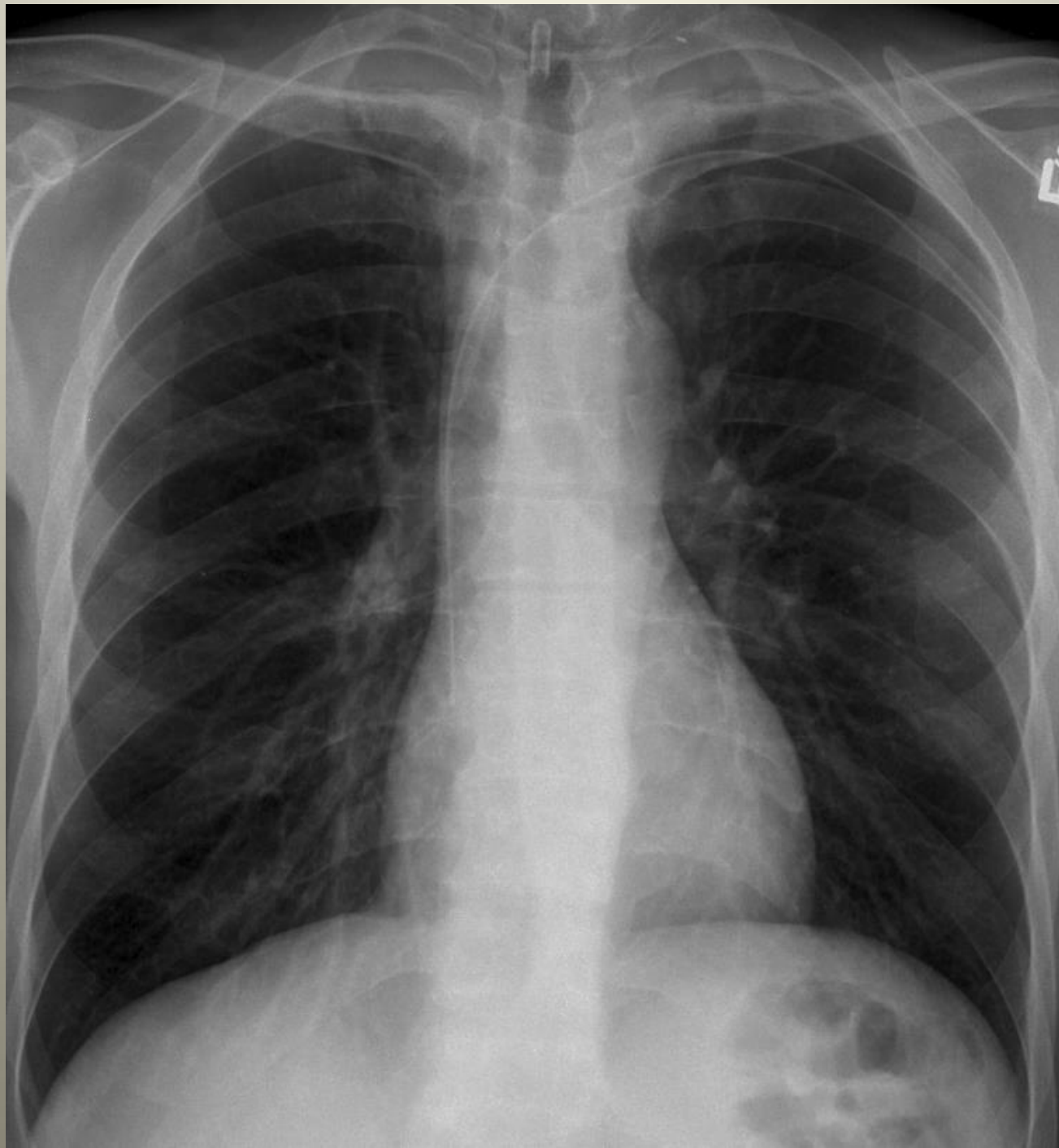


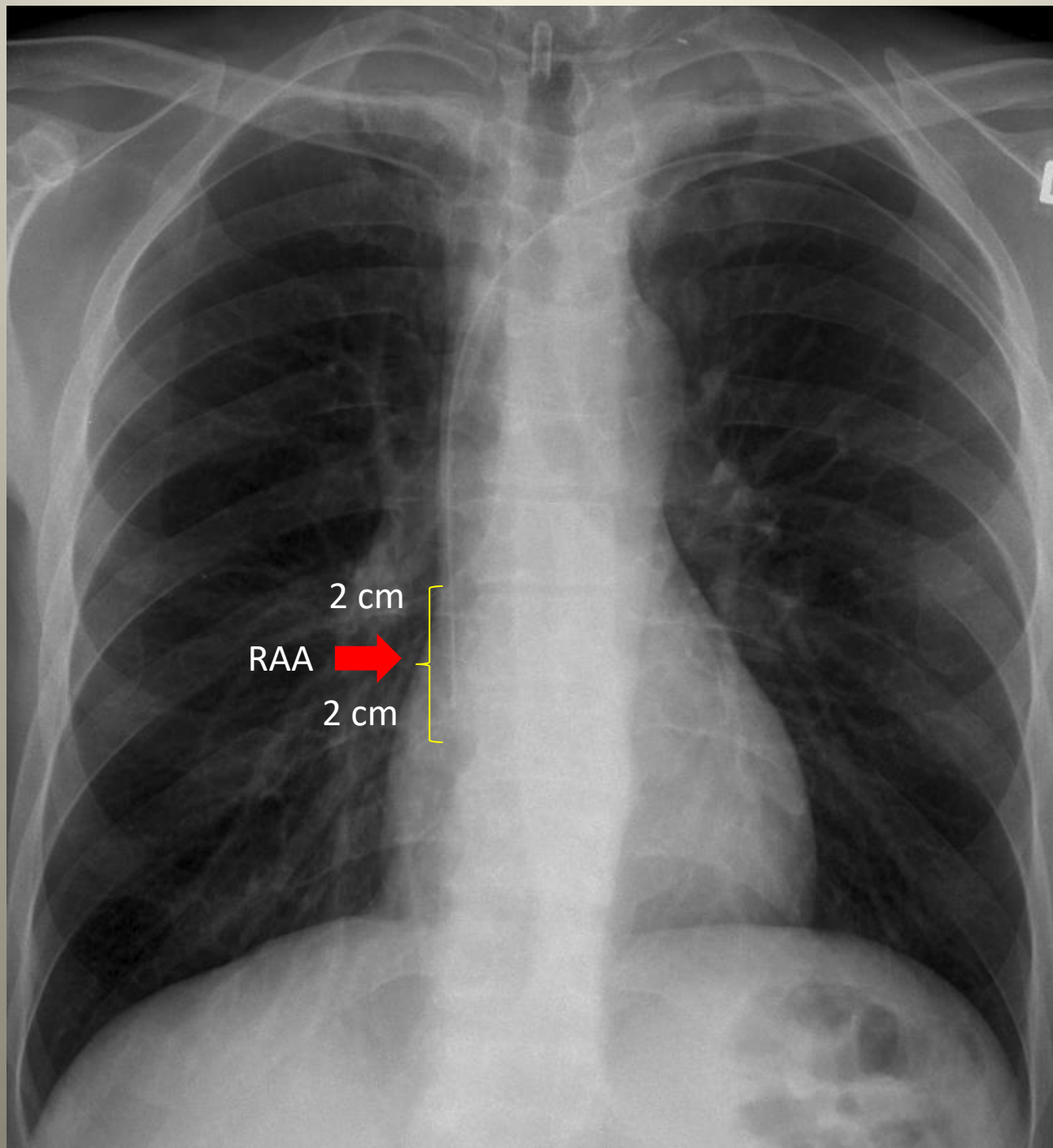


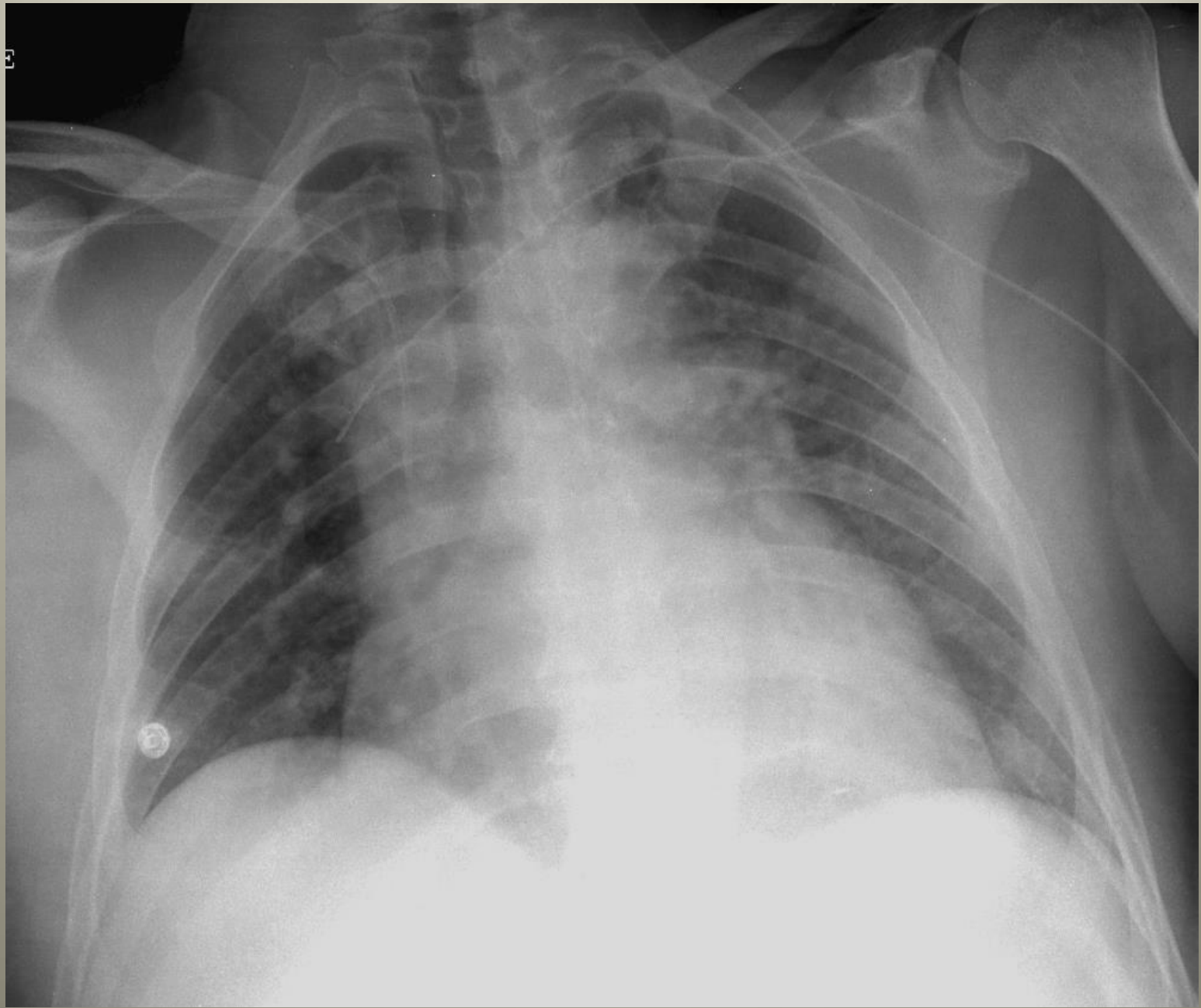


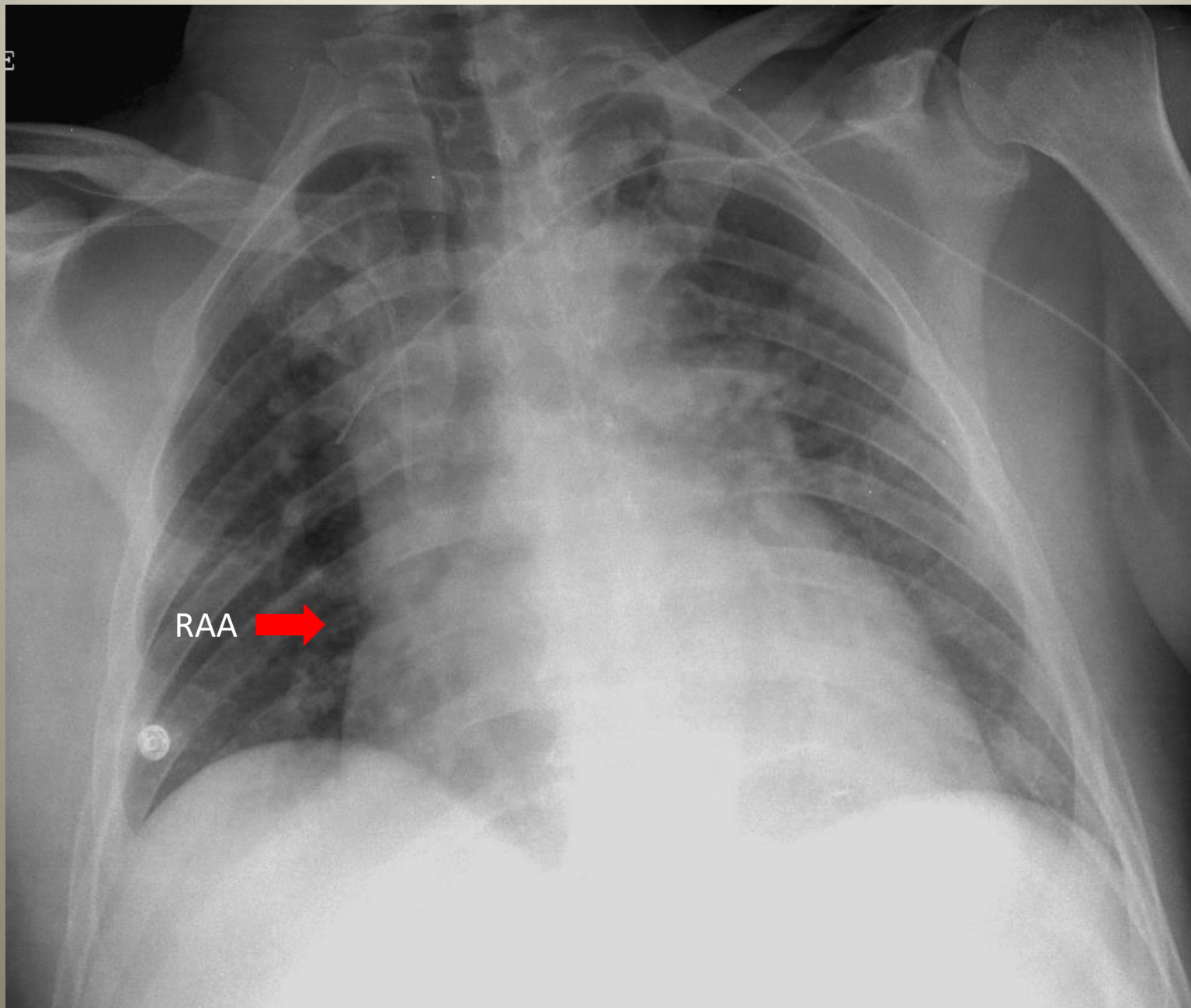




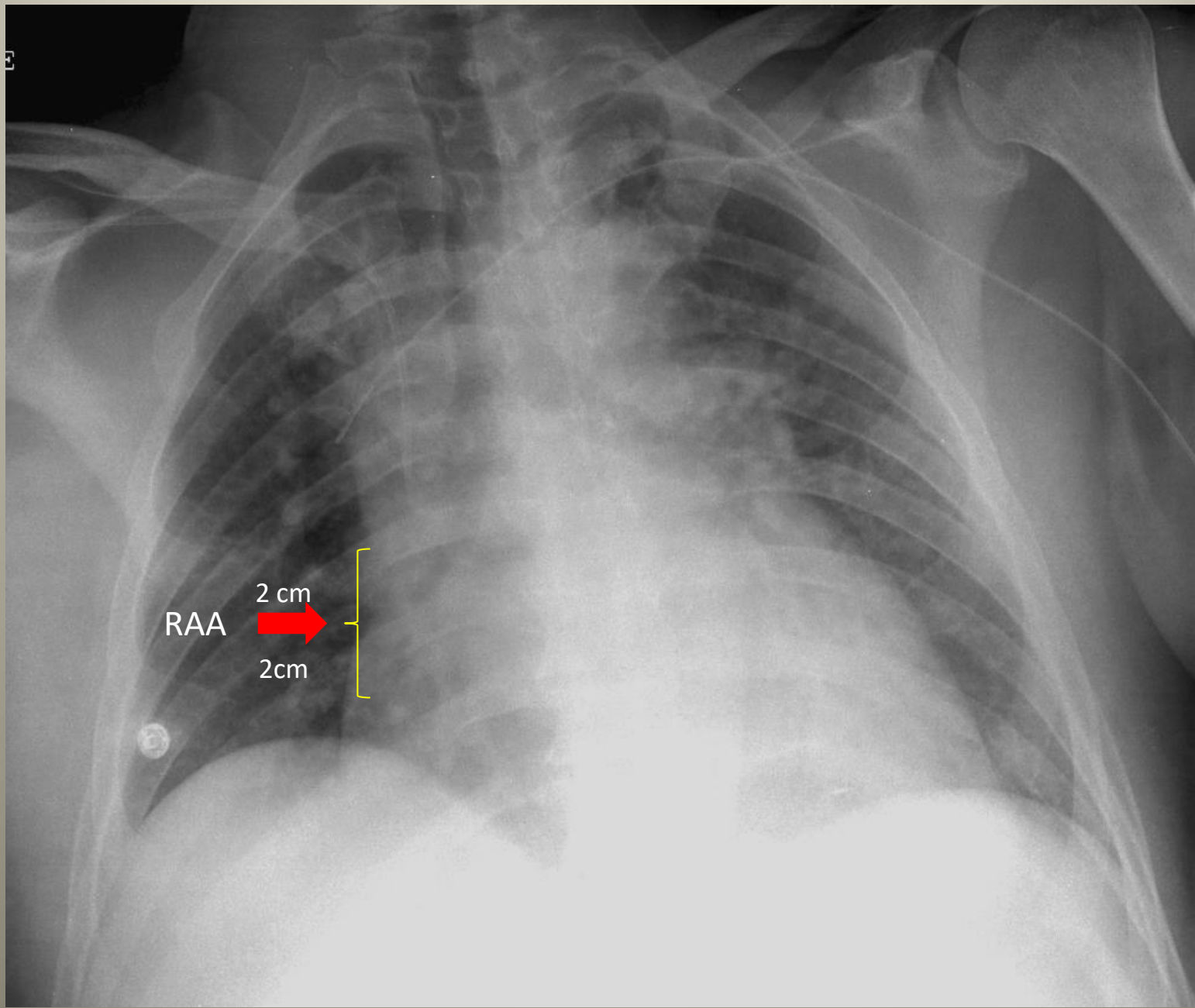






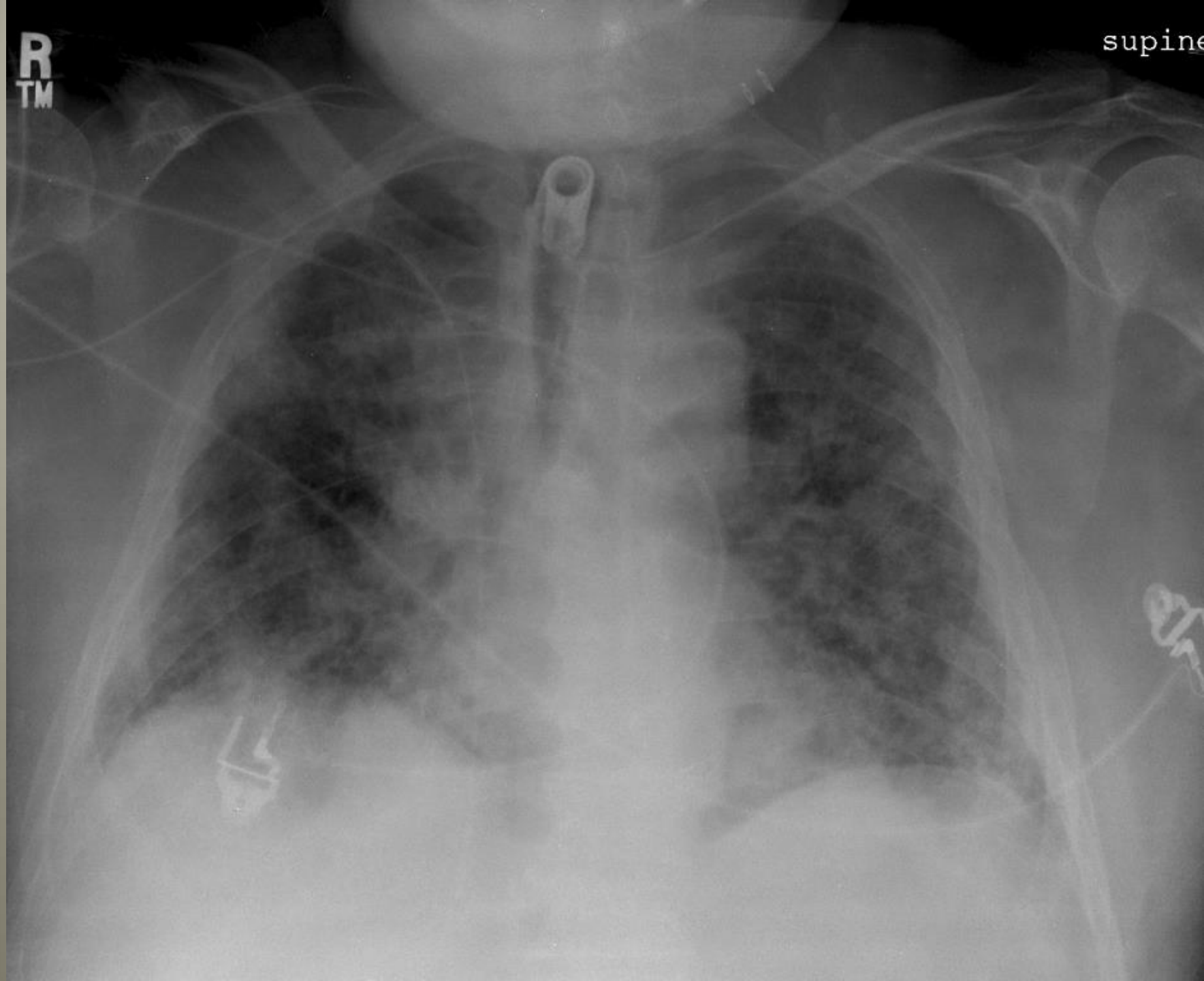


RAA →



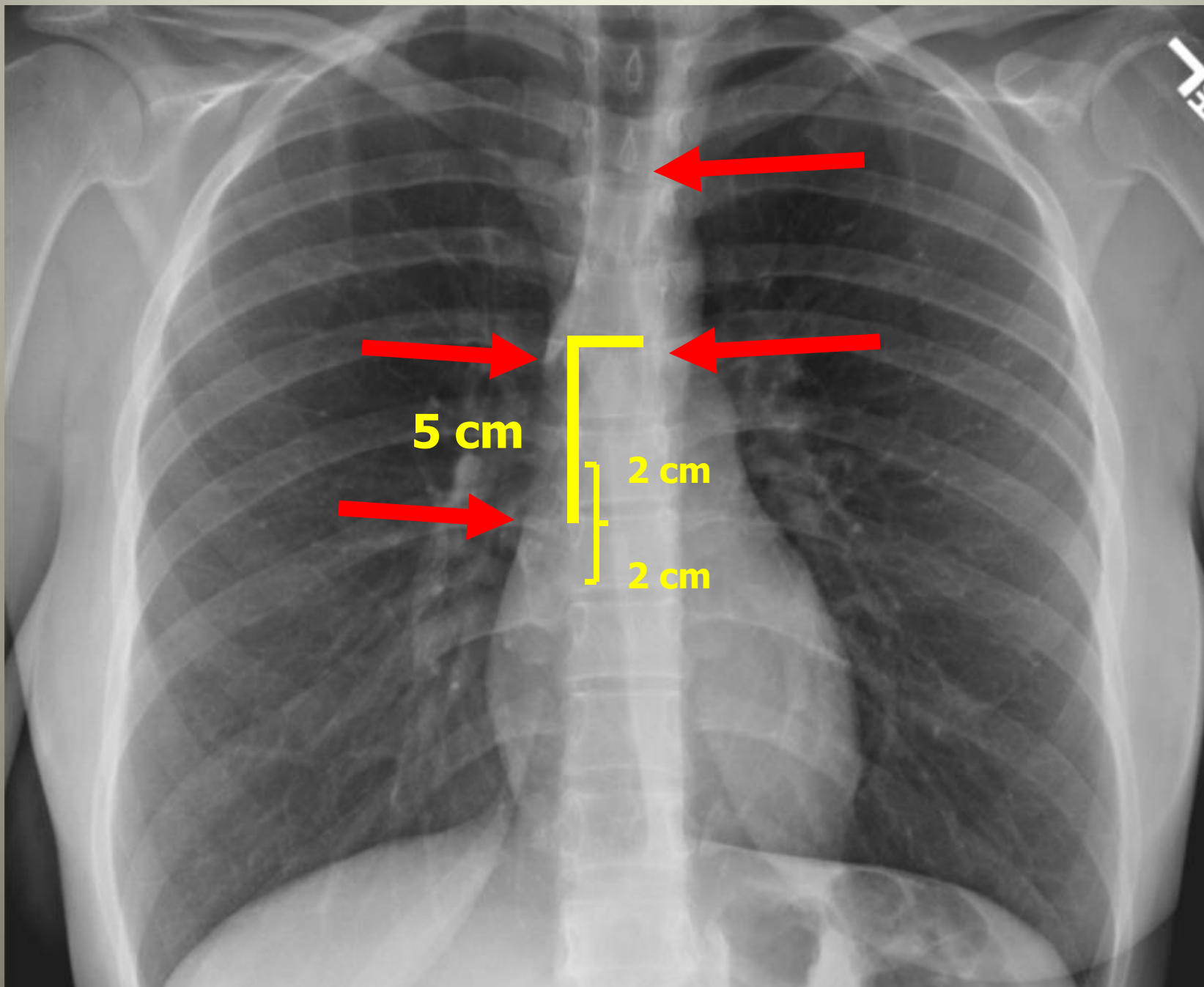
R
TM

supine



Defining Optimal PICC “Landing Zone”

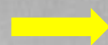
- Direct method
 - Utilizes vascular structures
 - Most reliable
- ***Indirect method***
 - ***Utilizes osseous structures and/or airway***
 - ***Less reliable***
 - ***Very helpful when vascular structures are obscured***

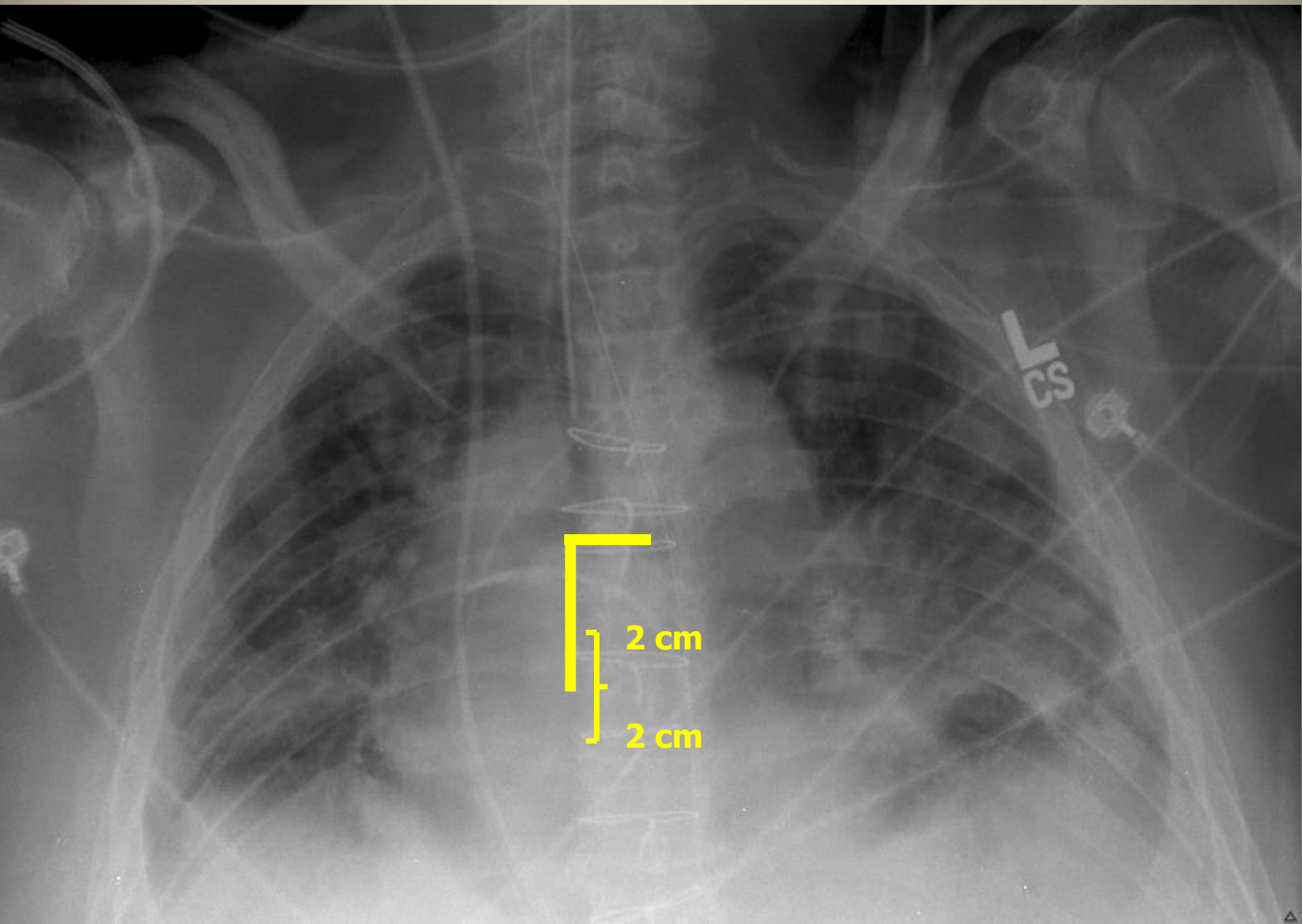


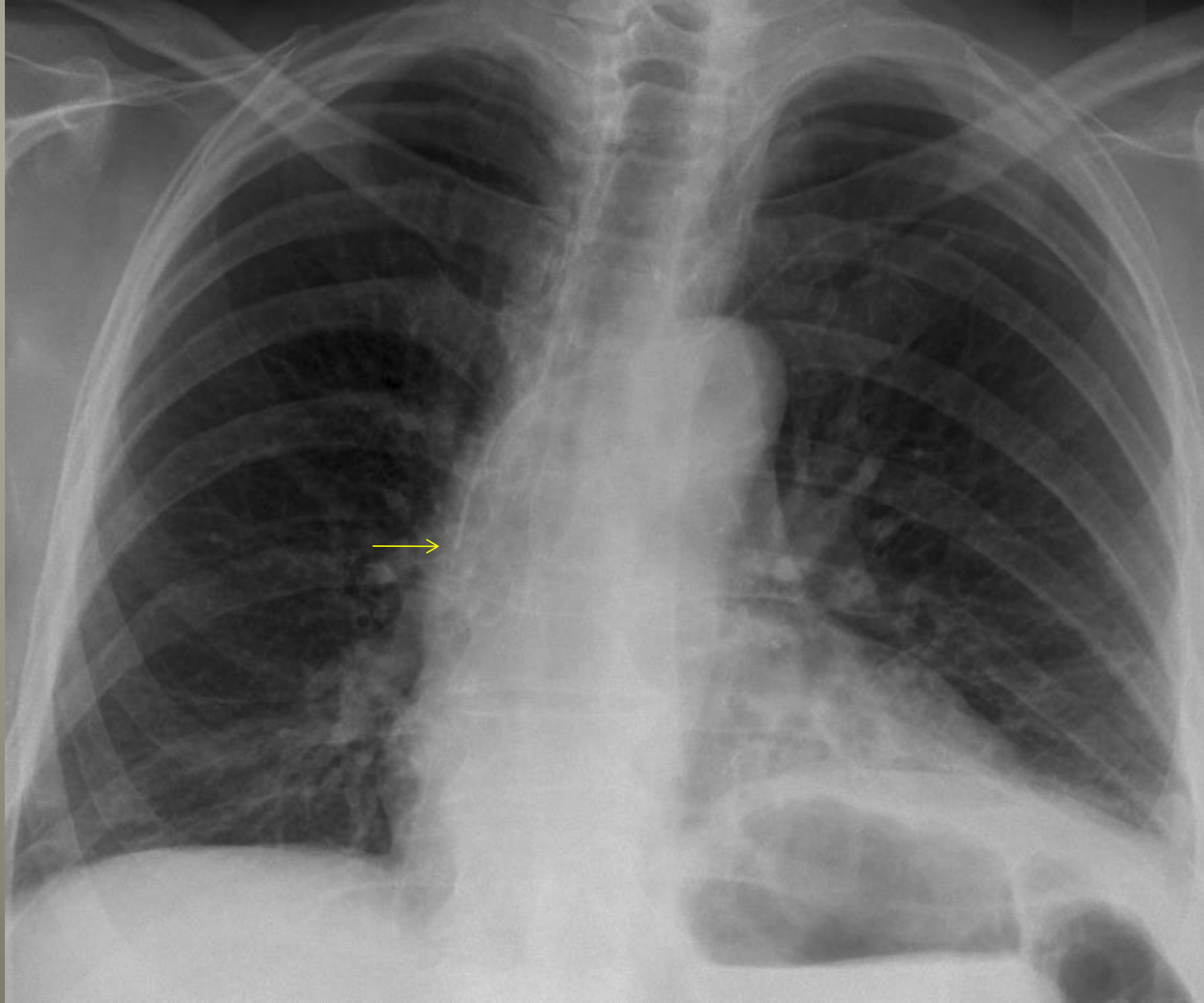
R
TM

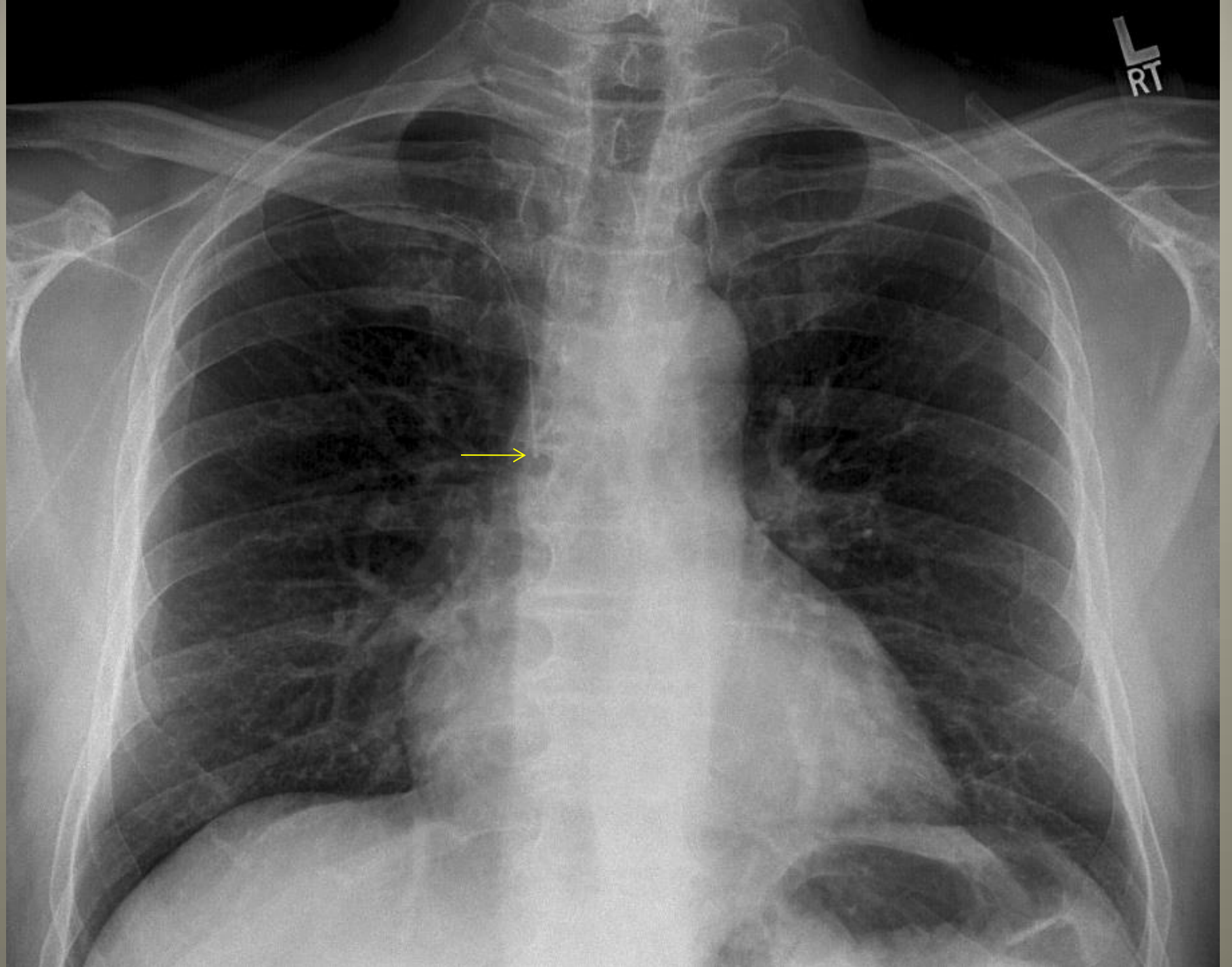
supine

2 cm
2 cm







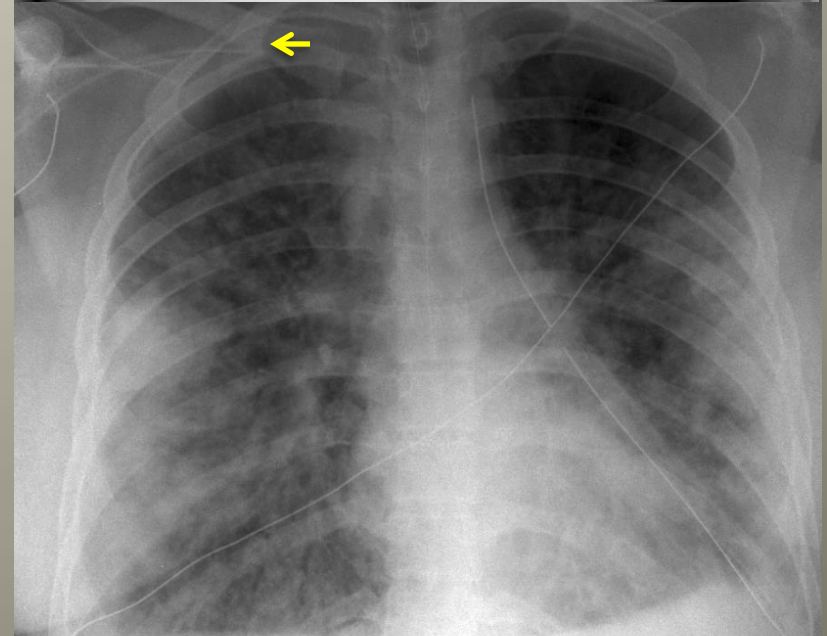
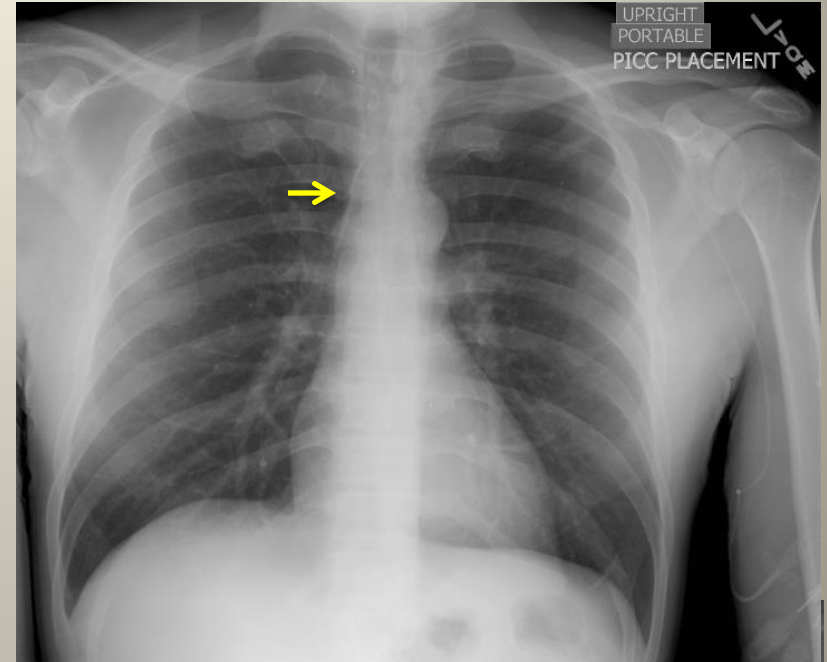


UPRIGHT
PORTABLE
PICC PLACEMENT

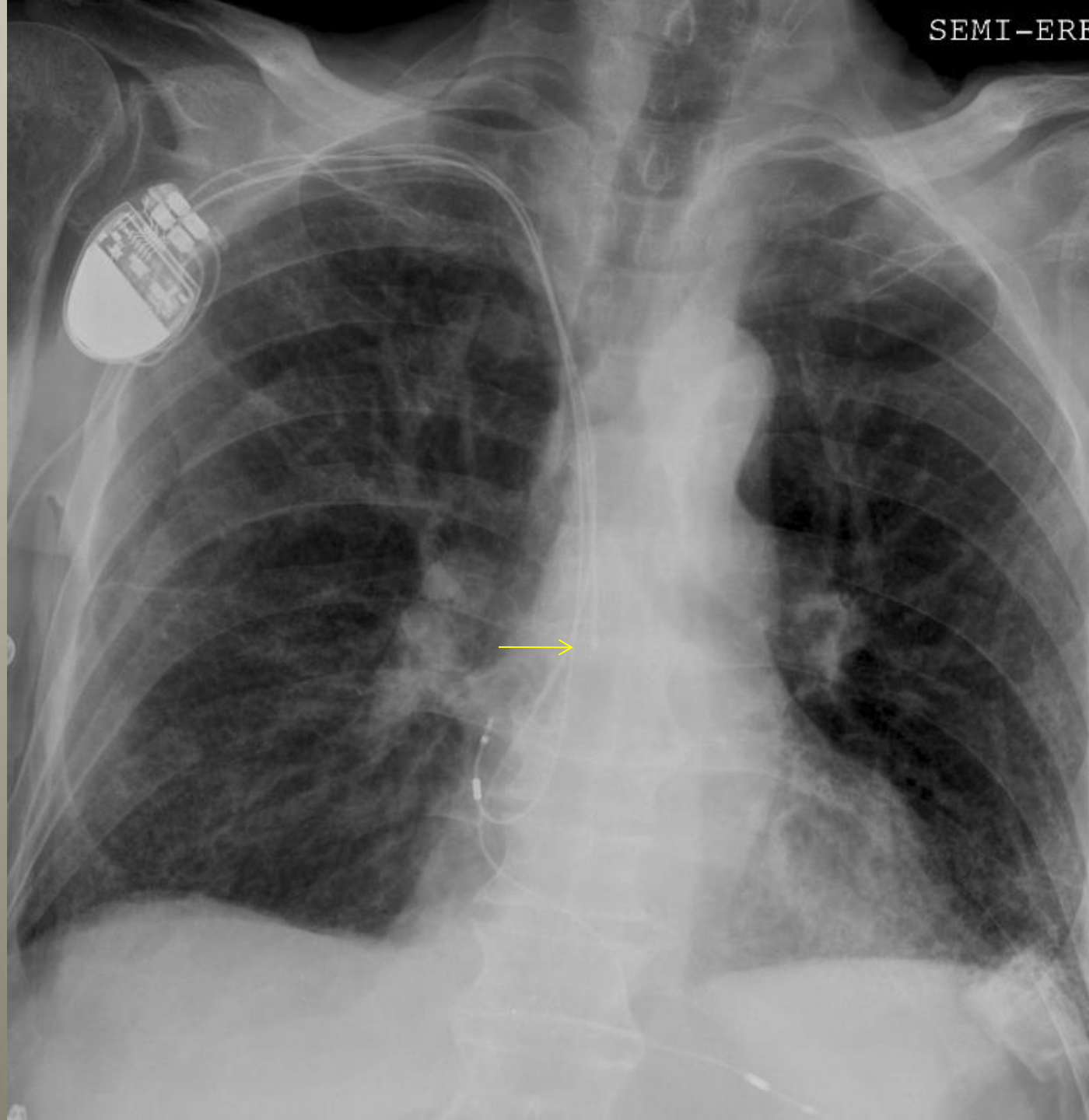


Non-Central Catheter Tip Locations

- Suboptimal
- INS Standard
 - *Avoid CVAD tip locations in veins distal to the SVC or IVC due to higher rates of complications (e.g., BCV, SCV, external or common iliac veins)*
 - *May be clinically indicated in rare cases d/t anatomic or pathophysiologic changes*



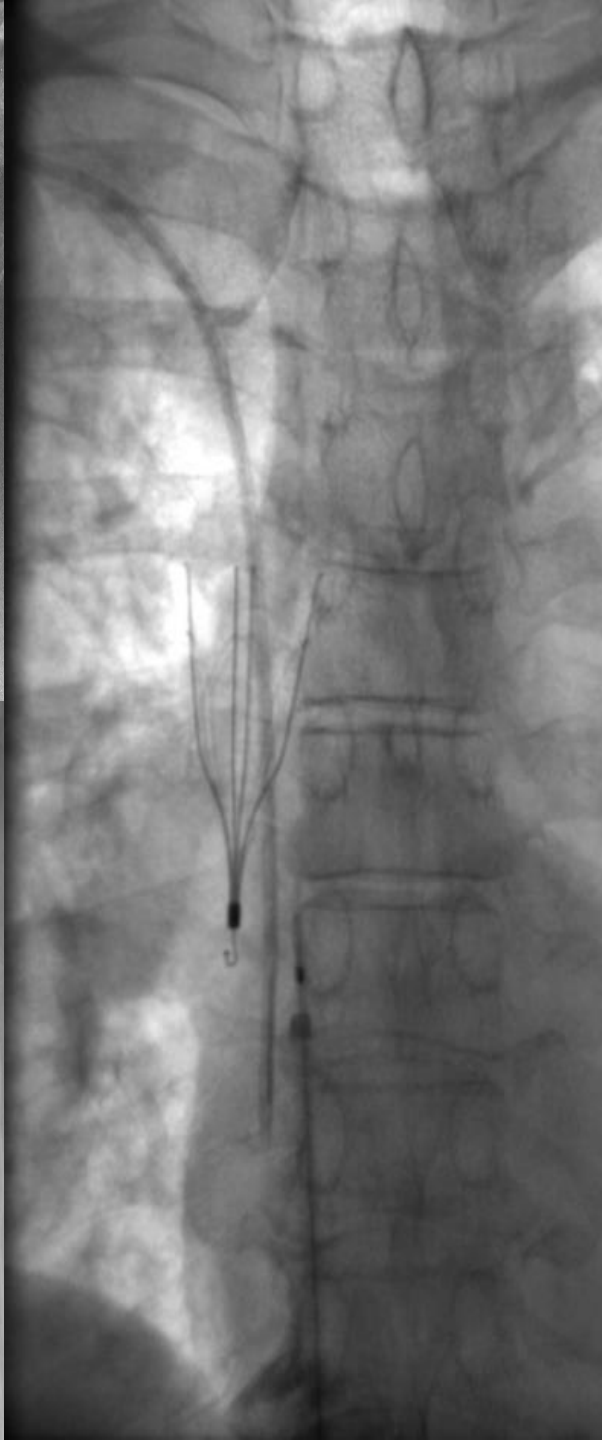
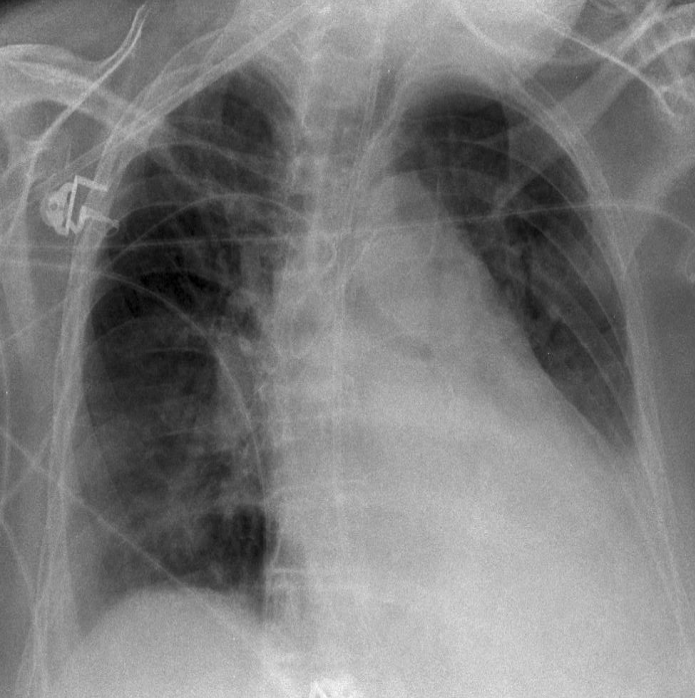
SEMI-ERE

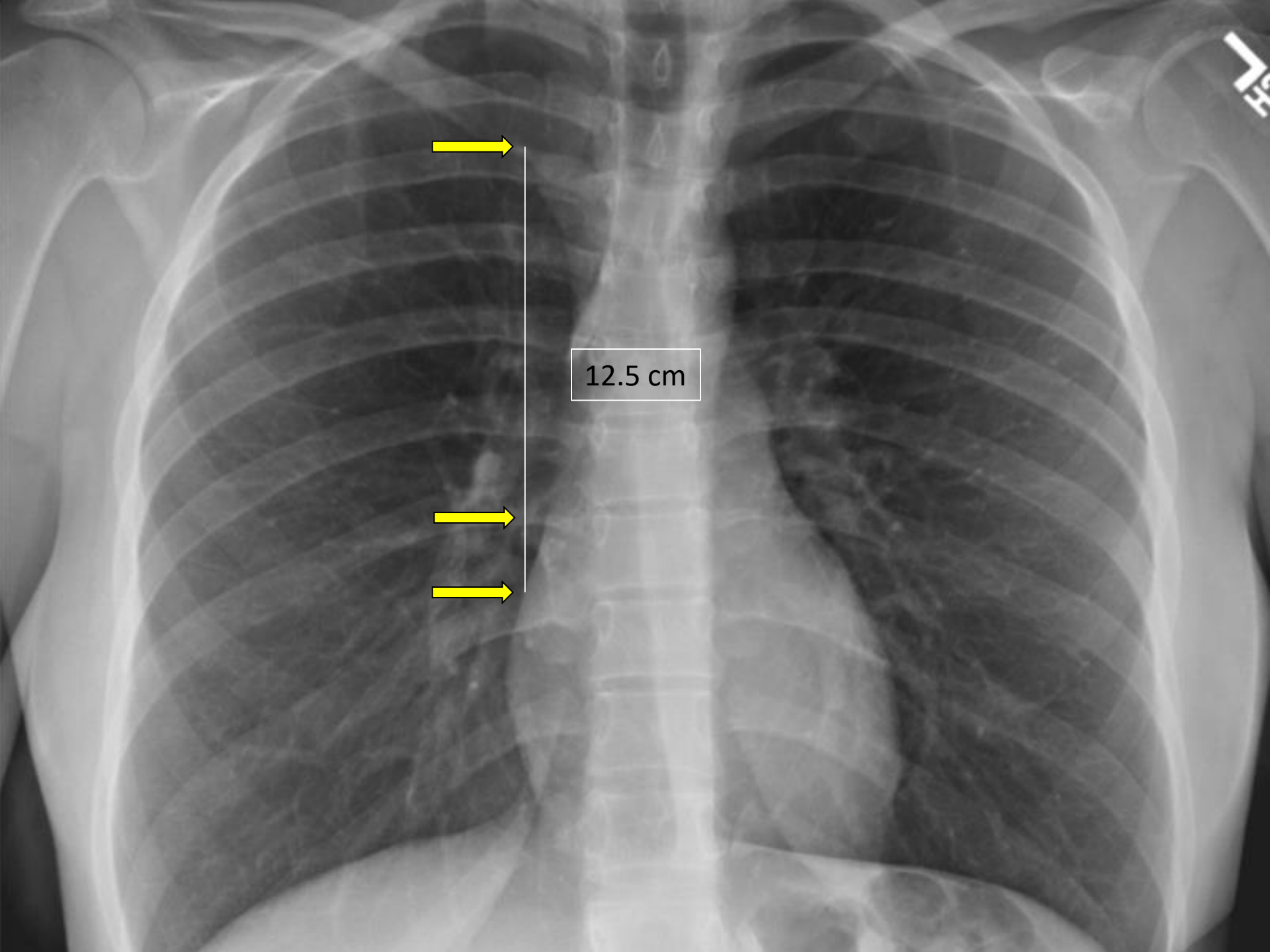


CVAD Insertion in Patients with Pacemakers

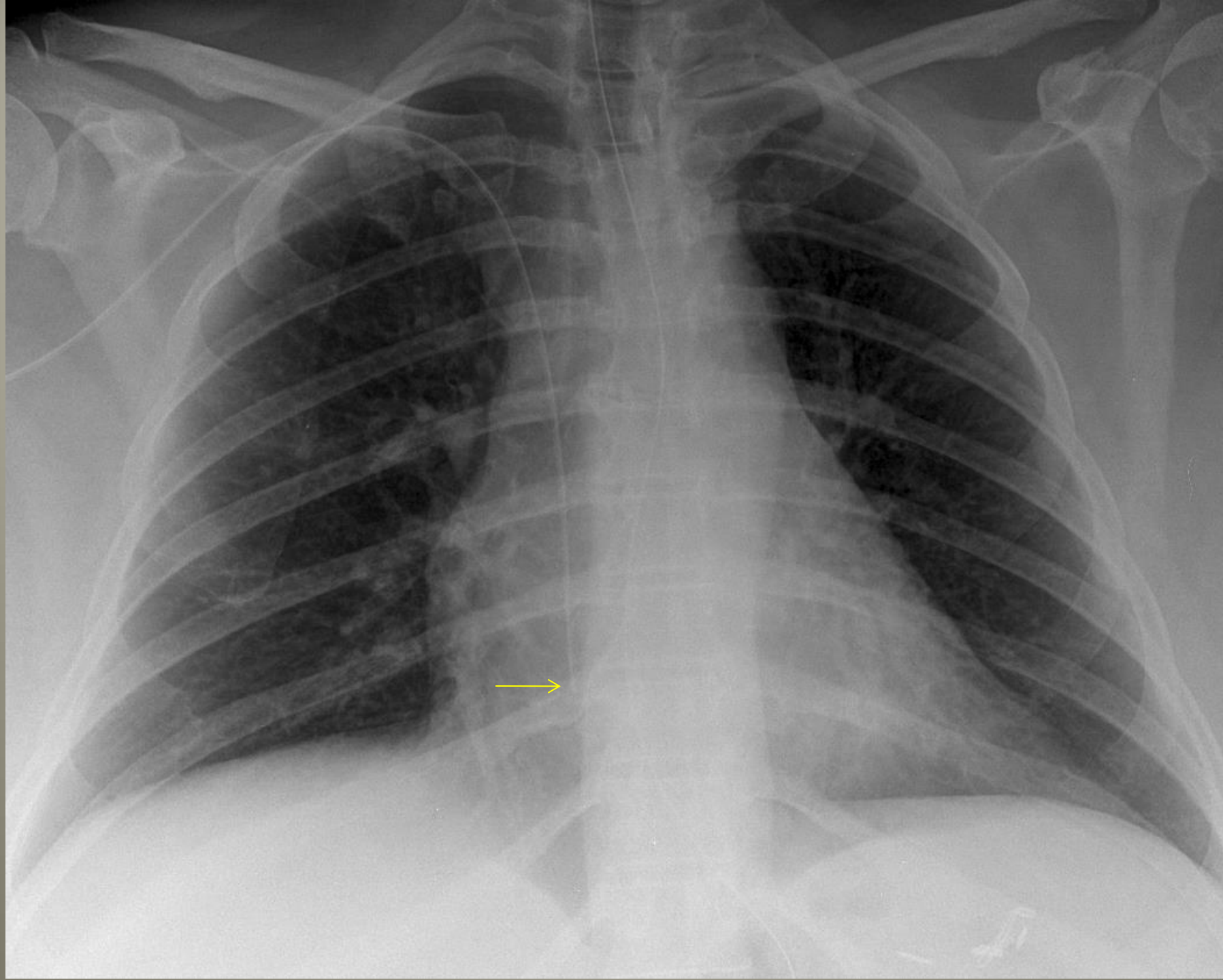
Practice Considerations

- *600,000 cardiac PMs inserted annually in USA*
- *PMs usually placed on left side*
- *Incidence of venous complications post-insertion is 30-45%*
 - *Most commonly thrombosis*
 - *PICC ipsilateral to PM increases risk*
- *Inspect for s/s of venous thrombosis prior to PICC insertion*
- **INS Standard 33.**
 - “The contralateral side is preferred for CVAD placement, but if the ipsilateral side is selected, a PICC may be the safest choice
- *Review previous radiographic studies prior to CVAD insertion*





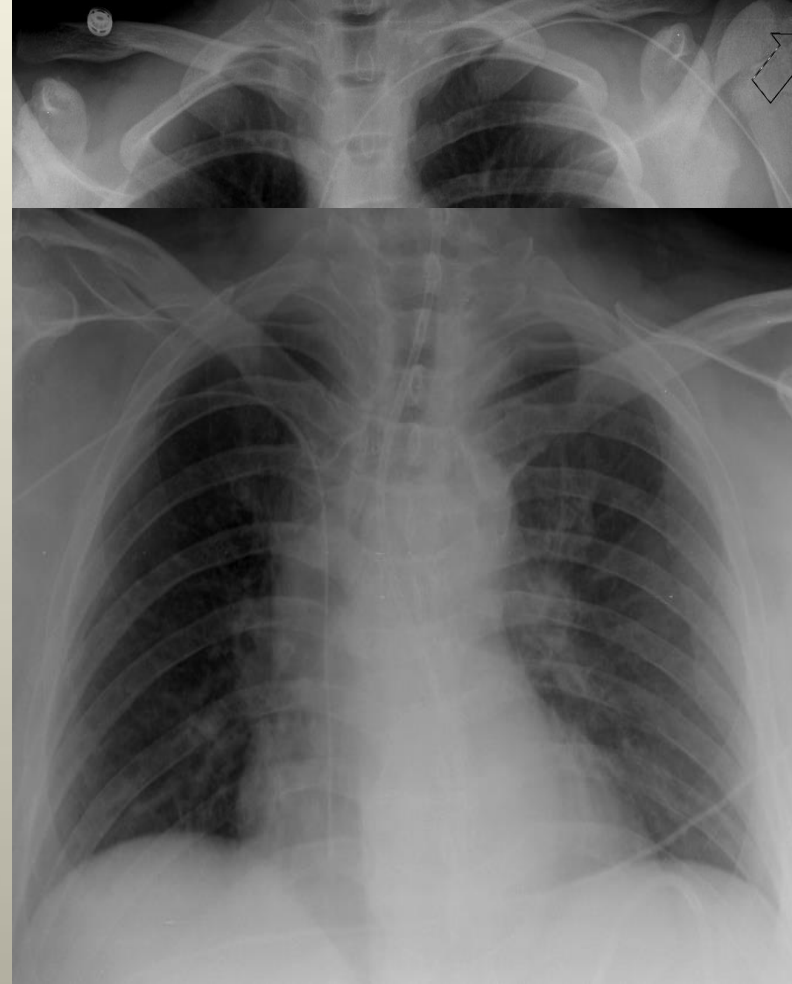
12.5 cm

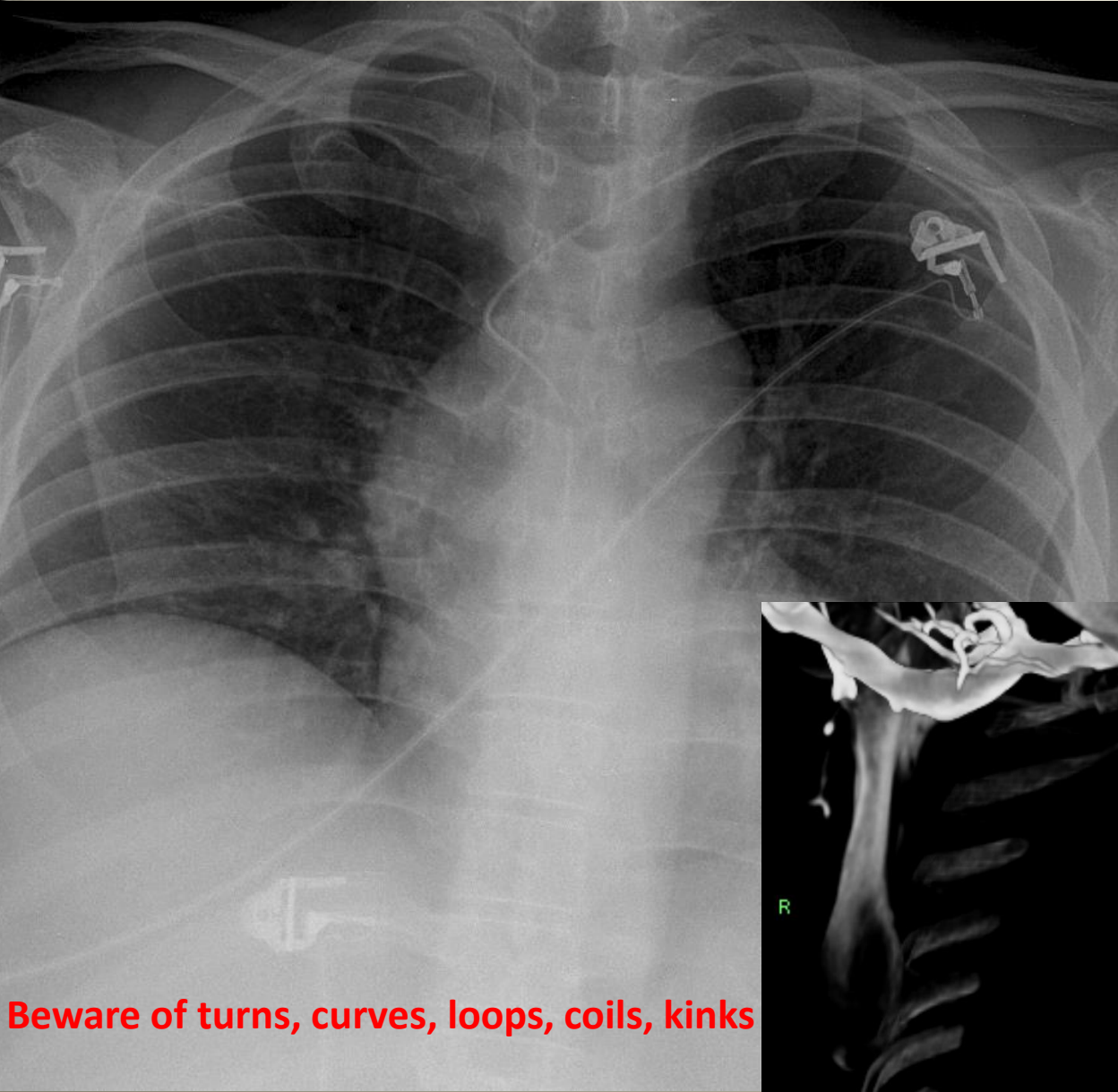




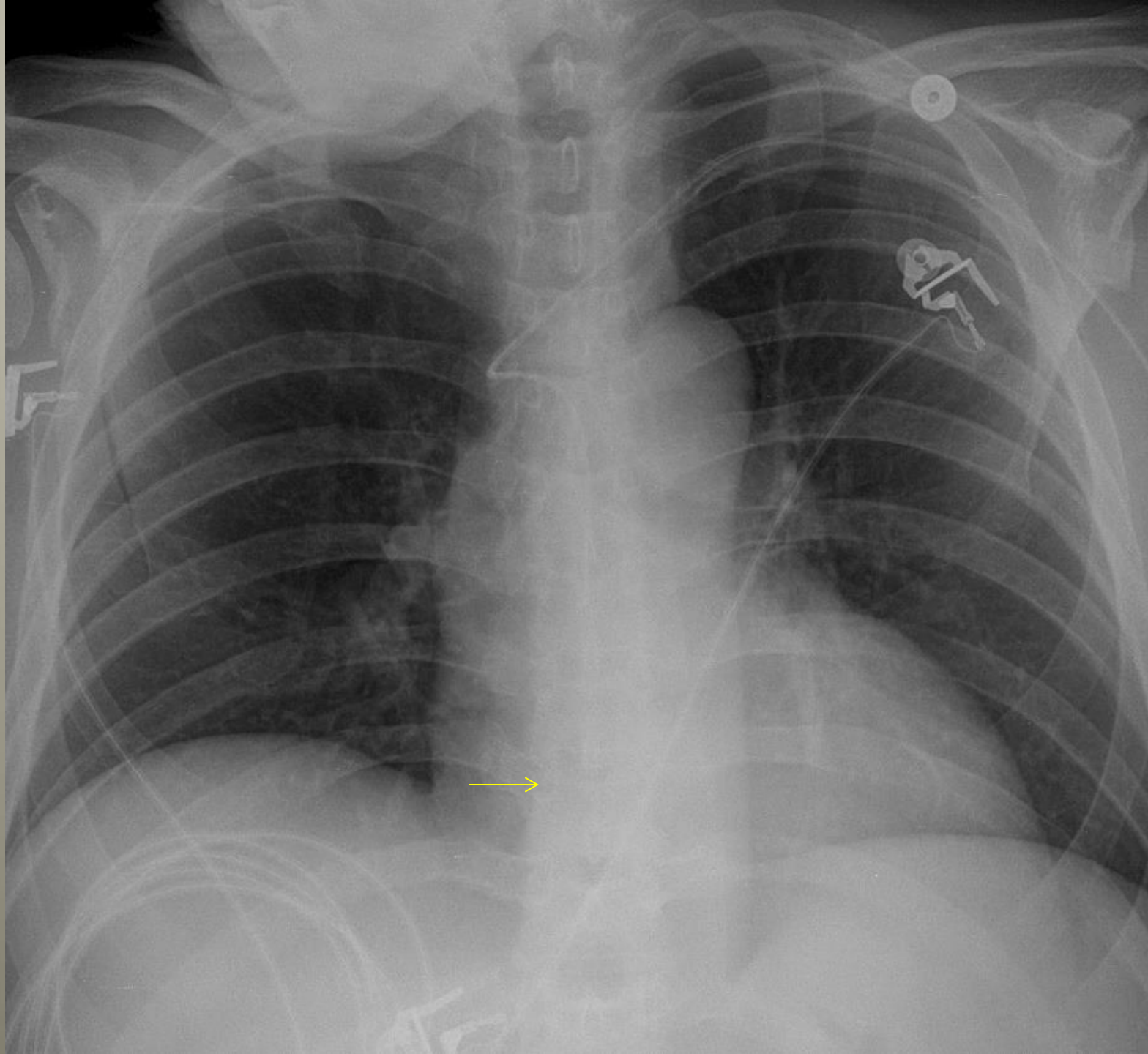
Redefining Guidelines for Optimal PICC Tip Position?

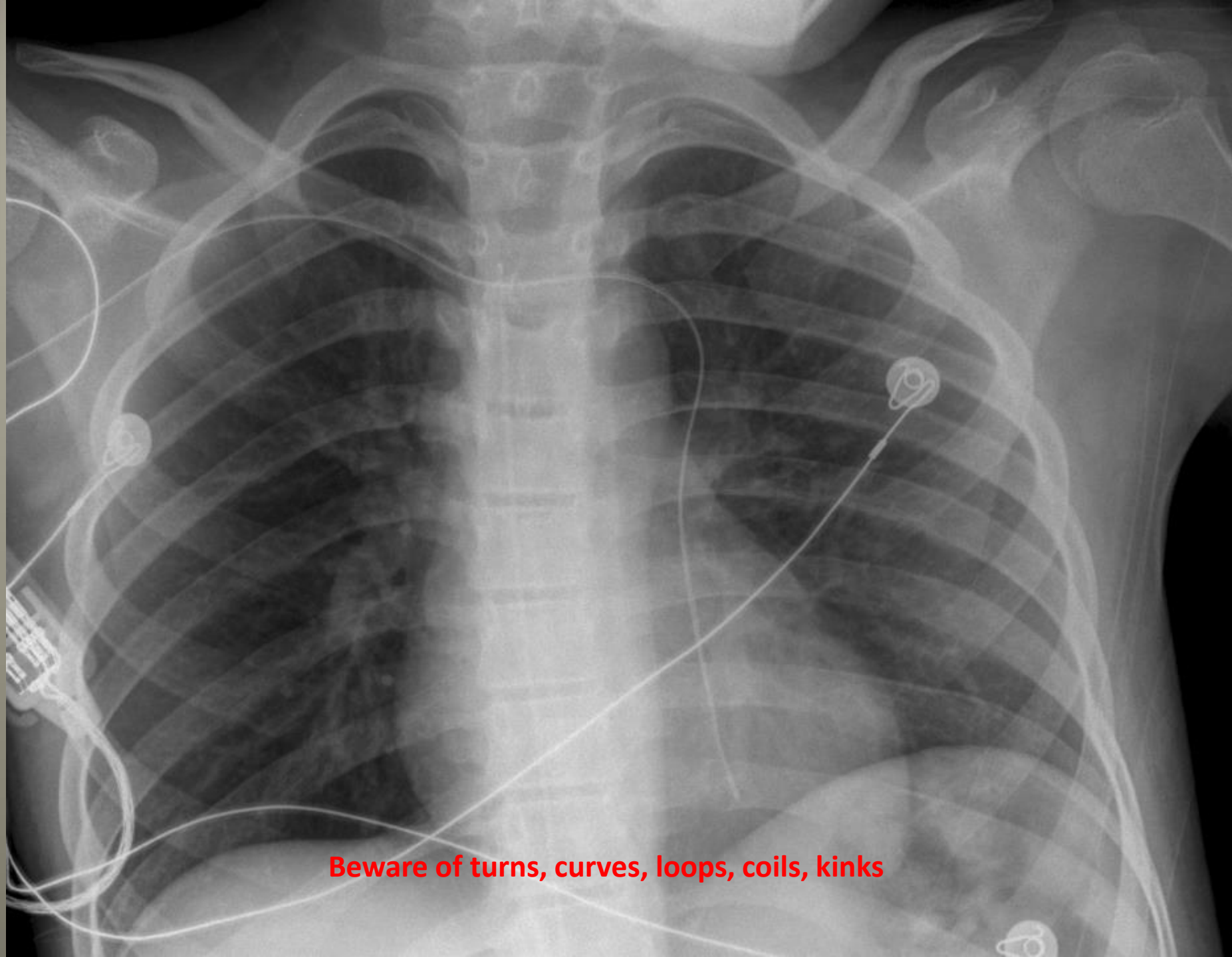
- *INS Standard 53. CVAD Malposition*
 - *Defined as tip position deep in the RA > 2cm below the CAJ*
 - *For intracardiac location that is more than 2 cm below the CAJ retract catheter based on ECG results or from measurement of the specific distance on the CXR*
 - *Avoid intracardiac tip location in neonates and infants less than one year of age*
- *MAGIC Consensus Statement*
 - *Adjustment of PICC tips that reside in the lower one third of the superior vena cava, cavoatrial junction, or right atrium is inappropriate*
 - *Only adjust PICCs that terminate in the upper or mid one third of the superior vena cava or right ventricle*





Beware of turns, curves, loops, coils, kinks





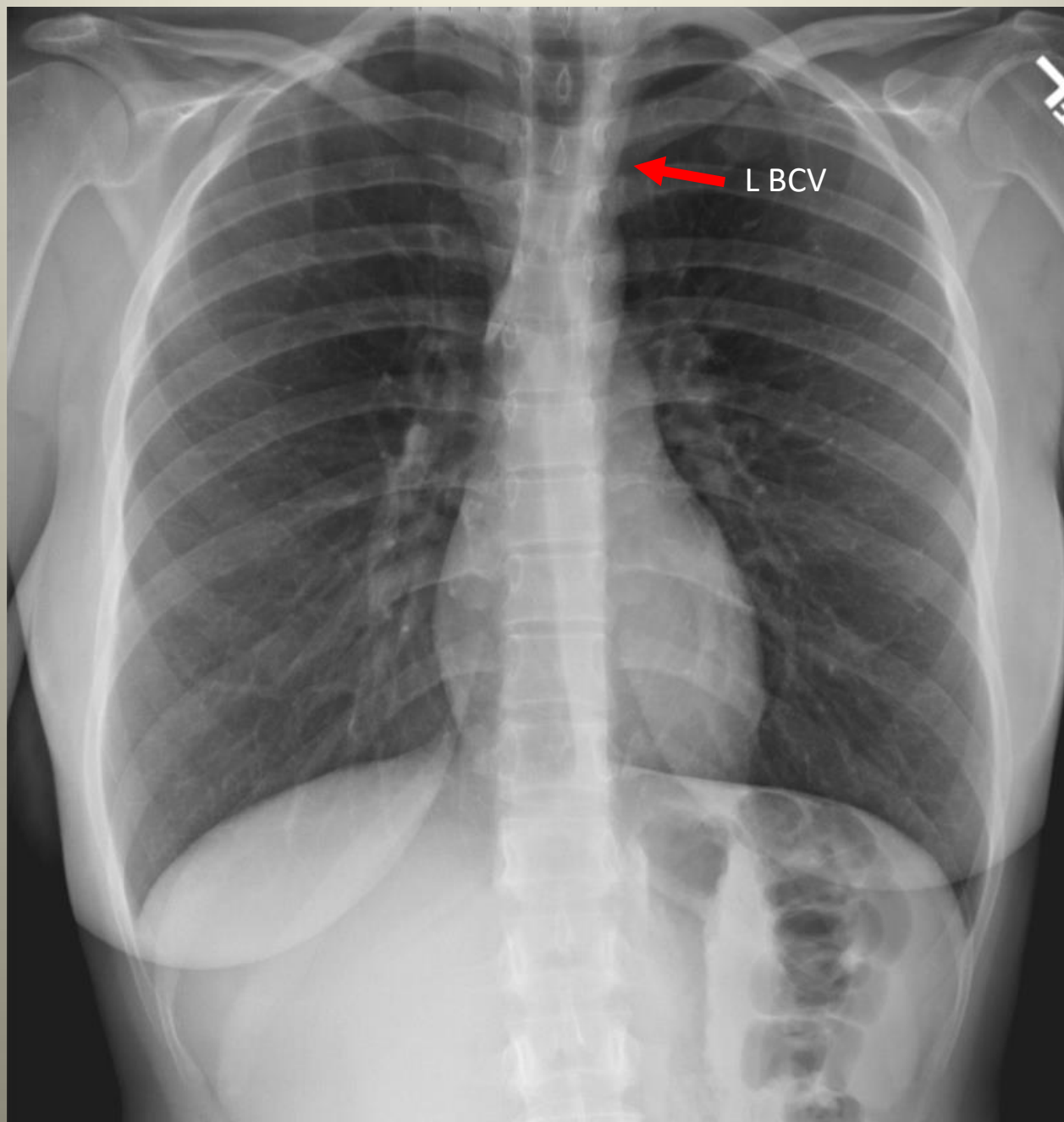
Beware of turns, curves, loops, coils, kinks

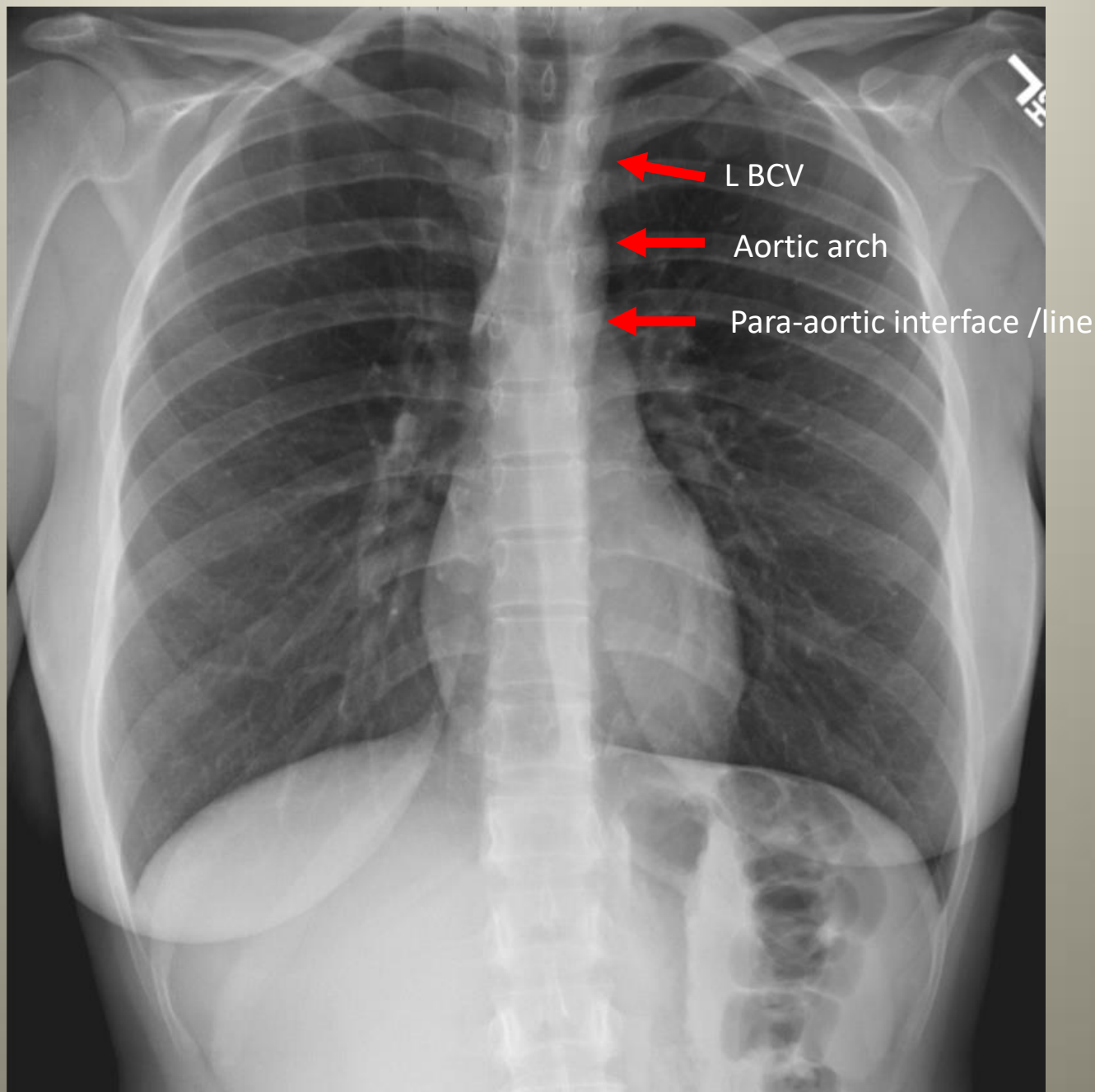
Left Mediastinal Border

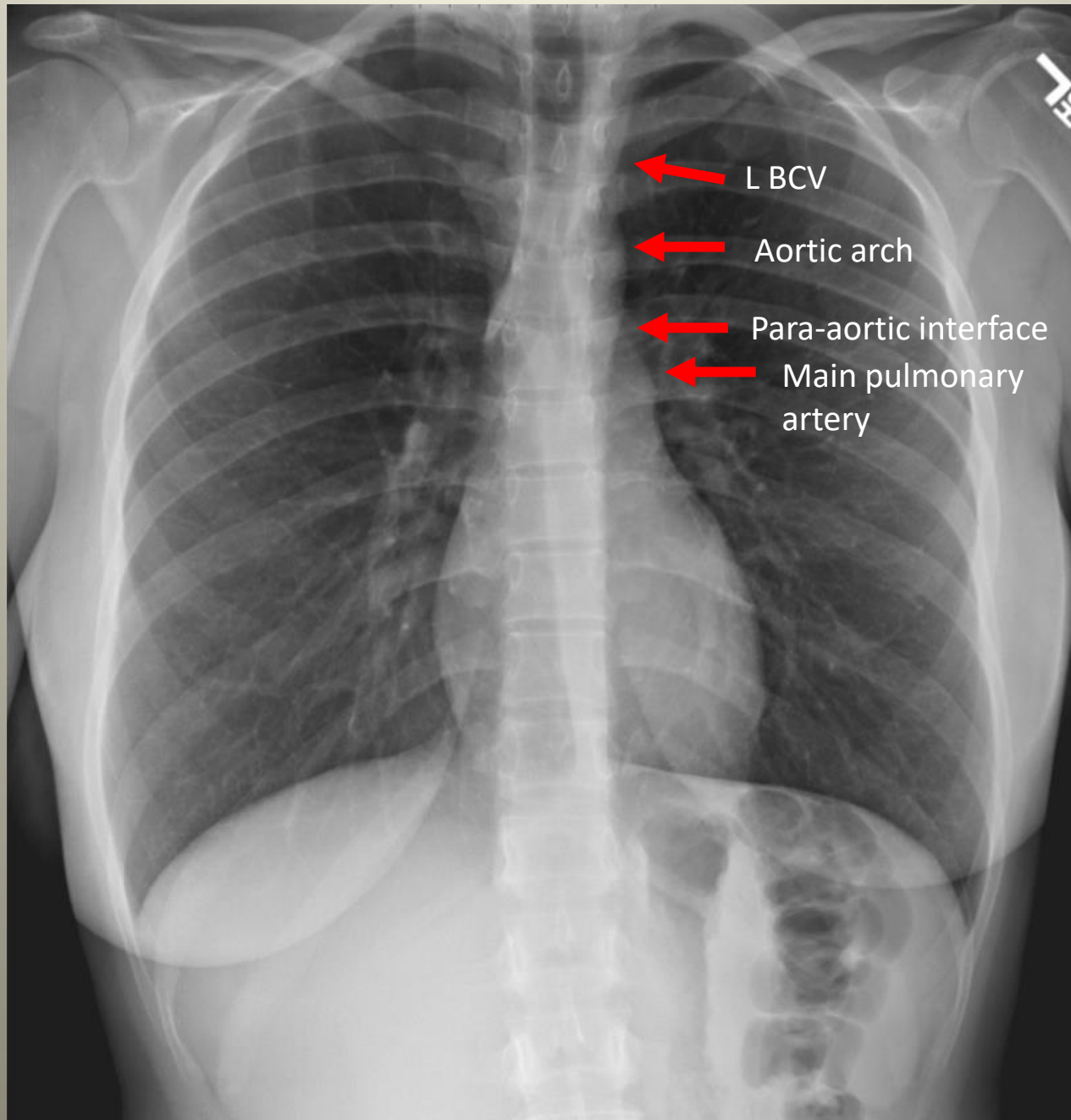
Superior to Inferior

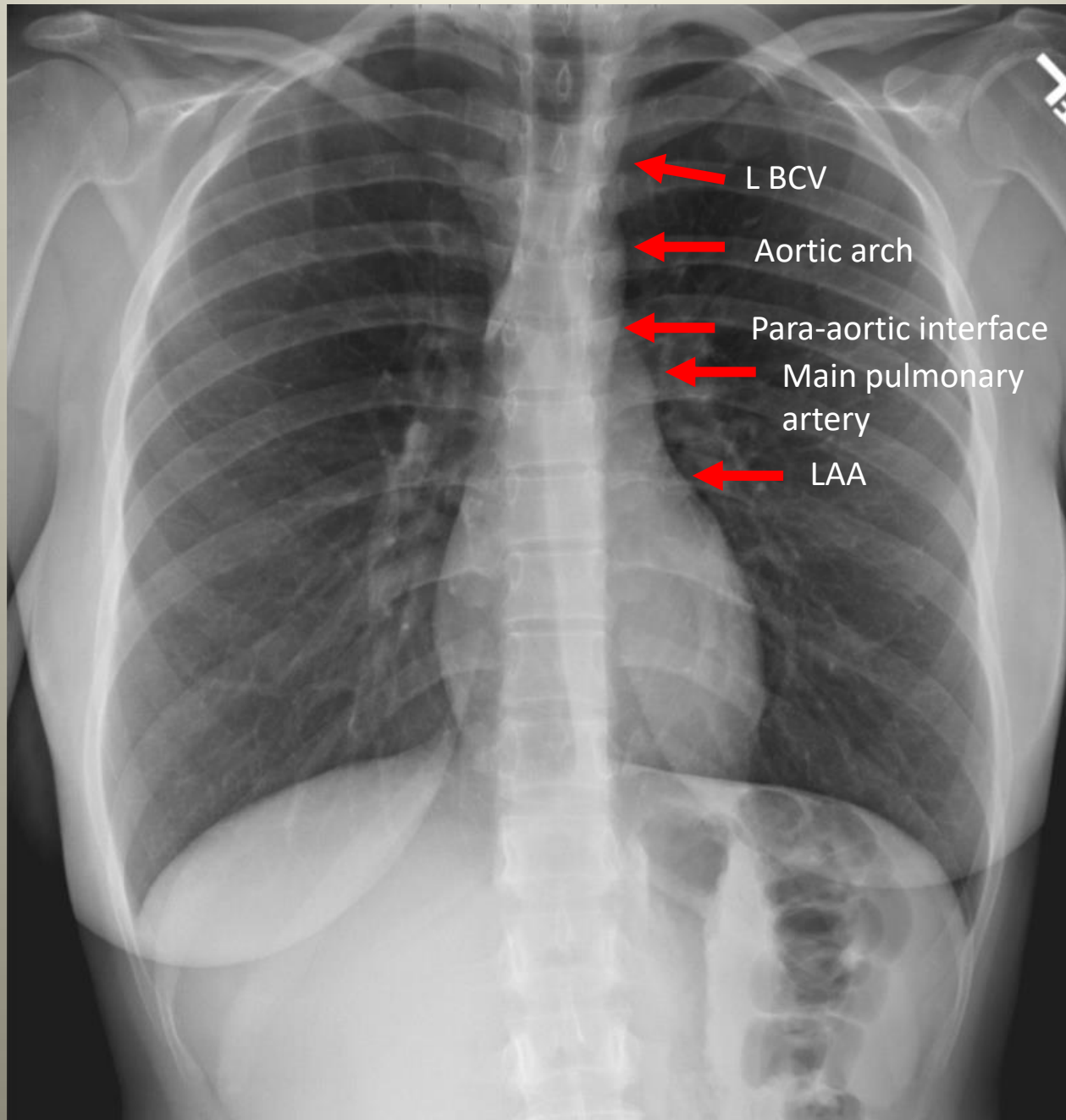
- **L BCV**
- **Aortic arch**
 - **Para-aortic interface or line**
- **Main pulmonary artery**
- **LAA**
- **LV**

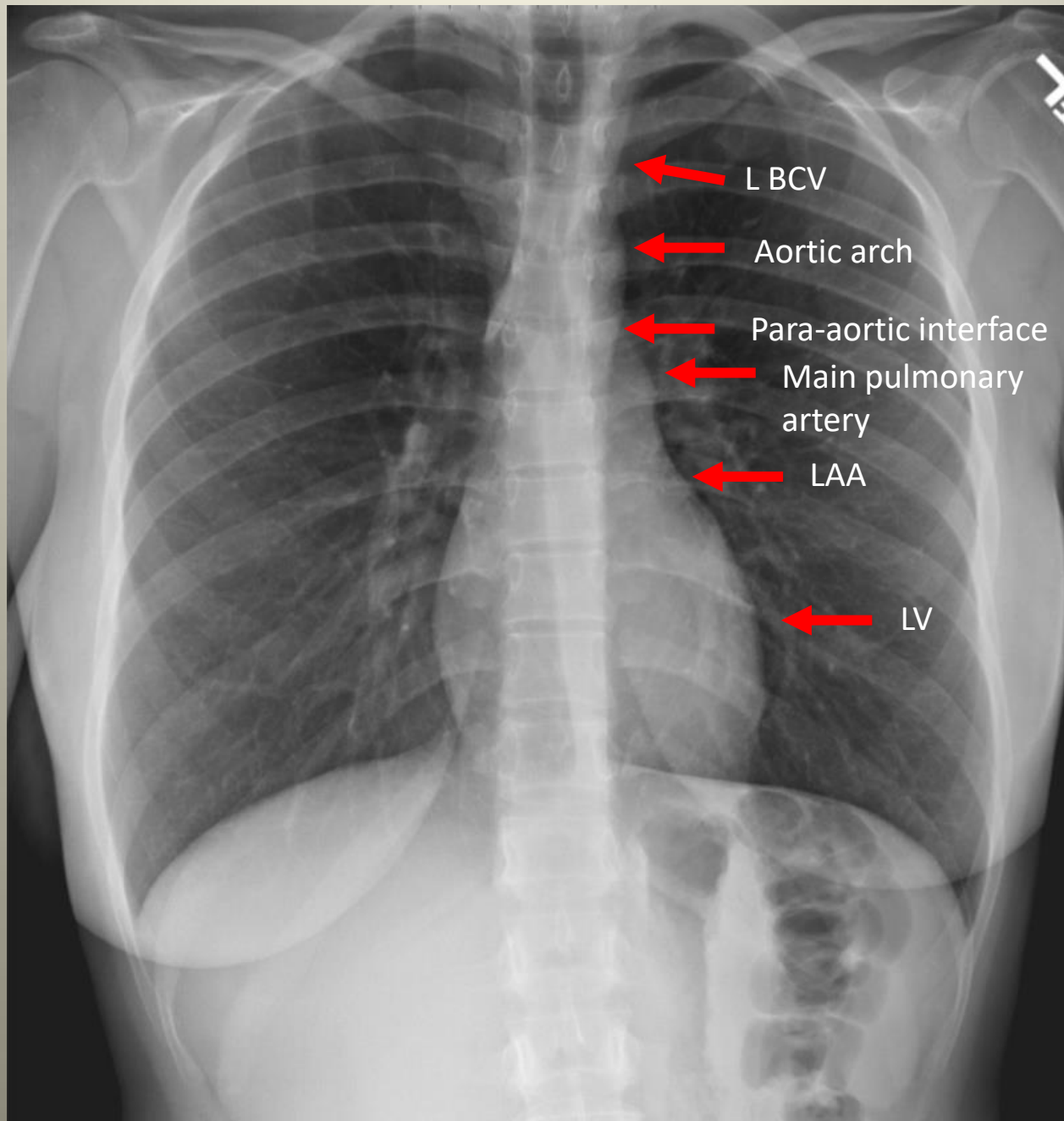


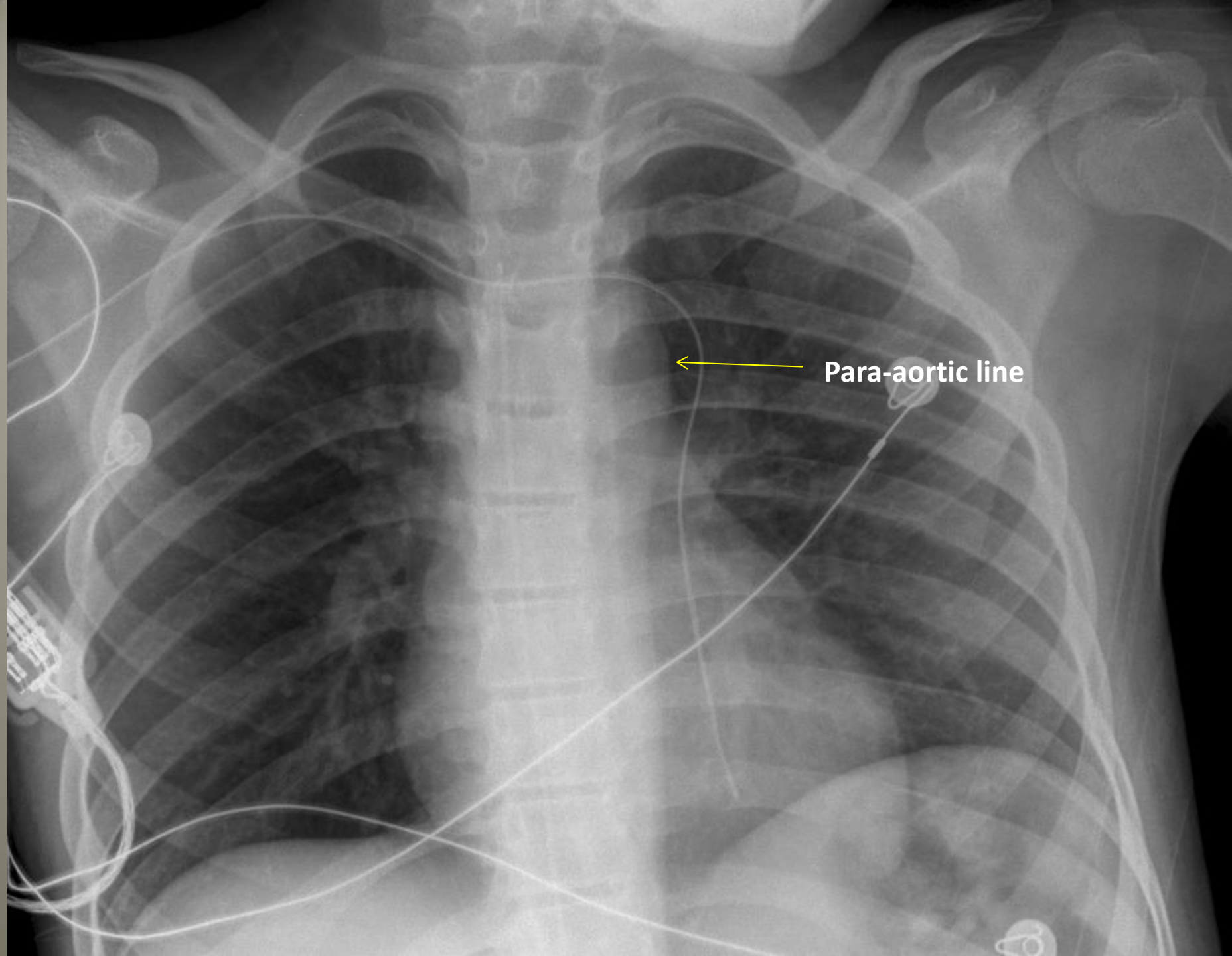




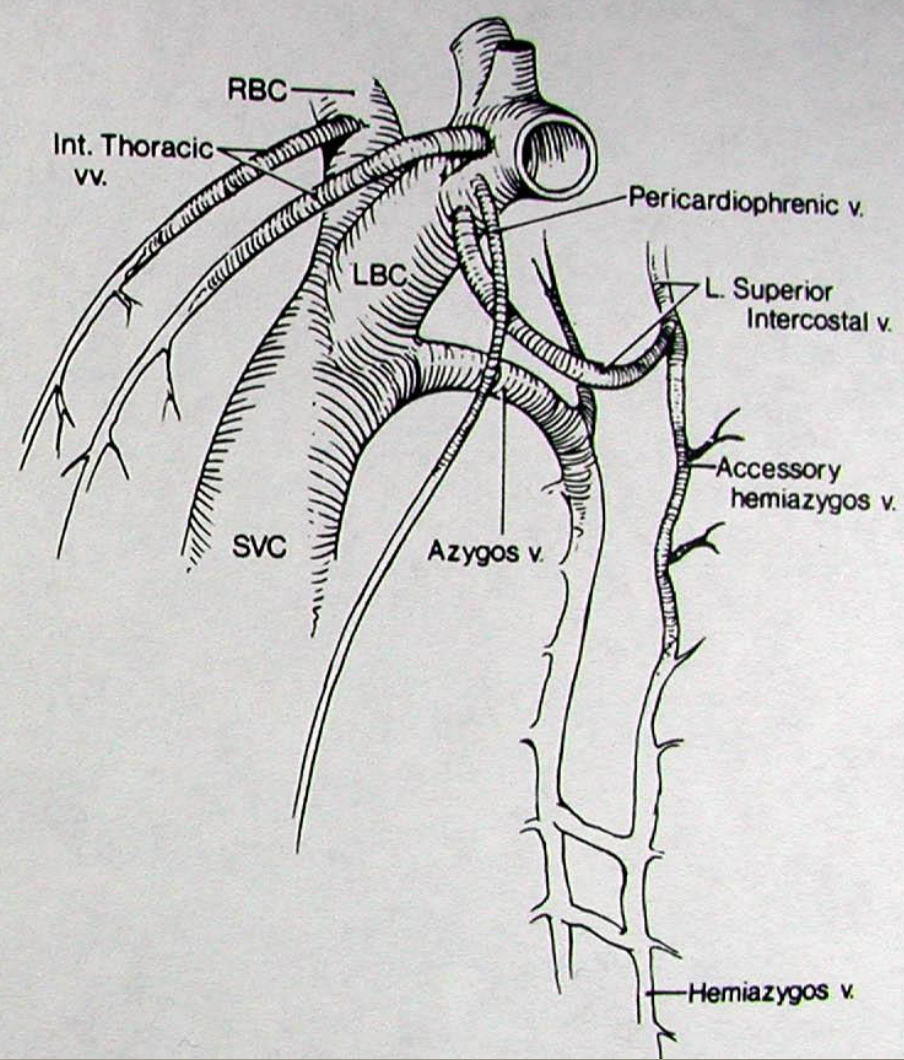
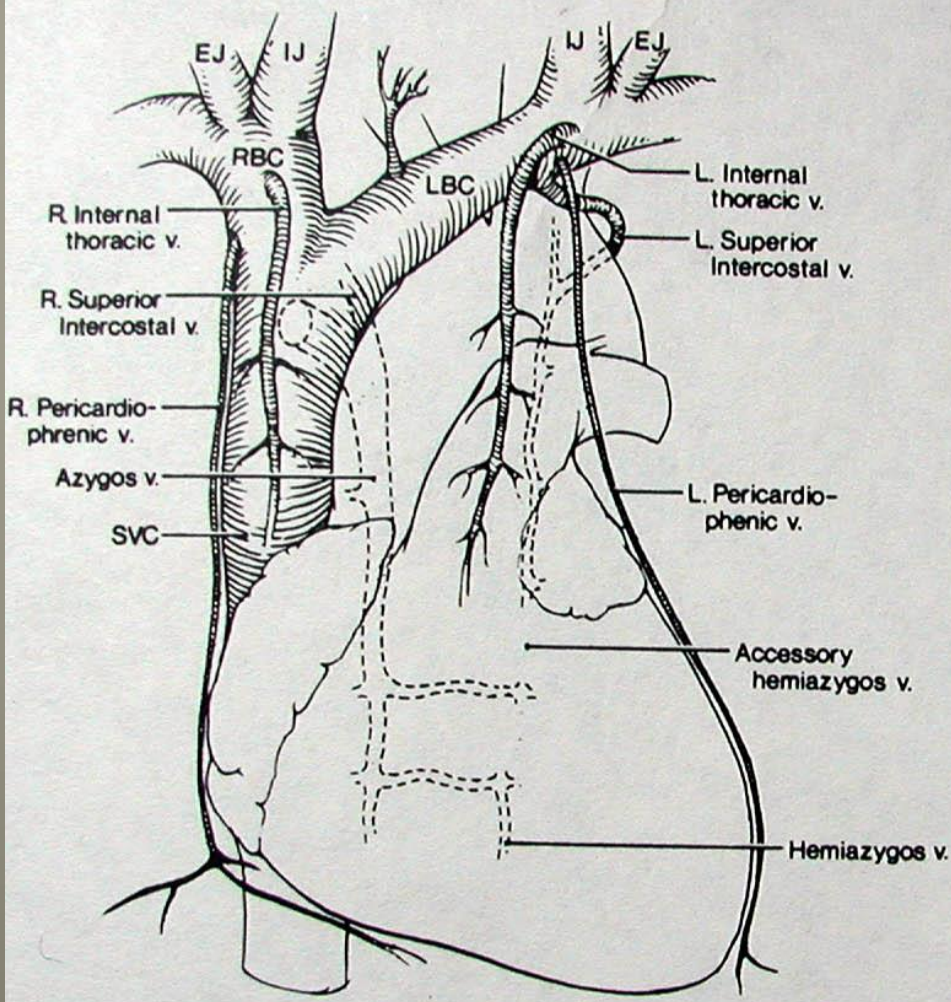


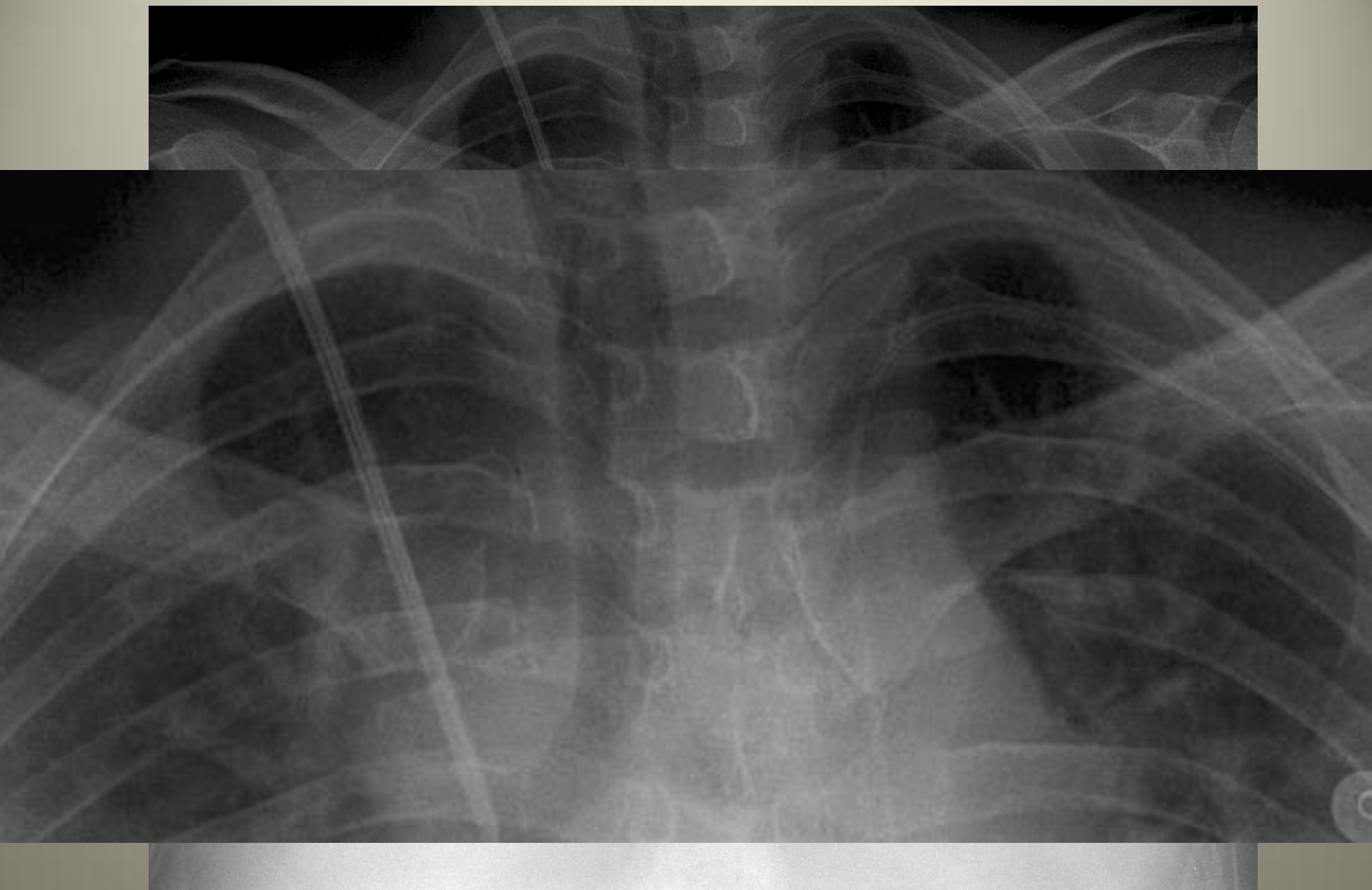






Para-aortic line





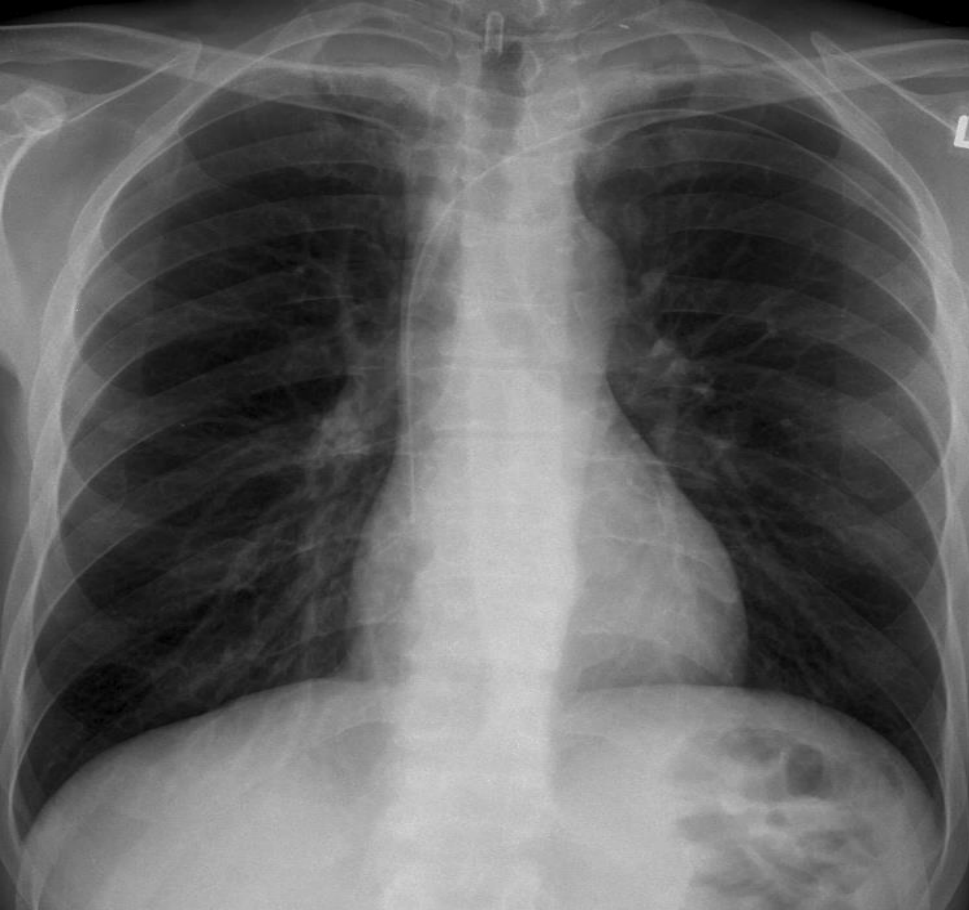


Intra-Arterial PICC Insertion

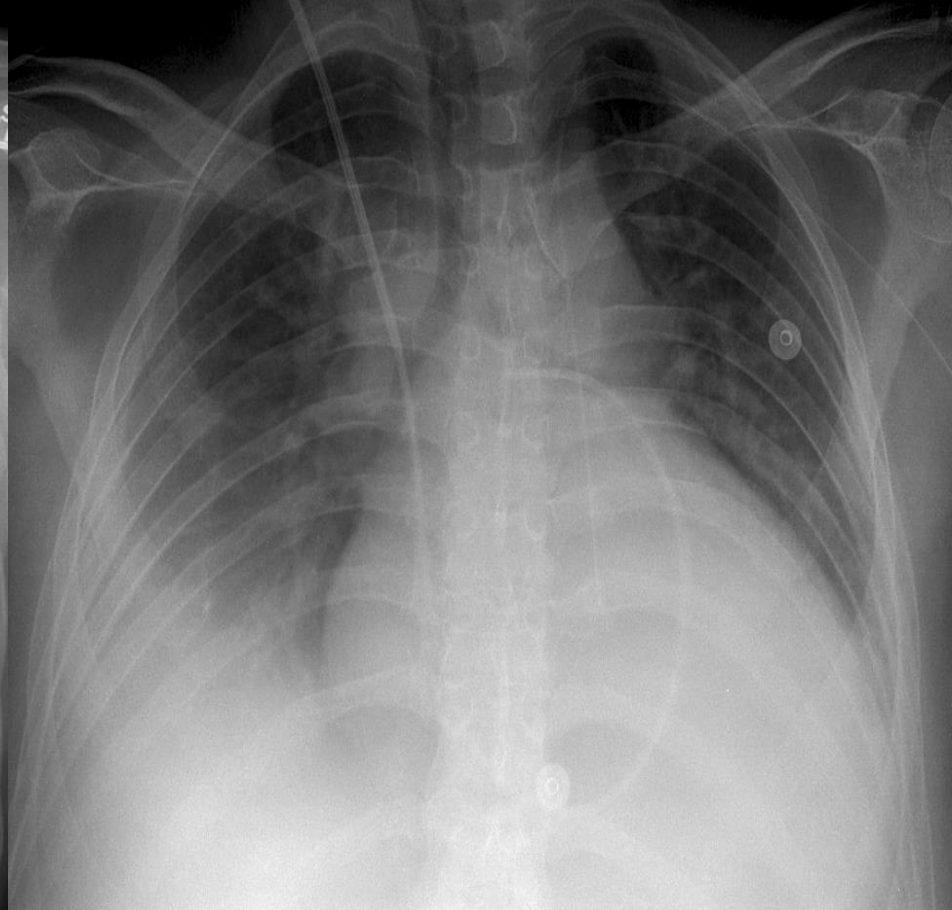
- Incidence is rare
- Catheter courses **above clavicle and to left of mediastinum**
- Whenever in doubt confirm venous residence of MST wire prior to advancing dilator and introducer sheath (ASA Guidelines for CVCs, 2012)
- Do not rely on color or absence of pulsatile flow to rule out intra-arterial placement (ASA & INS SOP)



Intravenous PICC



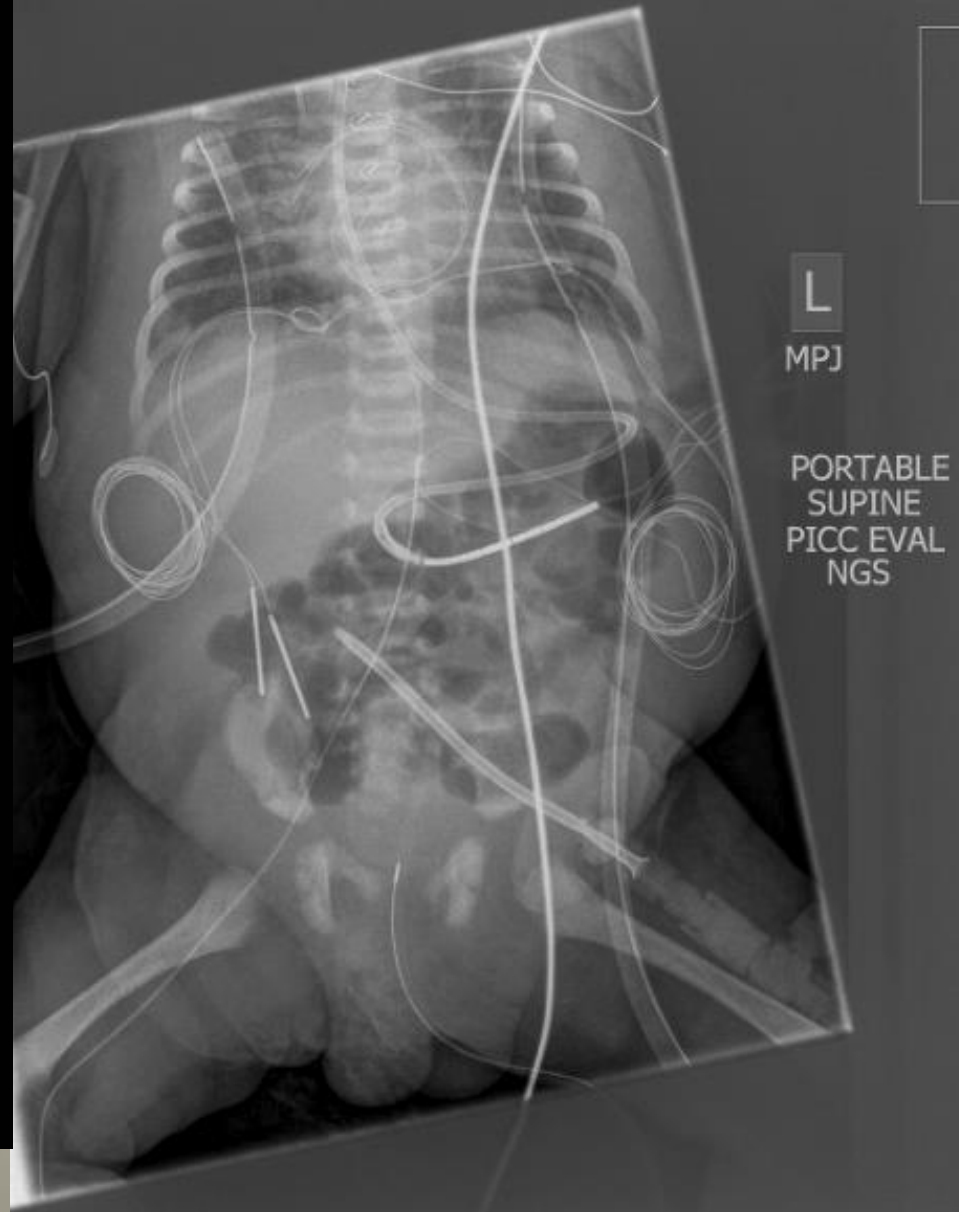
Intra-arterial PICC



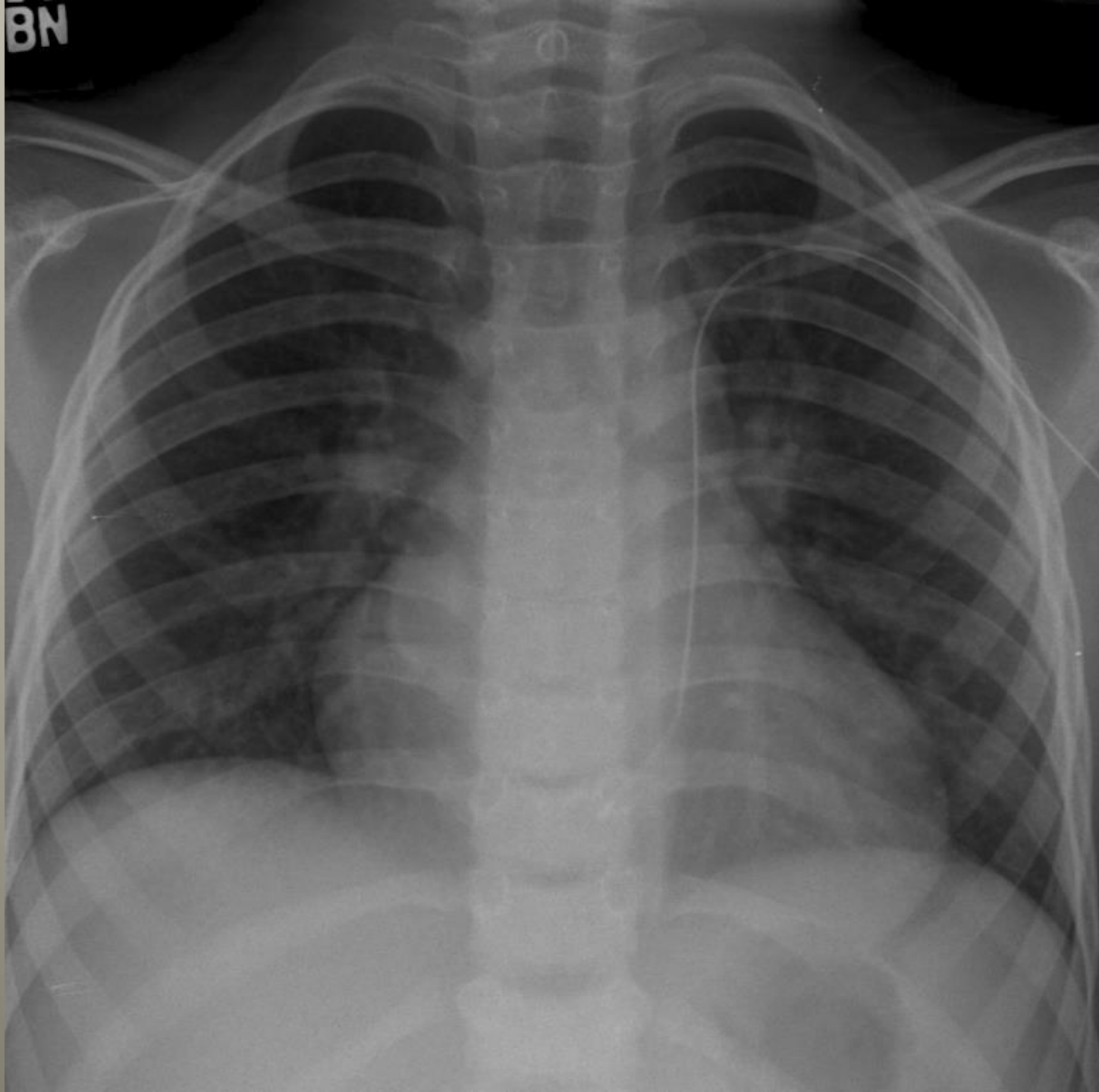
Intravenous PICC



Intra-arterial PICC



BN



RIGHT SVC

LEFT SVC

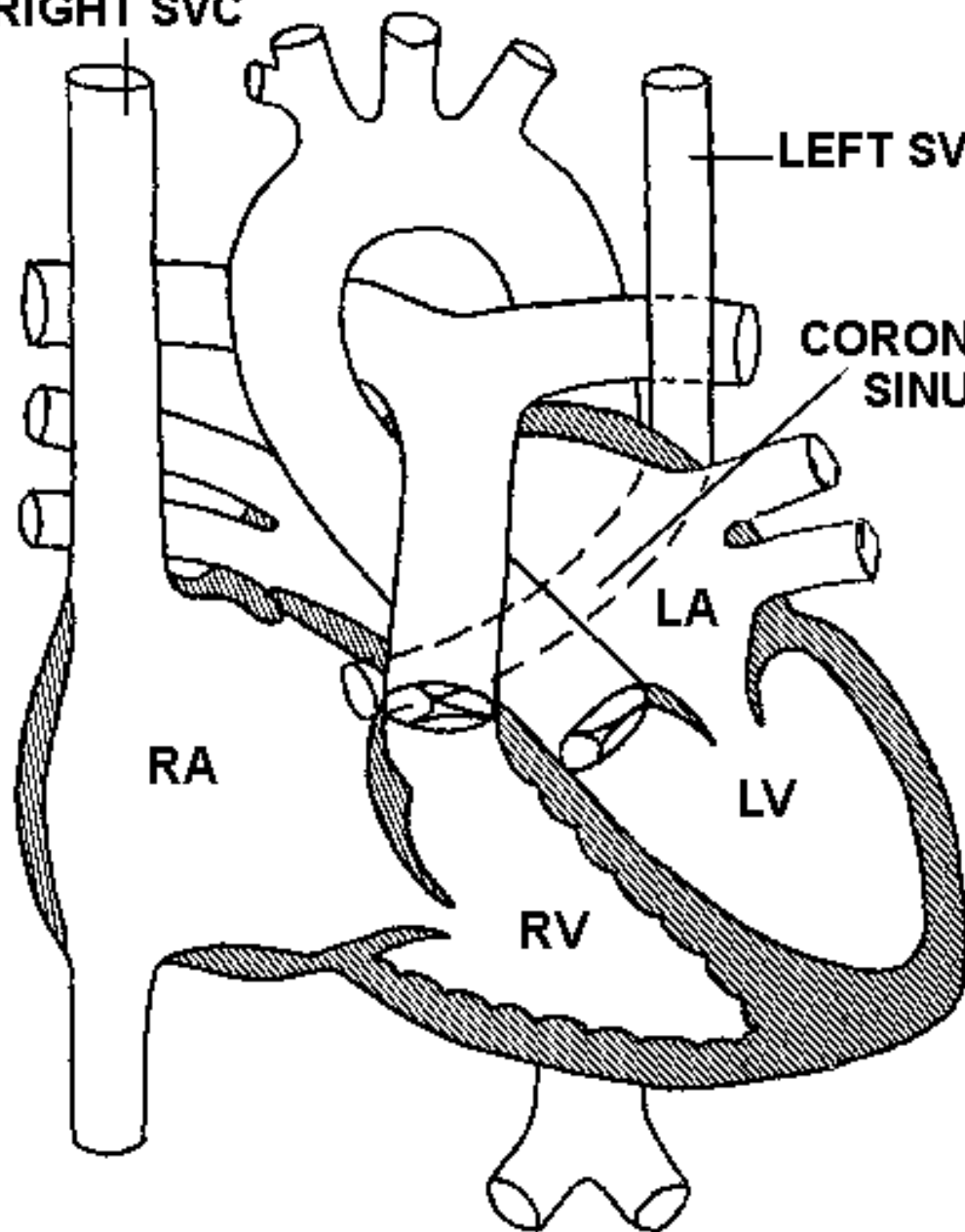
**CORONARY
SINUS**

RA

LA

LV

RV



Persistent Left SVC (PLSVC)

- Incidence <0.5% - 4% of patients with congenital heart disease
 - Most common form of cardiac congenital anomaly
 - Right side SVC present in approximately 80% cases
 - PLSVC drains into coronary sinus
- INS Standard 53.
 - Before using a CVAD in a PLSVC, cardiac imaging studies are needed to determine blood flow characteristics
 - Blood flow into L atrium and right-to-left cardiac shunting pose significant risk for air or thrombotic emboli to a variety of anatomic locations (e.g., brain, kidney) requiring repositioning of CVAD

AS:

V: 140.0

AST BOLUS & OPTI 90CC



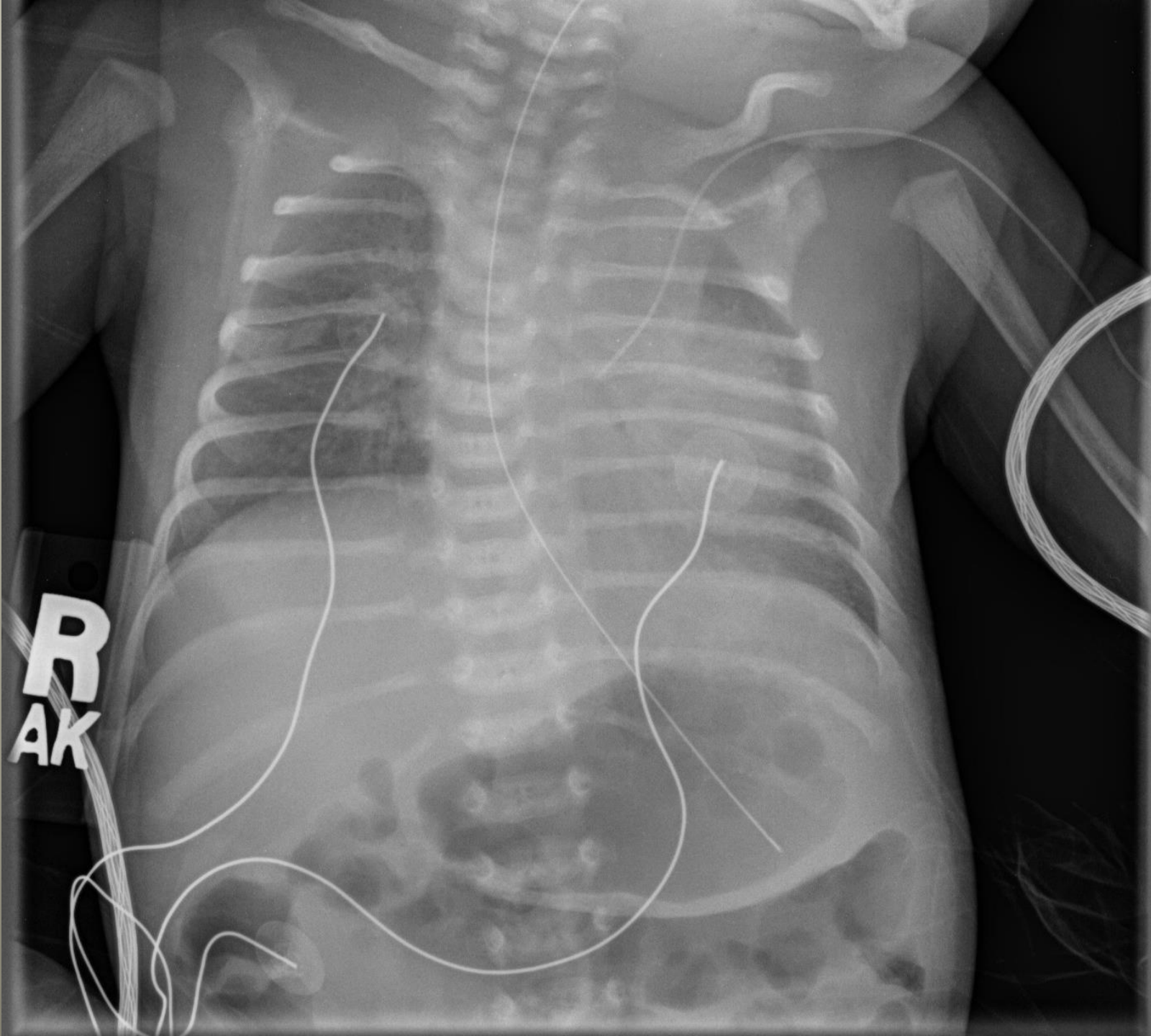
H

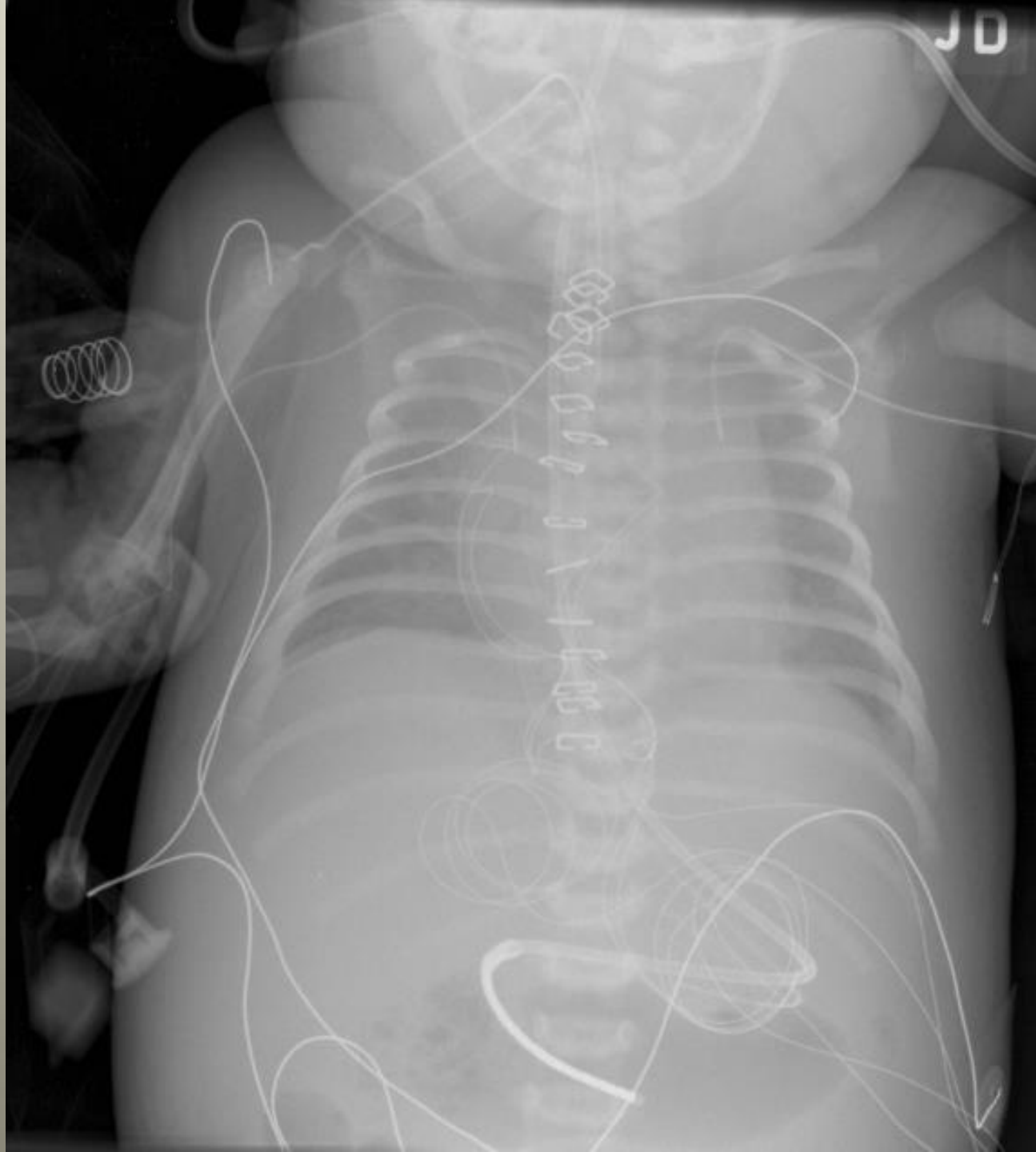


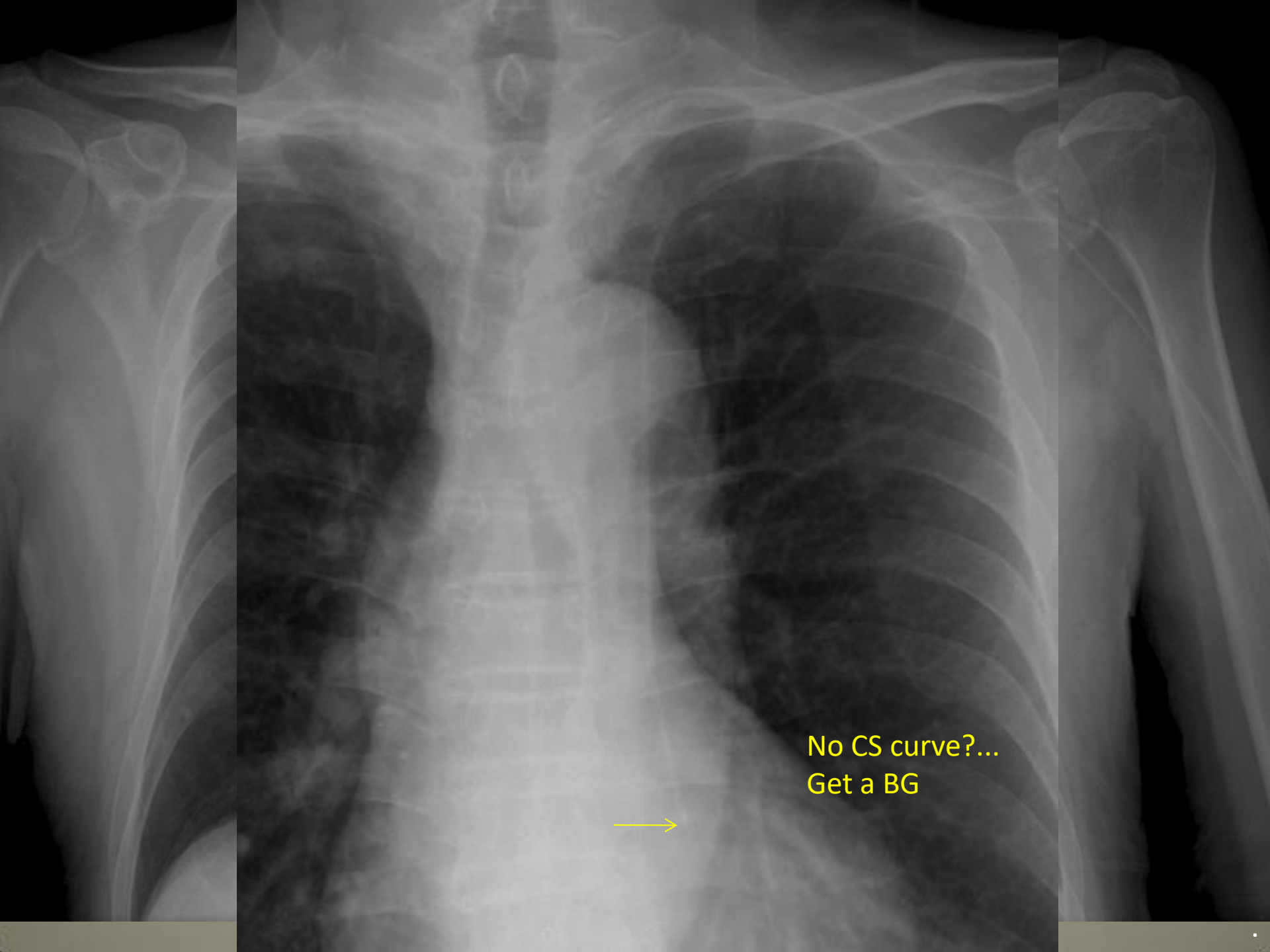
F



R
AK

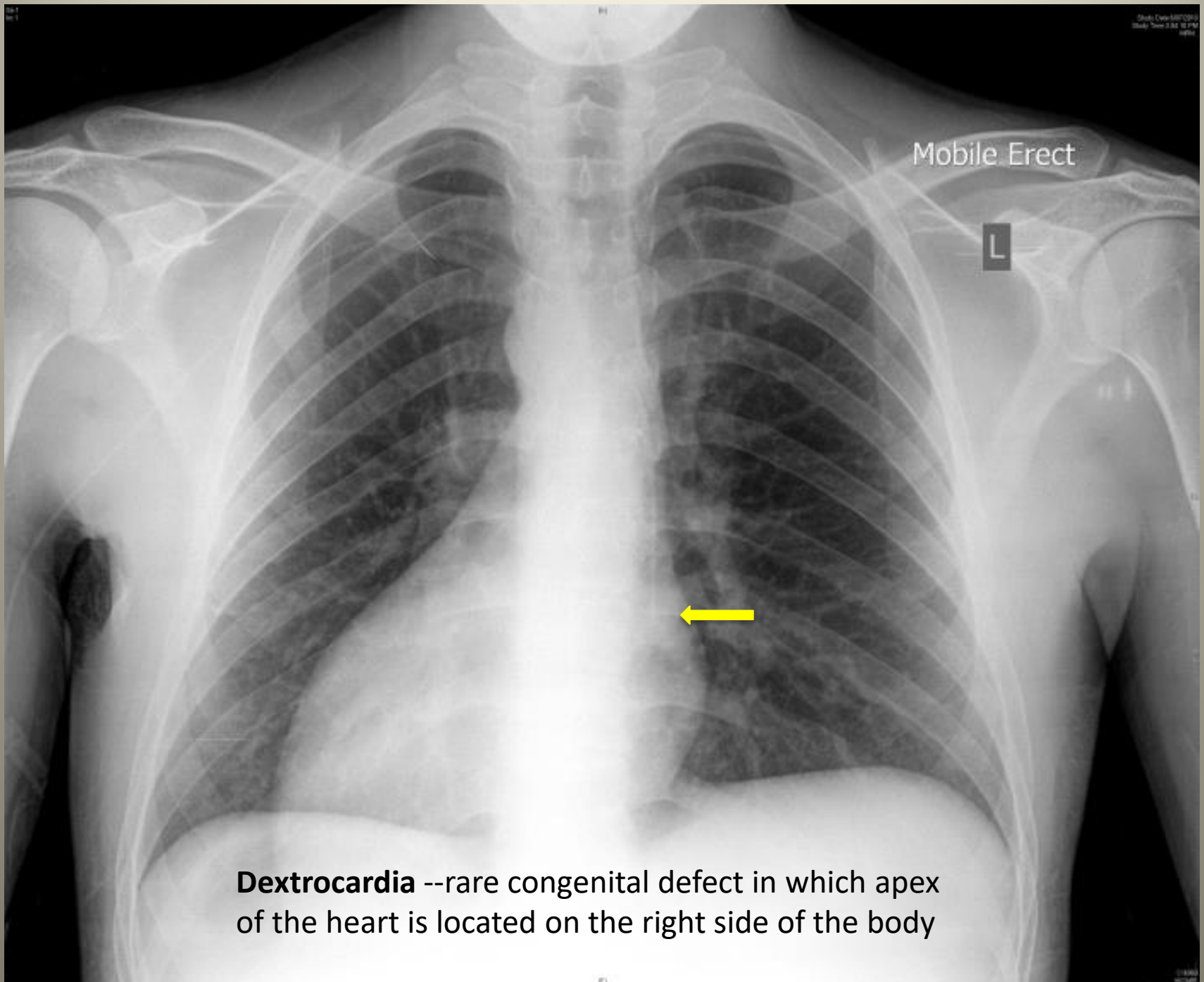


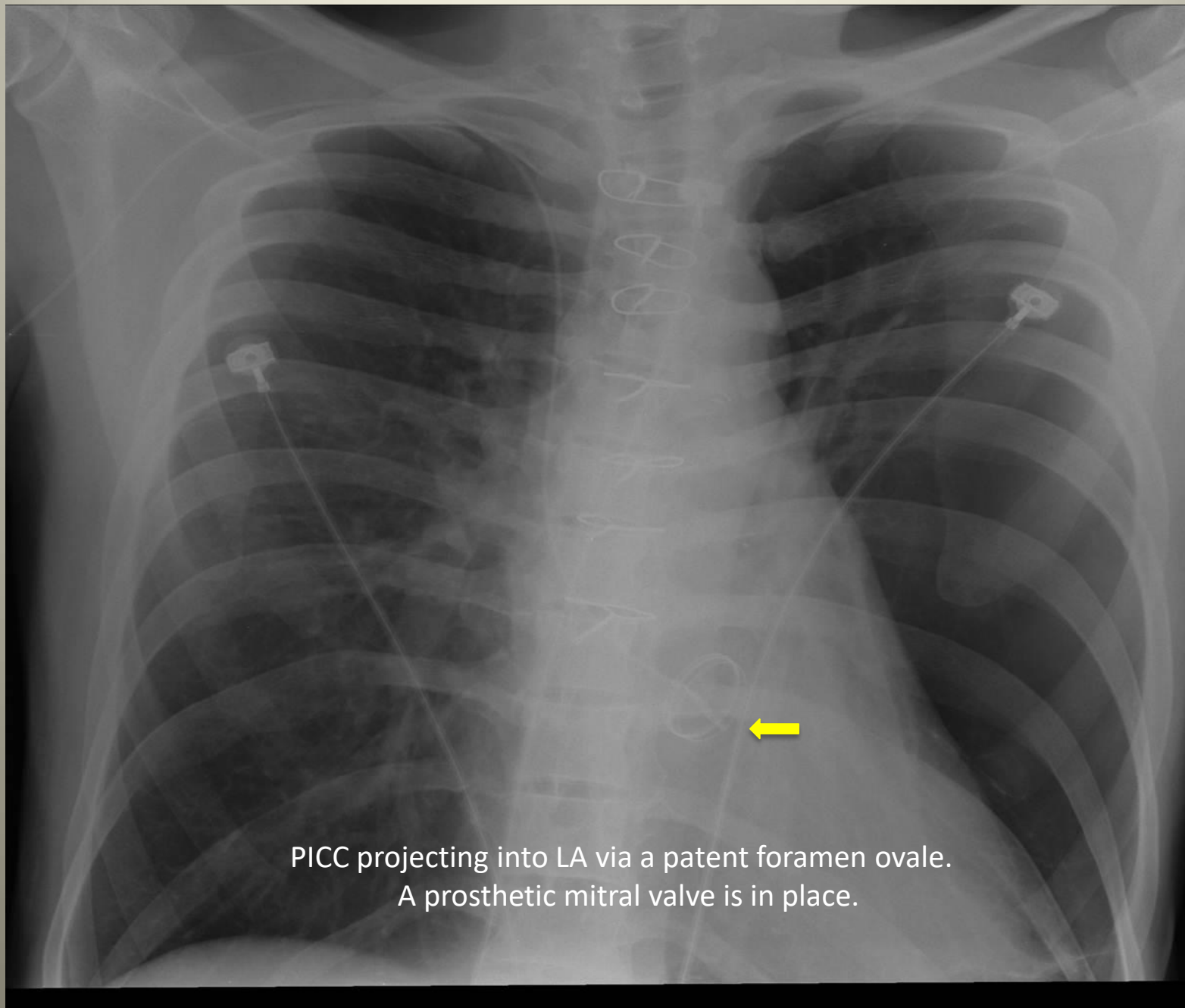




No CS curve?...
Get a BG







PICC projecting into LA via a patent foramen ovale.
A prosthetic mitral valve is in place.

May.11.2016
17.45

AP UPRIGHT
LEFT

Don't get fooled by rotation or pathology

Zoom:0.3

W:4096
C:2048
17.51

PICC Coursing to Left of Mediastinum

Potential Causes

- Intra-arterial
- Left internal thoracic (mammory) vein
 - Look for superior curve
- Persistent left SVC (PLSVC)
 - Look for inferior curve
- Dextrocardia
- Severe left pulmonary atelectasis
- Patent foramen ovale

Summary

- PICCs should follow a smooth, predictable course
 - Basilic, brachial, cephalic v. → axillary v. → subclavian v. → brachiocephalic v. → SVC → CAJ
 - Sharp turns, curves, loops, coils, kinks or catheter course to the midline or left of mediastinum requires further investigation
- Always make sure you find the PICC tip with 100% certainty
 - Whenever in doubt, consult radiologist
- Whenever accessing veins near an artery, confirm venous residence of MST wire prior to advancement of dilator-introducer
- Remember...the most superior right heart border-forming structure is the RAA...not the RA
 - CAJ is approximately 2 cm inferior to the RAA or 5-7 cm (2-3 vertebral body units) inferior to the carina

REFERENCES

1. Albrecht K, Nave H, Breitmeier D, Panning H, et al. (2004) Applied anatomy of the superior vena cava—the carina as a landmark to guide central venous catheter placement. *Br J Anaesthesiology*, 92:75-77.
2. Association for Vascular Access (2008) Position Statement: Interpretation of chest radiographs by nurses for verification of PICC tip position. Retrieved from www.avainfo.org.
3. Ballard, D.H., Samra, N.S., Gifford, K.S., et al. (2016) Distance of the internal central venous catheter tip from the right atrium is positively correlated with central venous thrombosis. *Emerg Radiol*, 23(3):269-73.
4. Dariushnia, S.R., Wallace, M.J., Nasir, H.S., et al. (2010) Quality improvement guidelines for central venous access. *Jour of Vasc and Interven Radiol*, 21:976-981.
5. Fletcher SJ, Bodenham AR. (2000) Safe placement of central venous catheters: where should the tip of the catheter lie? *Br J Anaesthesiology*, 85:188-191.
6. Forauer AR, Alonzo M. (2000) Change in peripherally inserted central catheter position with abduction and adduction of the upper extremity. *Jour of Vasc and Interven Radiol*, 11:1315-1318.
7. Infusion Nursing Society (2010) Position Paper: The role of the registered nurse in determining distal tip placement of PICCs by chest radiograph. *JIN*, 33(1);19-20.
8. Gorski, L.A., Hadaway, L, Hagel, M.E., et al. (2016) Infusion therapy standards of practice. *JIN*, 39(suppl 1).
9. Marcovich, M.B. (2008) The expanding role of the infusion nurse in radiographic interpretation for PICC tip position. *Jour of Infusion Nursing*, 31(2):96-103.
10. Pacana, CL. (2009) The risk of CVC placement ipsilateral to the permanent pacemaker. *Jour of the Association for Vascular Access*, 14(1):28-30.
11. Petersen J, Delaney JH, Brakstad MT, Rowbotham RK, Bagley CM. (1999) Silicone venous access devices positioned with their tips high in the superior vena cava are more likely to malfunction. *Am J Surg*:178:38-41.
12. Pocius, S., et al. (2009) Accuracy and timeliness of RN vs. MD radiological interpretation of PICC tips. *Jour of the Association for Vascular Access*, 14(3):143-146.
13. Royer, T.I. (2002) A process for certifying registered nurses to read chest x-rays: experience in Washington state. *Jour of Vascular Access Devices*, 7(4):33-36.
14. Royer, T., Earhart, A. (2007) Taking the leap from PICC placement to tip placement. *Jour of the Association for Vascular Access*, 12(3):148-155.
15. Rupp, S.M., Apfelbaum, J.L., Blitt, C., et al. (2012) Practice Guidelines for Central Venous Access: A Report by the American Society of Anesthesiologists Task Force on Central Venous Access. *Anesthesiology*, 116(3):539-73.
16. Santolucito, J.B. (2007) The role of PICCs in the treatment of the critically-ill. *Jour of the Association for Vascular Access*, 12(4):208-217.
17. Verhey, P.T., Gosselin, M.D., Primack, S.L. (2008) The right mediastinal border and central venous anatomy on frontal chest radiograph—direct CT correlation. *Jour of the Association for Vascular Access*, 13(1):32-35.
18. Vesely, T.M. (2003) Central venous catheter tip position: a continuing controversy. *Jour of Vasc and Interven Radiol*, 14:527-534.