Introduction to Swan-Ganz catheterization

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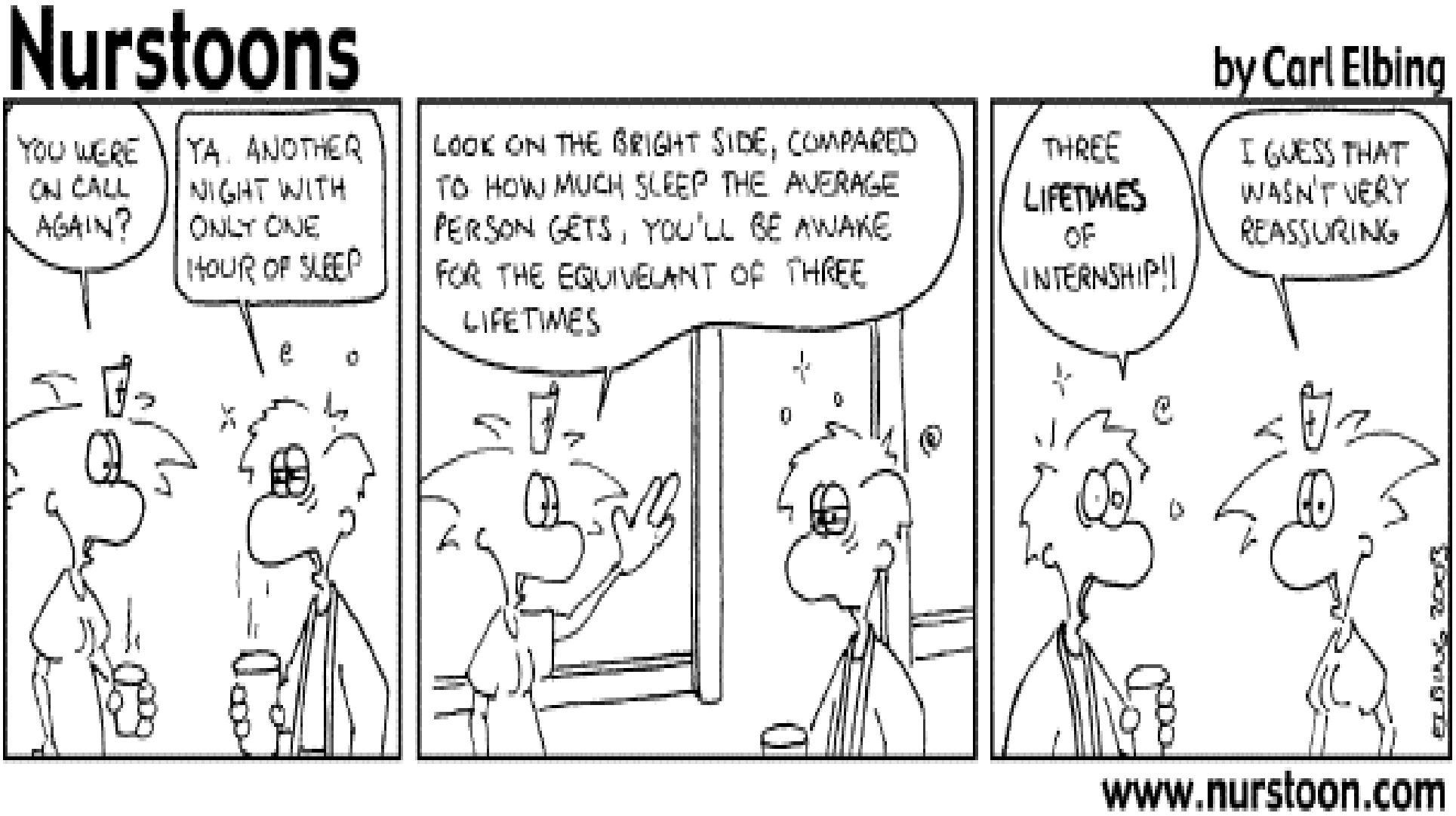
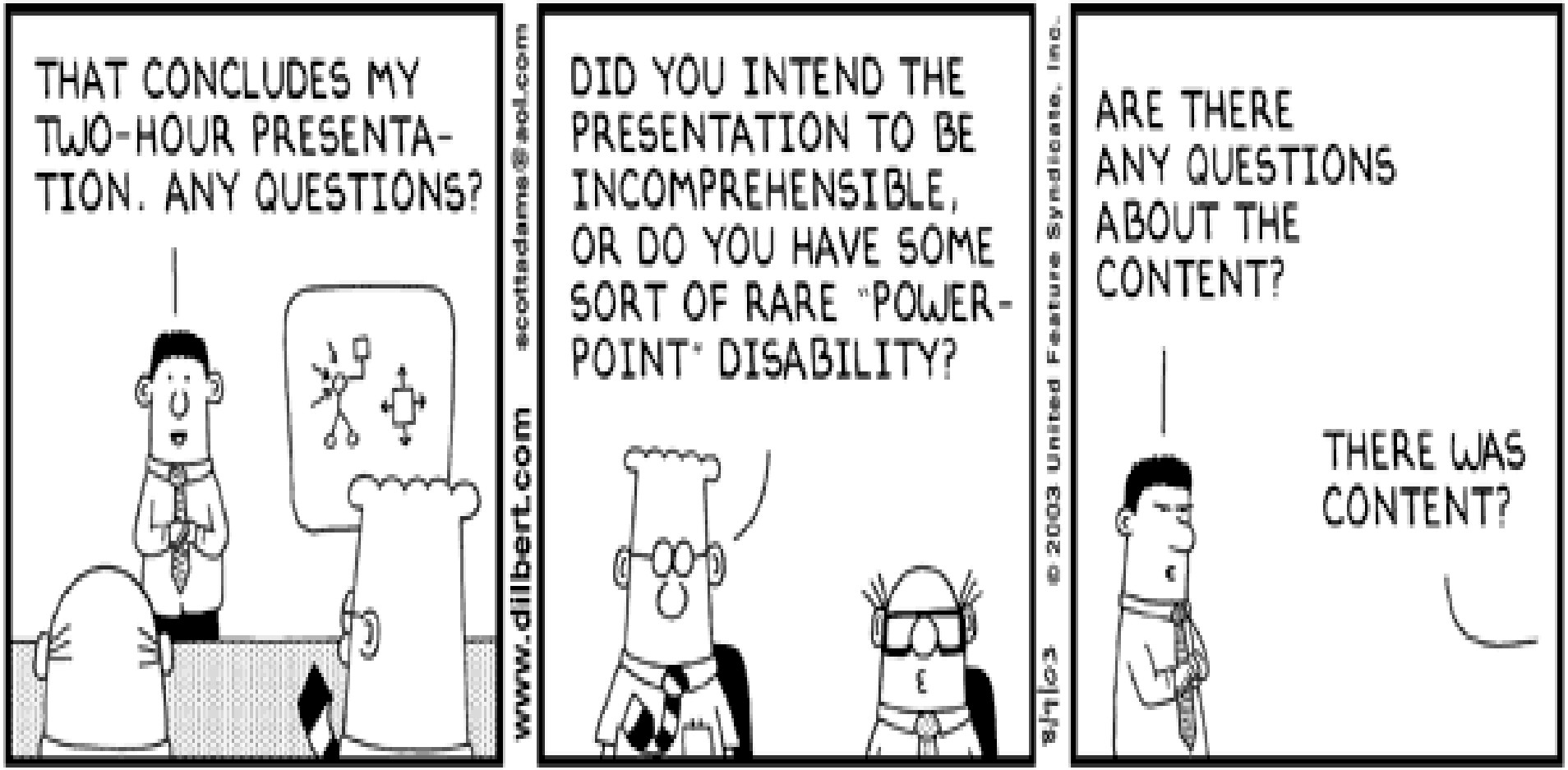
Internship





Topics to be covered

- Should I even be using a PA catheter, and if so, in whom should I use them?
- How do I place a Swan-Ganz?
- What information do the numbers tell me?
- When can the numbers be misleading?
- What complications should I be aware of?

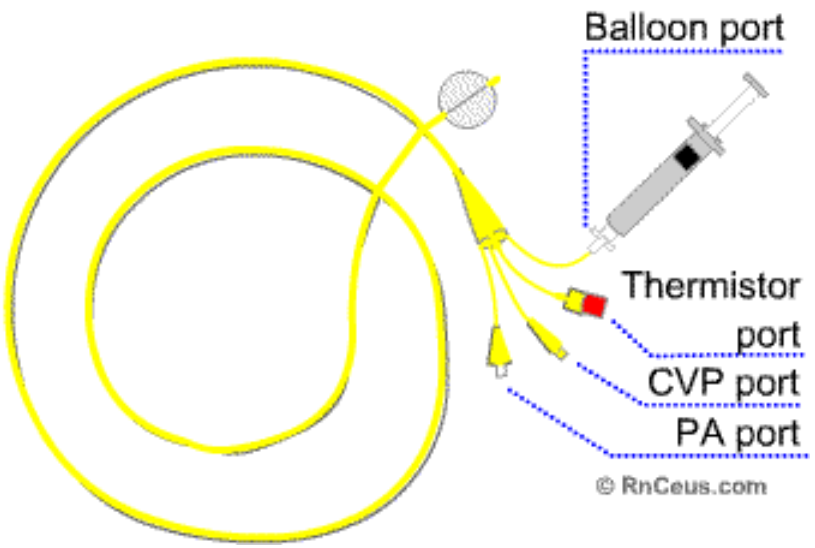
A Perspective

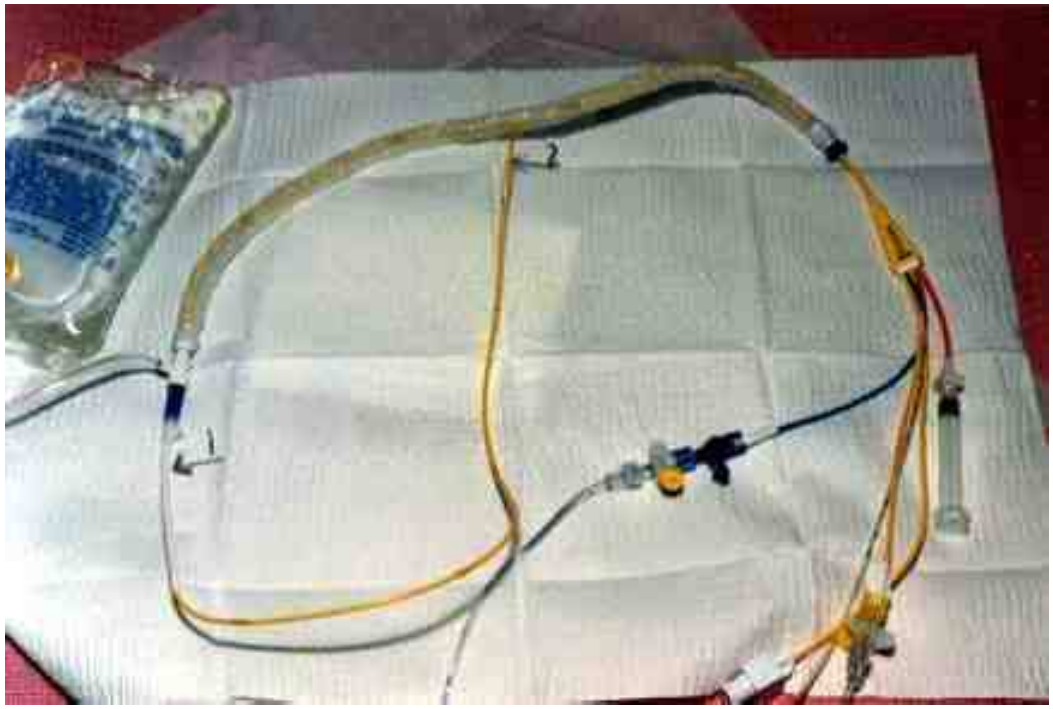
- 1930's Wiggers and Katz advocate application of physiological principles toward management of cardiovascular disease
- 1940-1950's Cardiac catheterization developed, applicable only in specialized labs
- 1960's ICU developed, critical care emerges
- 1970 Balloon tipped "flow directed" catheter approach used for right heart catheterization

The Swan-Ganz Cathether

AKA Right Heart Catheter

AKA Pulmonary Artery Catheter





http://www.rnceus.com/hemo/pacath.htm

- 7.5 French (2.31 mm diameter)
- 110 cm Long
- Black rings at 10 cm intervals

Ports

- Distal
- Right Atrial (30 cm from tip)
- Venous infusion (31 cm from tip)
- Thermister Bead (5 cm from tip)

Information to be gained

- Cardiac output (thermodilution)
- Central temperature
- RA, PA, PCWP pressures
- Blood gas
- *Pacing
- *Continuous cardiac output

Should I use a PA catheter?

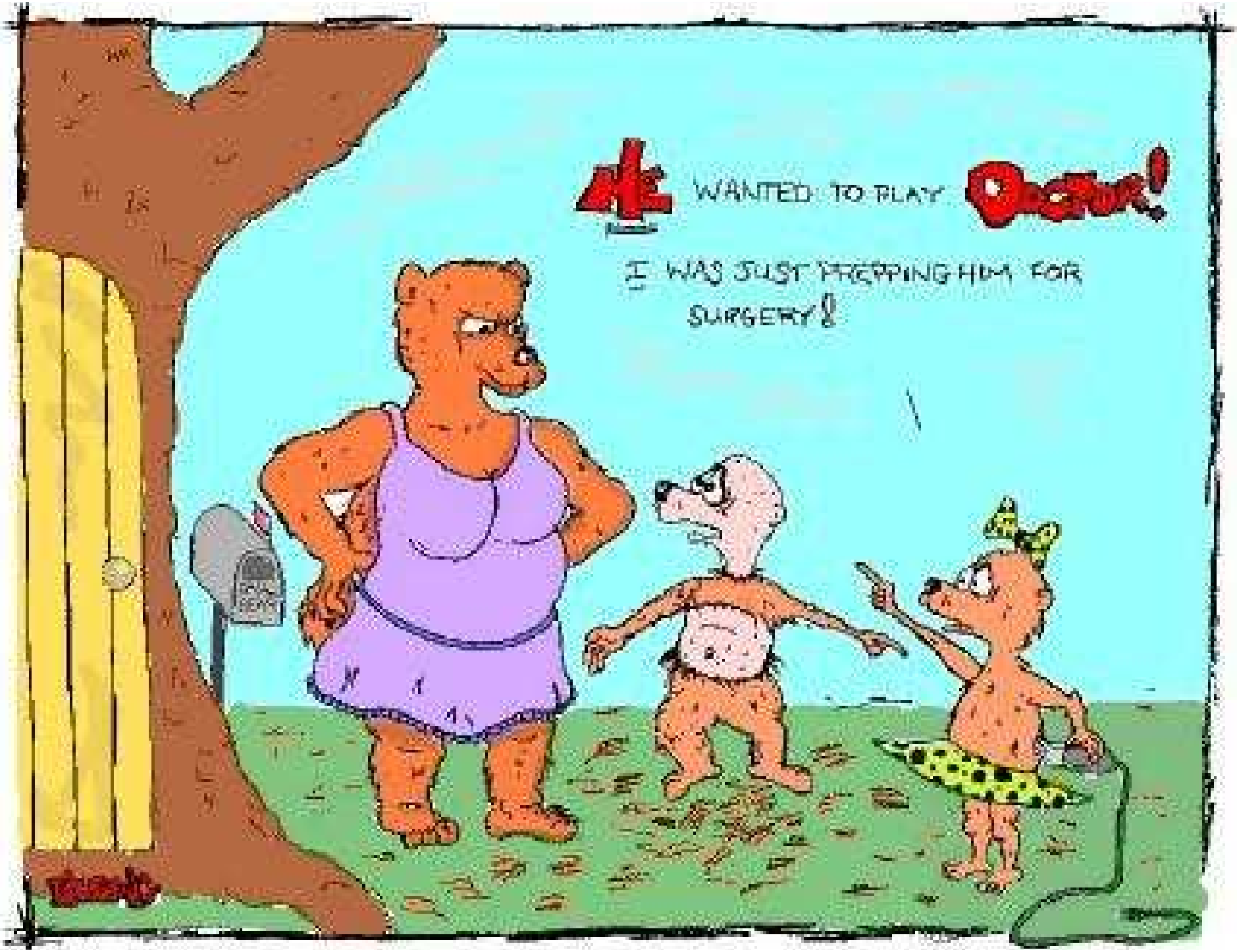
- In summary, studies have never demonstrated mortality benefit from the use of Swan-Ganz catheters
- Swan-Ganz use continues mainly due to criticisms of studies and perceived benefit in selected patients

Why are PA catheters used in the critical care setting?

- Aid in differentiating mechanism of shock
  - Sepsis
  - Cardiogenic
  - Hypovolemic
- Monitor fluid status
  - CHF
- Diagnose Other Cardiac Abnormalities
  - Tamponade
  - Valvular Regurgitation

Who is an appropriate candidate for a PA catheter?

- In general, use in critically ill patients when stability of their condition cannot be assessed by clinical indicators
  - Persistent hypotension despite adequate fluid resuscitation
  - Pulmonary edema not responding to diuresis
  - Pulmonary edema with hypotension or pulmonary hypertension
  - Respiratory failure with high PEEP settings


HE WANTED TO PLAY DOCTOR!
I WAS JUST PREPPING HIM FOR SURGERY!

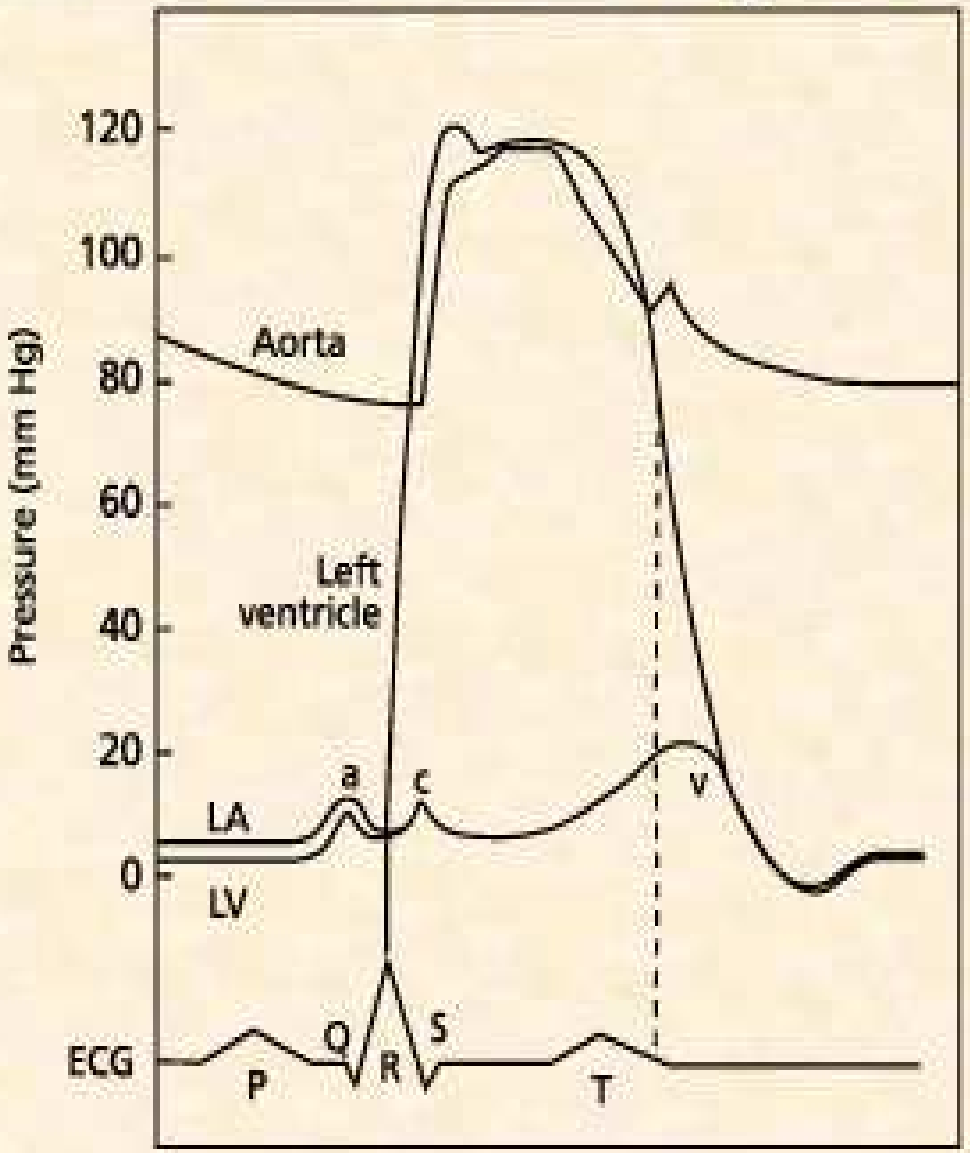
How do I place a PA Catheter?

- Acquire central venous access with an 8.5F introducer
  - Right IJ and Left Subclavian are preffered sites
  - Right Subclavian can be used
  - Left IJ is difficult without fluor
- Test balloon (1–1.5cc air)
- Flush all ports

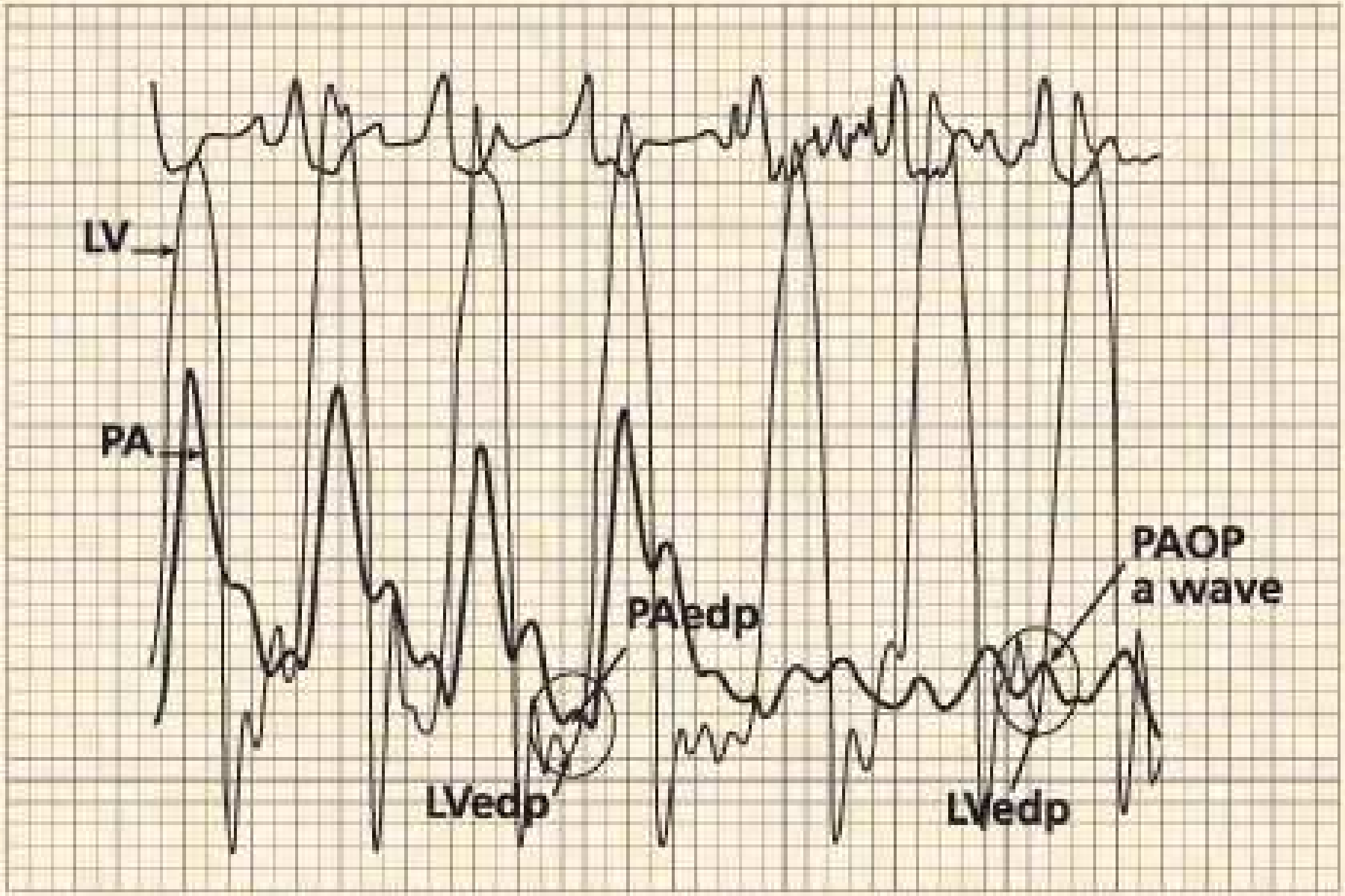
Placing a PA Catheter

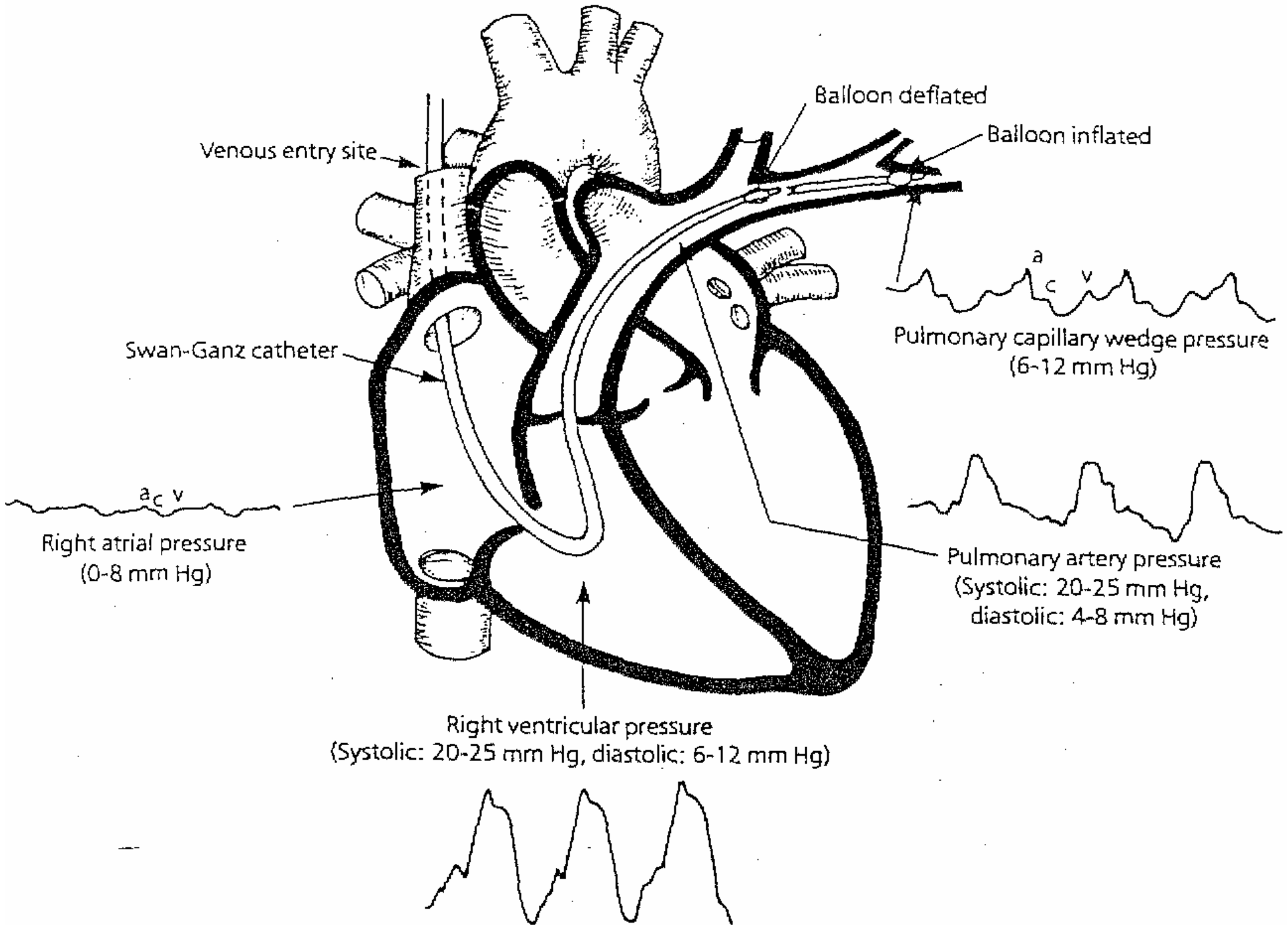
- Attach transducer
- Place protective sleeve over catheter
- Insert tip of catheter into the introducer
- Advance 15 cm, then call for “Balloon up”
  - Always advance with balloon up, withdraw with balloon down
- Watch waveforms
- In general, catheter will advance 45-55 cm

The Cardiac Cycle



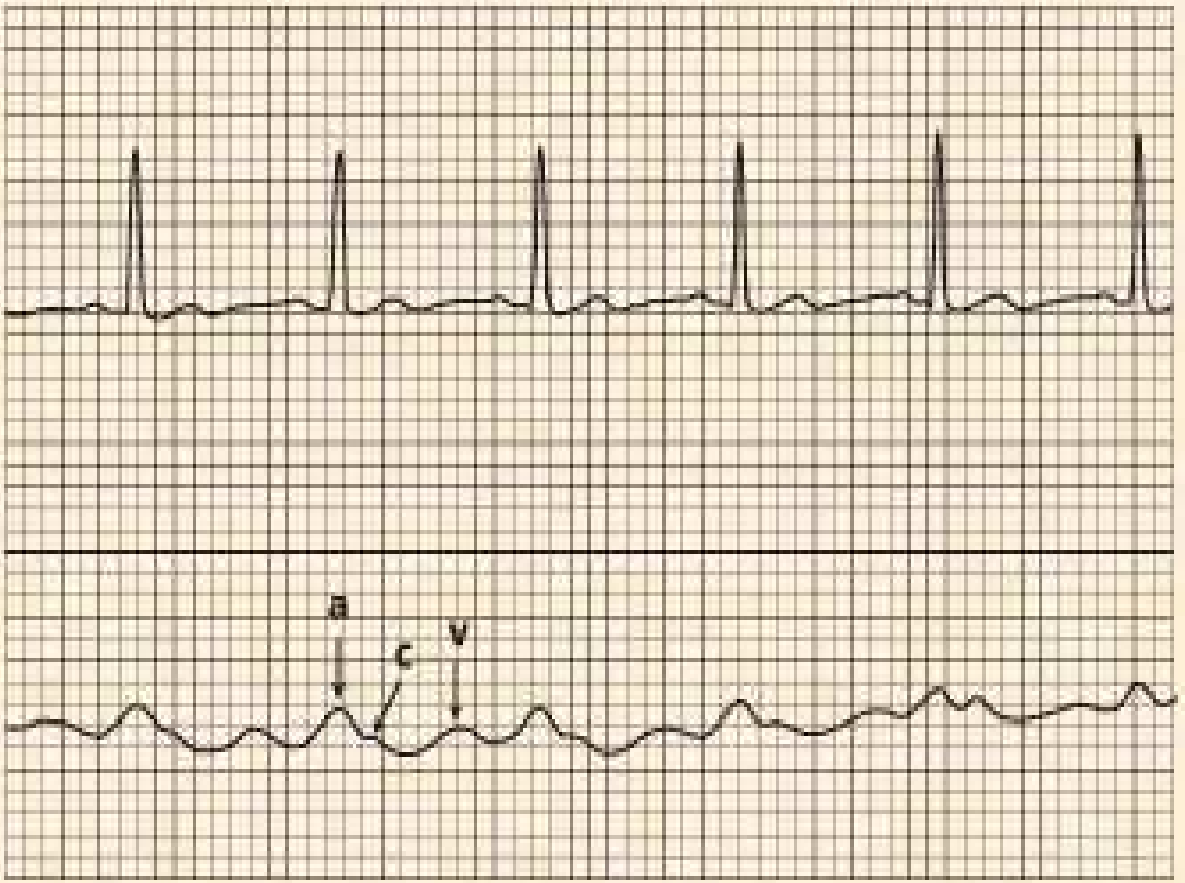
PAedp and PAOP ≈ LVedp



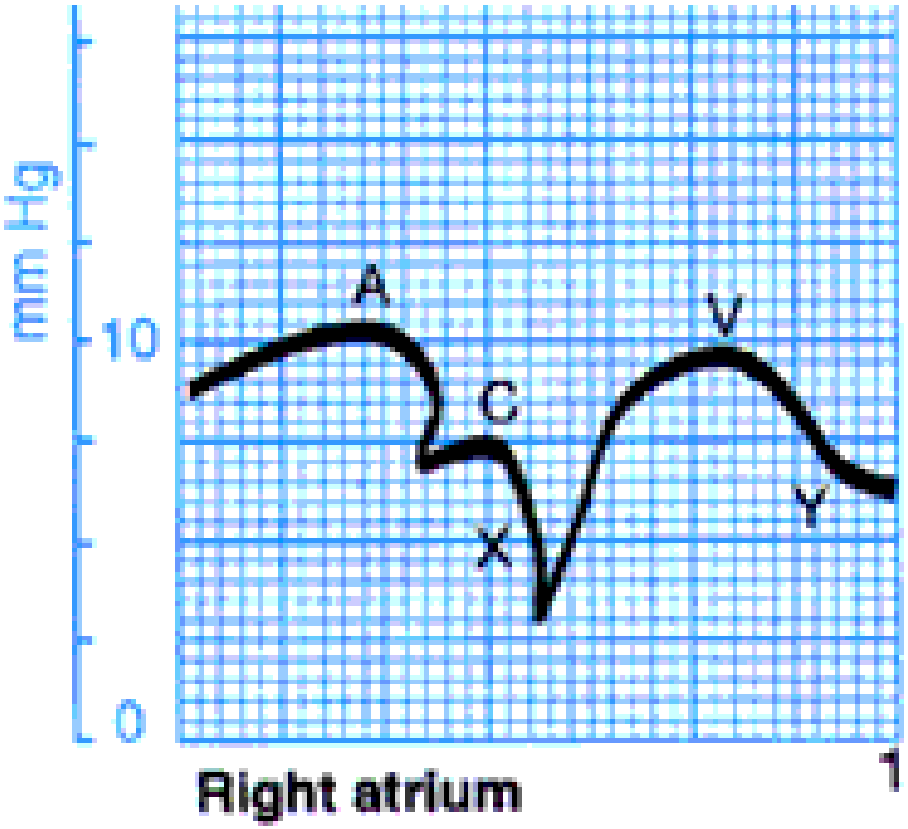

Balloon deflated
Balloon inflated
Venous entry site
a
c
v
Pulmonary capillary wedge pressure
(6-12 mm Hg)
Swan-Ganz catheter
a c v
Right atrial pressure
(0-8 mm Hg)
Pulmonary artery pressure
(Systolic: 20-25 mm Hg,
diastolic: 4-8 mm Hg)
Right ventricular pressure
(Systolic: 20-25 mm Hg, diastolic: 6-12 mm Hg)

CVP/RA Waveform

- *a* wave - occurs with atrial contraction
- *c* wave - occurs with closure of tricuspid valve
- *v* wave - due to blood filling the atrium when the tricuspid valve is closed



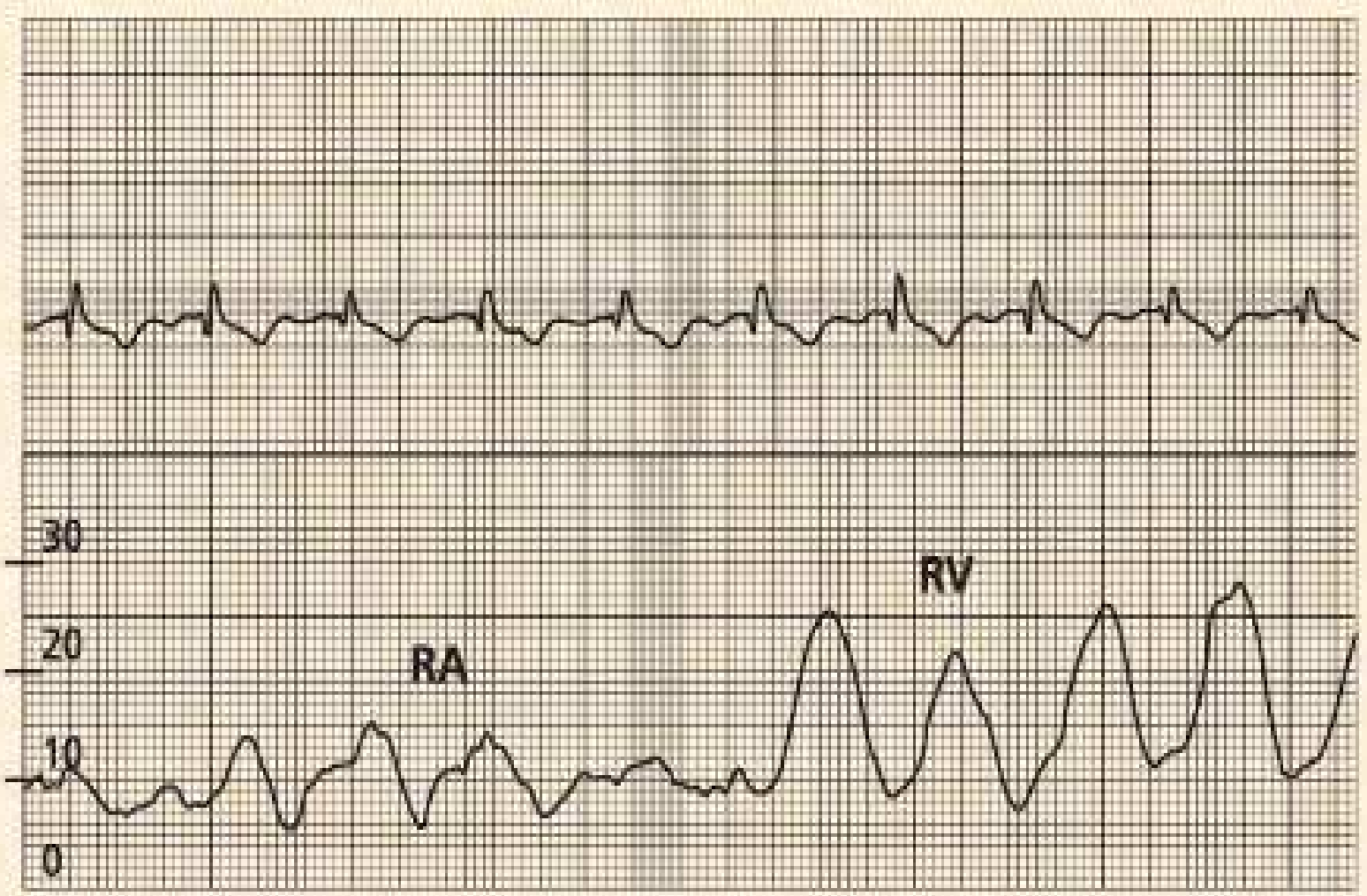
Right Atrial Waveform



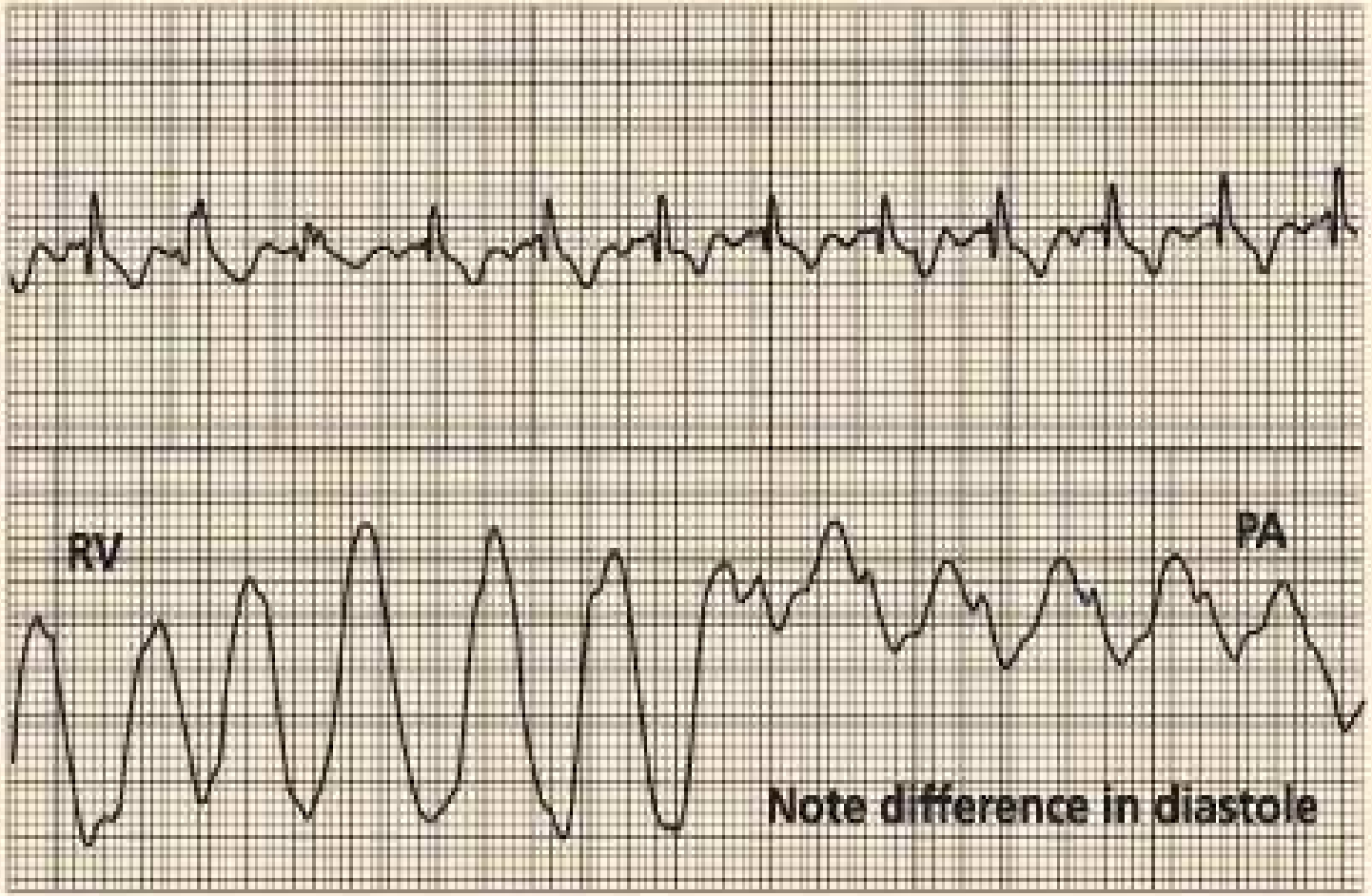
a wave - RA contraction
elevated in RV failure
c wave - tricuspid closure
v wave - passive filling of RA during ventricular systole = T wave on ECG
elevated in tricuspid regurgitation
x descent - atrial diastole
y descent - atrial emptying

http://www.staff.vu.edu.au/CriticalCare/Critical%20Care/lecture2_notes.htm

RV Waveform

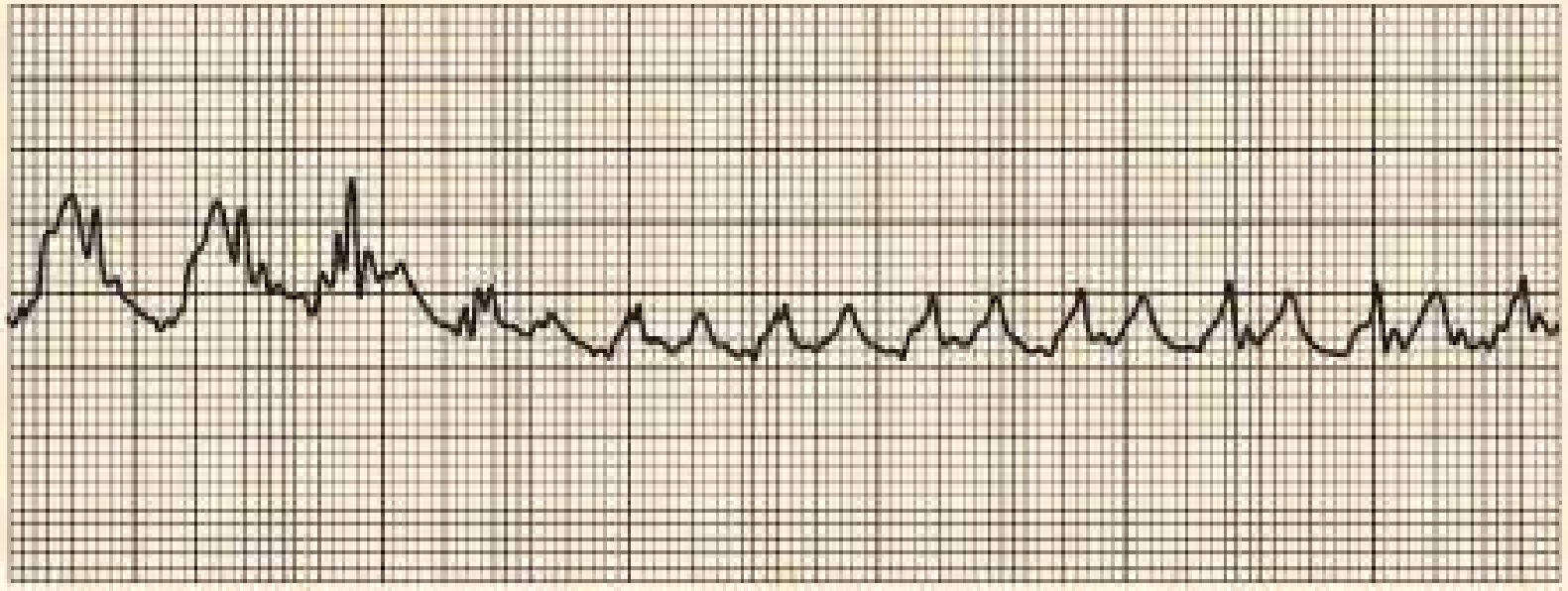


Changes in Waveform as Catheter Is Advanced From the RV to the PA



The PAOP Waveform

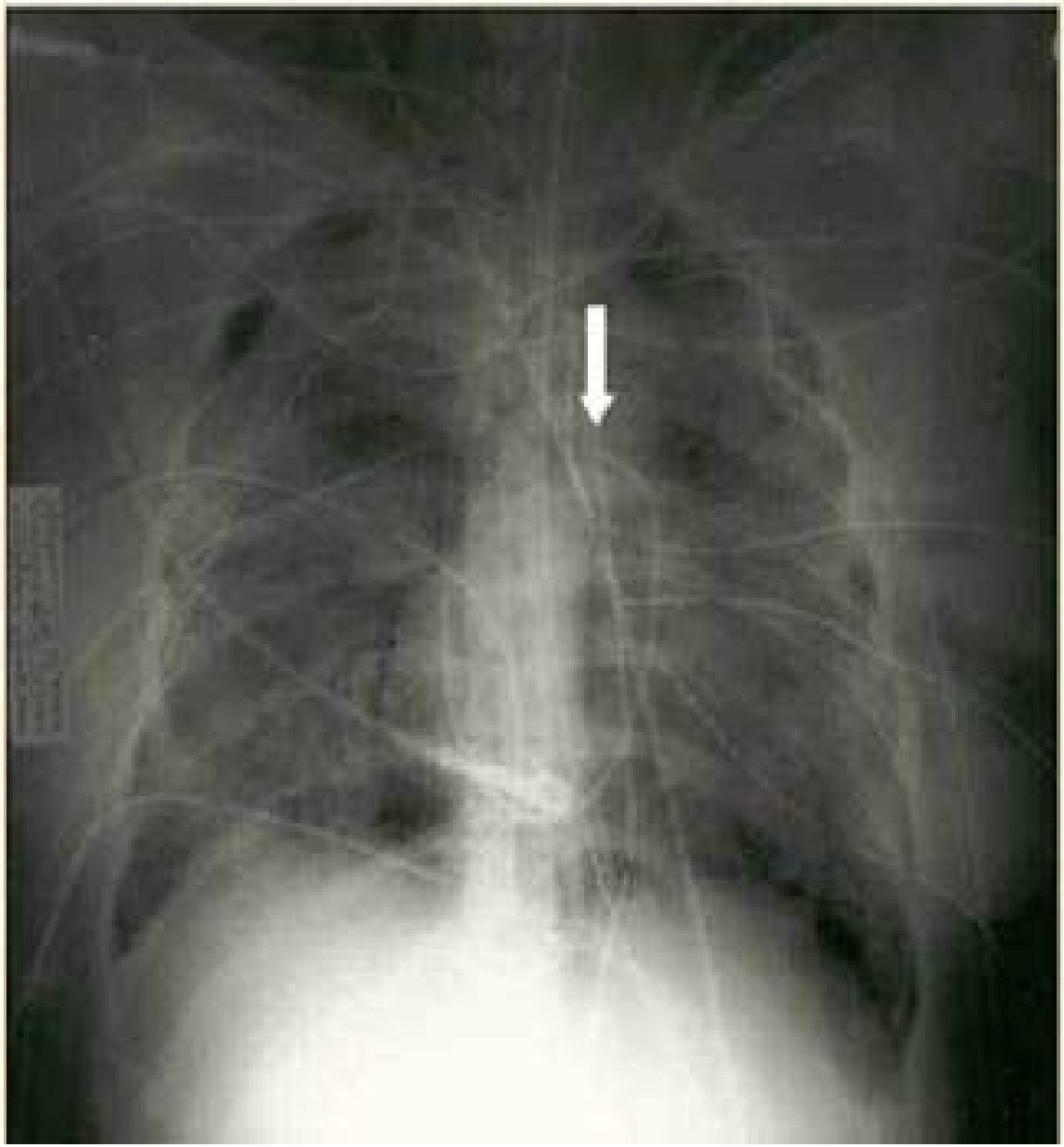
- Inflation of the balloon of the PAC stops measurement of the PA waveform
- The waveform changes to a PAOP waveform with *a* and *v* waves.
- The mean PAOP value is close to the PA diastolic value



Lung Zones

- Zone 1 – Upper lung
  - Essentially no capillary blood flow
- Zone 2 – Central lung
  - Alveolar pressure exceeds capillary pressure, wedging results in no flow
- *Zone 3 – Lower lung
  - PA and venous pressures exceed alveolar pressure; allows wedging

Correct PAC Position

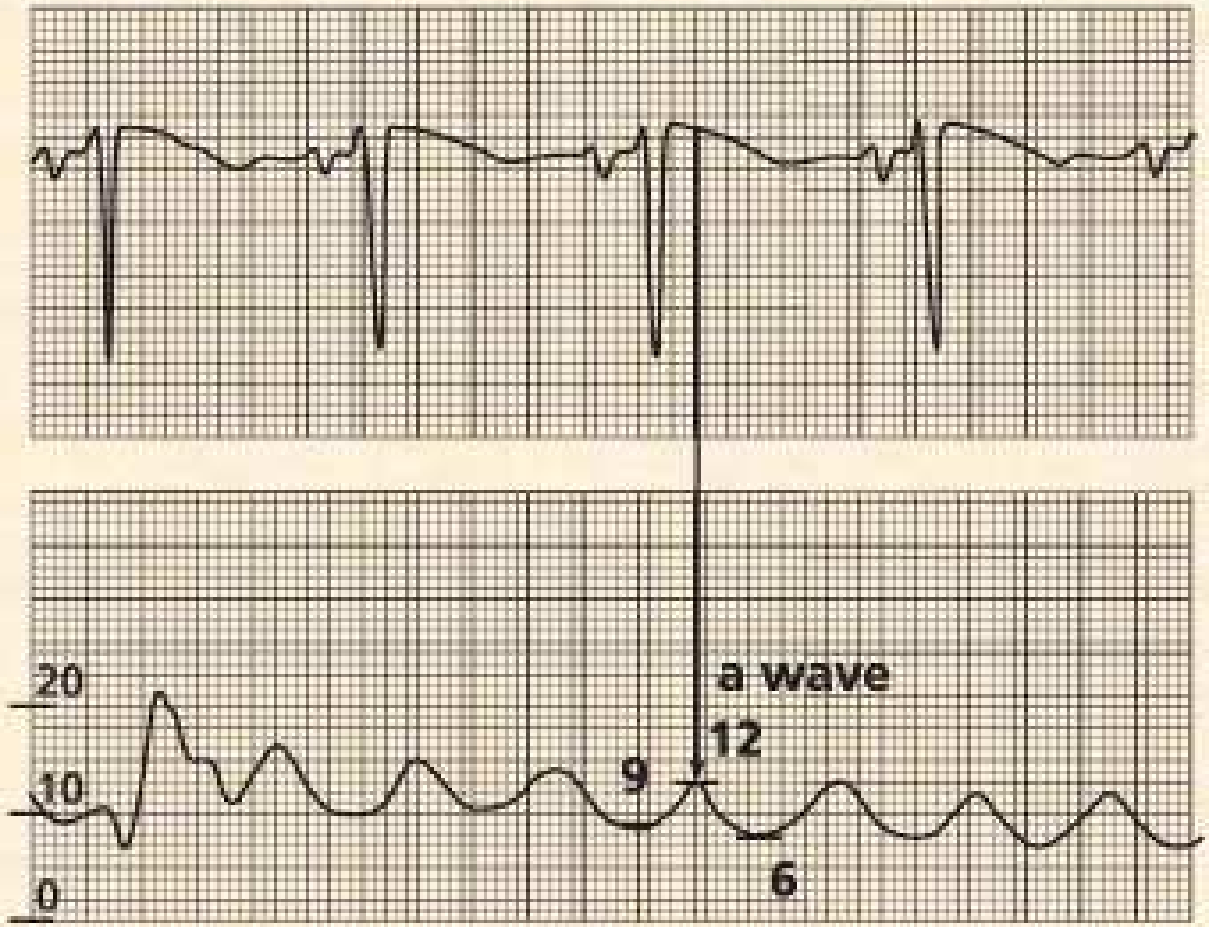


Distal PAC Position

Measuring the PCWP

To measure the mean PAOP value

- Locate the a wave near or after the QRS Complex
- Measure the top and bottom of the a wave values and average these values



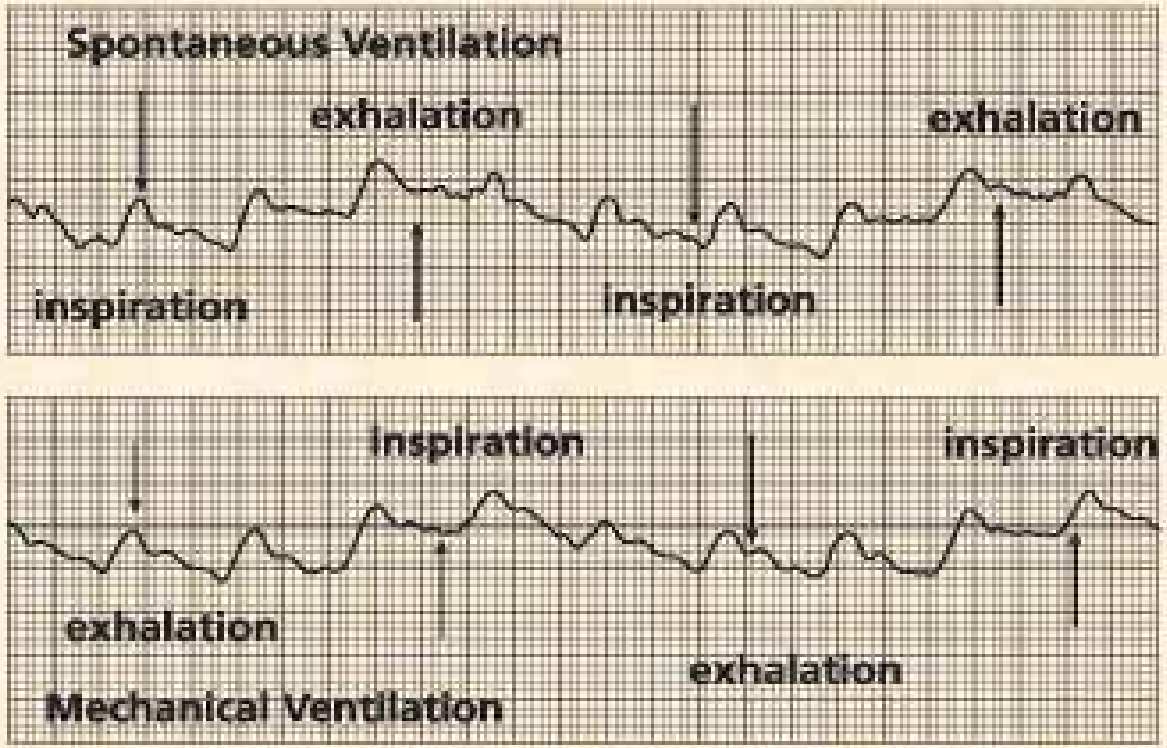
Answer

12+6/2= 9

PCWP and ventilation

Effects of Respiration on Waveforms

Spontaneous Ventilation

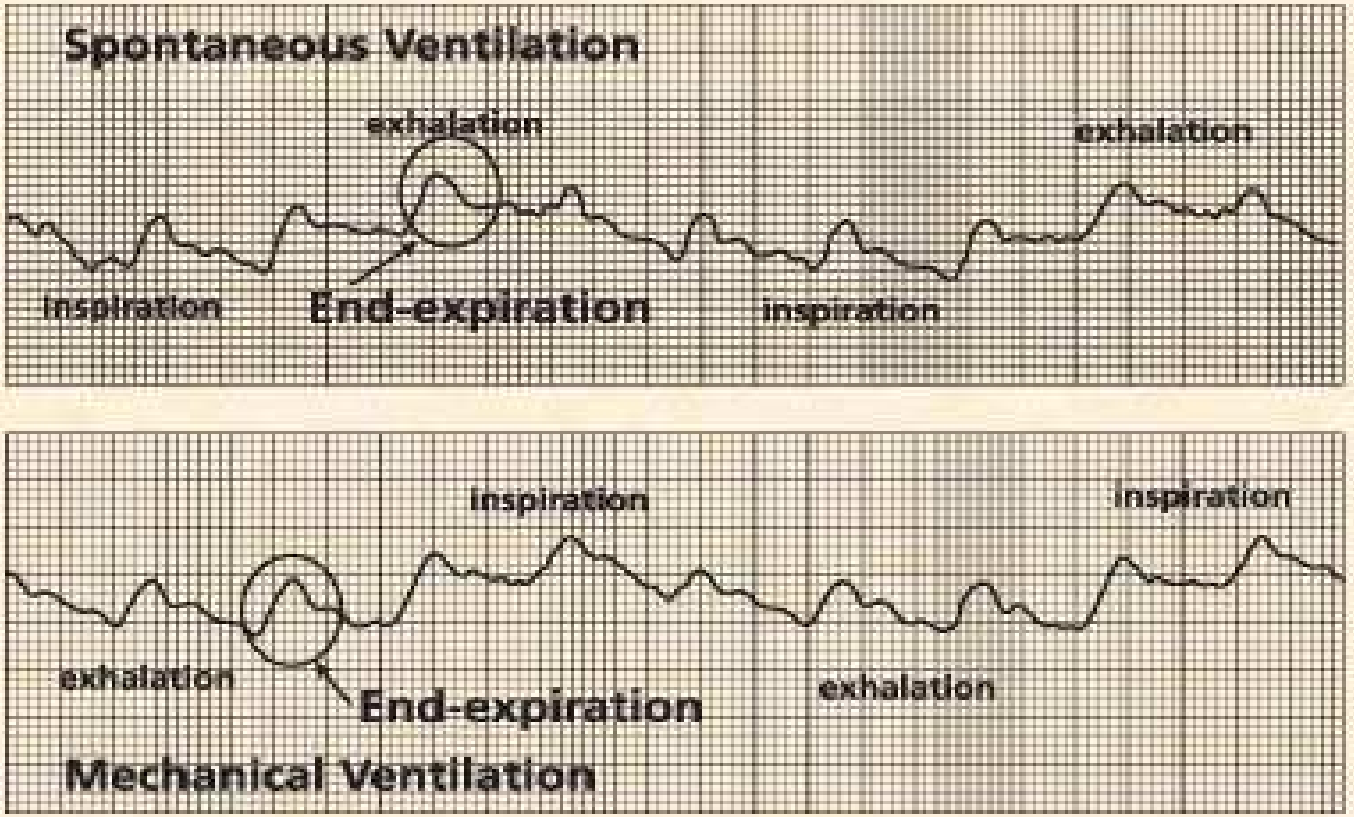


Always measure at end expiration

Spontaneous breathing is UP

Mechanical breathing is DOWN

End-Expiration



Interpretation of the numbers SvO_2 – often overlooked

- Measure of tissue oxygenation
- Less than 60% reflects poor oxygenation
  - Low Cardiac Index
    - Hypovolemia, LV failure
  - Low Hgb
    - Bleeding
  - Low SaO_2
    - Pulmonary Dysfunction
- High SvO_2 (>80%) seen in sepsis, cirrhosis, AV shunt
- Normal SvO2 with low CI reflects adequate tissue oxygenation

Stroke Volume/Index

- Fall in stroke volume maintain a normal CO/CI if heart rate increases
  - Cardiac Causes
    - CHF
    - MI
    - Tamponade
    - PE
  - Hypovolemia

CVP
Useful for Right Sided Assessment

- Reflection of RV filling pressure
- Low CVP
  - Hypovolemia (Bleeding, third spacing)
- High CVP
  - RV failure
  - Pulmonary hypertension
  - PE
  - Tamponade
  - Constrictive pericarditis

PCWP

The number everyone wants

- Reflects Left Ventricular filling pressure
- Low PCWP (<10-12)
  - Hypovolemia (Bleeding, third spacing)
  - RV failure
  - PE
- High PCWP (>18)
  - LV failure
  - Hypertension
  - Constrictive pericarditis

SVR

SVR and PVR

- Useful to assess afterload
- Low SVR (<960 dynes x sec x cm^{-5})
  - Sepsis
- High SVR (>1500 dynes x sec x cm^{-5})
  - LV failure
  - Hypovolemia
- High PVR (>250 dynes x sec x cm^{-5})
  - PE
  - Pulmonary Hypertension

Cardiac Output/Index

- Thermodilution technique
- High CI (>4.2 L/min/m^2)
  - Sepsis
- Low CI (<2.4)
  - LV/RV failure
  - Hypovolemic shock
  - PE
  - Tamponade

Tips with the numbers

- In absence of Swan, a CVP and mixed venous O_2 sat (SvO_2) can be very useful
- PAEDP should be the same as PCWP
  - Except when tachycardic or PVR is elevated
- Normal SvO_2 in the face of low CI may warrant just close followup
- Use clinical situation to guide therapies!

Common Clinical Patterns Shock

- Cardiogenic Shock
  - PCWP elevated, CI low, SVR elevated
- Hypovolemic Shock
  - PCWP low, CI low, SVR elevated
- Septic shock (early)
  - CI elevated, SVR low, PVR elevated

Common Clinical Patterns

- RV failure
  - CVP elevated, CVP ≥ PCWP, CI low
- Tricuspid Regurgitation
  - CVP elevated, RVEDP elevated
- Acute Mitral Regurgitation
  - Elevated PCWP, prominent *v* waves
- Acute Ventricular Septal Defect
  - Oxygen step-up from RA to RV, RV to PA

Common Clinical Patterns Pulmonary

- Acute Pulmonary Embolism
  - CO low, PA high, PVR high, PCWP normal
- Chronic Pulmonary Hypertension (precapillary)
  - CVP high, RV Systolic high, PA high, PVR high, PCWP normal

Common Clinical Patterns Uncommon Things

- Cardiac Tamponade
  - CVP = PCWP (“Equalization of Pressures)
  - PCWP/CVP elevated, CI low
- Constrictive/Restrictive Pericarditis
  - CVP elevated, PCWP elevated
  - Diastolic pressures equal

When can the numbers be misleading?

- Tricuspid Stenosis
  - Elevates CVP
- Tricuspid Regurgitation
  - Elevates CVP
  - Lowers CO/CI

When can the numbers be misleading?

- Mitral Regurgitation
  - Elevated LA and PCWP pressures
  - Accentuated *v* waves similar to PA systolic
    - *V* wave occurs during T wave, simultaneous EKG may be helpful
- Mitral Stenosis
  - PCWP will be artificially elevated
- Mechanical Ventilation
  - Measure PCWP at end-expiration

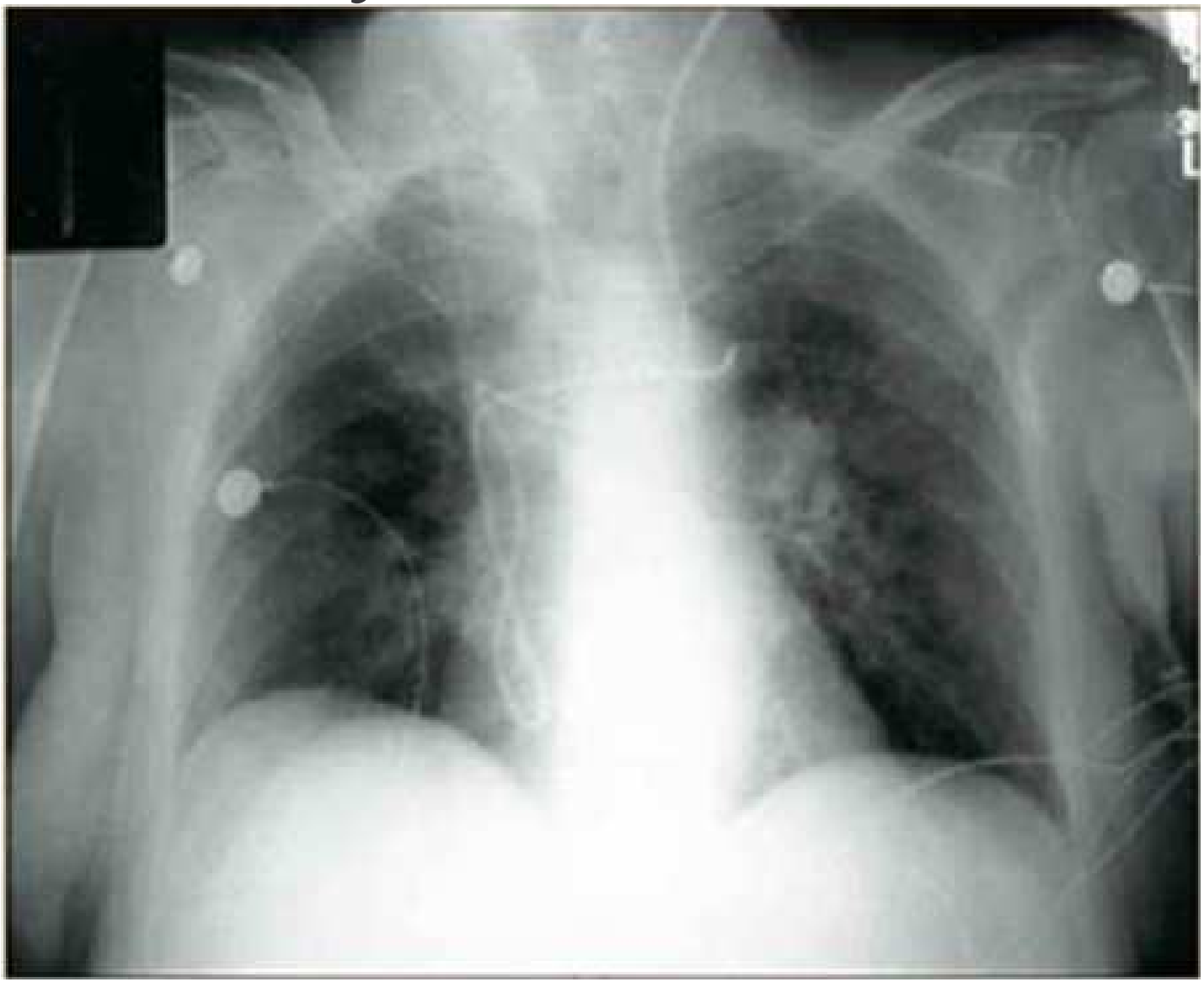
When can the numbers be misleading?

- "Overwedging" – occurs when tip is distal to optimal position, high PCWP
  - Can occur with tip migration
  - Resistance noted with inflation of balloon
  - Pull back catheter in ½-1 cm increments

Difficulties

- Catheter wedges in RV papillary muscles
  - No difference in ‘wedged’ and unwedged tracings
- Catheter ‘fails to wedge’
  - Mitral regurgitation?
  - Loop in RV?
  - Try refloating Swan

Difficulty – Coiled Catheter



Complications of Insertion

- Arterial Puncture
  - Use anatomic landmarks, proper technique
- Pneumothorax/Hemothorax
  - Dx by chest xray, treat with chest tube
- Air Embolism
  - Acute respiratory distress, cyanosis
  - Mill Wheel murmur
  - Left lateral decubitus, 100% FiO_2

Ventricular Arrythmia

- Most are transient during insertion
- Keep balloon inflated, keep advancing!
- If sustained, deflate balloon and remove catheter
- Defibrillate if VF/Pulseless VT

Heart Block

- Do not place PA catheter in a patient with Left Bundle Branch Block unless you have backup pacing!
- Insertion can cause transient RBBB which would become complete heart block

Catheter loops and knots

- Avoid advancing catheter against resistance or if waveforms are not as expected
  - At 30 cm should see RV
- Do not allow loops to remain in RV
- If knot develops, use fluoroscopy for guidance

Complications during use

- Pulmonary Artery Rupture
- Pulmonary Infarction
  - High pressure wedging
  - Keep inflation duration <15 seconds
- Infection
- Ventricular Arrythmias
- **Remove PA catheter when information is no longer useful!**

References

- http://www.pacep.org
- Amin DK, Shah PK, Swan HJC. The Swan-Ganz Catheter. J Crit Illness 1(4):24-45 and 1(5):40-61, 1986)