

Pulmonary Artery Catheter Helpful Hints 2017

Swan Ganz Catheter

1) Gather Equipment

Hint1: **Introducer** is the actual catheter [Cordis is a brand name: at GW we use **Arrow** brand]

Hint 2: **9 Fr** Introducer for Swan Placement & Rapid Infusion [**6 Fr** Introducer for Transvenous Pacer]

9 Fr Introducer

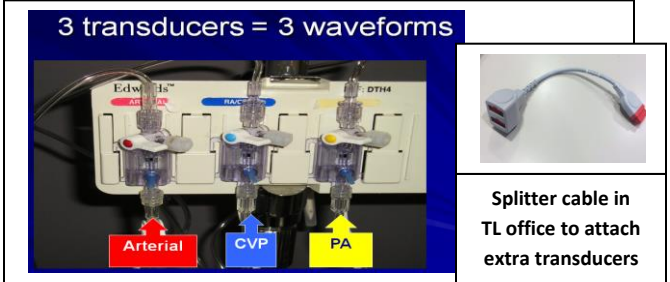
[ARROWgard Blue PSI Kit]



7.5 Swan Ganz VIP



Pressure Tubing Setup



Transducer tubing

Preferable: Bifurcated tubing with 2 transducers
Trifurcated tubing with 3 transducers

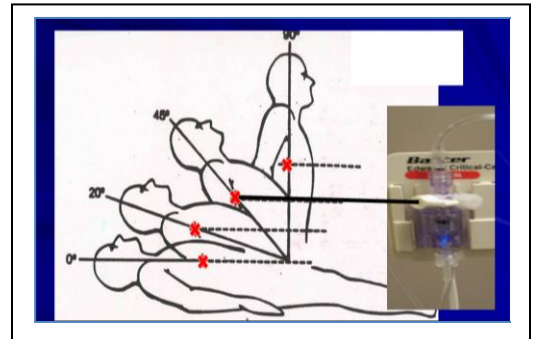
PA & CVP waveforms both display on monitor unless the proximal port is needed for fluid / medication administration.

2) Describe introducer insertion technique

- Hand Hygiene
- Maximal Barrier Precautions [Full body sterile drape / Cap / Mask / Sterile Gown & Gloves]
- Chlorhexidine 30 sec back & forth scrub Dry time 2 minutes
- Optimal Catheter Site Selection [avoid femoral lines]
- Place patient in Trendelenberg for introducer insertion
- Aspirate blood from side port & flush with NS

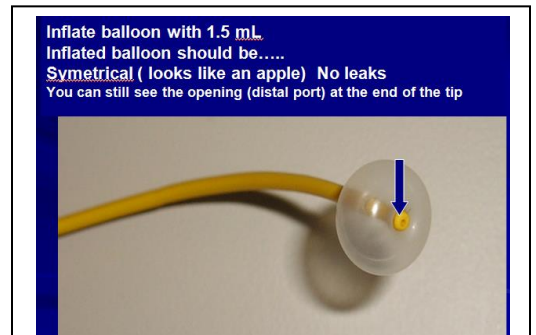
3) Set up pressure bag / transducer

- 500mL Saline / Burp the bag free of air
- Prime /flush tubing and ports
- 300mmHg Pressure Bag
- Level transducer zero port to phlebostatic axis: level to right atrium
 - 4th intercostal space Mid Anterior / Posterior chest
 - Re-level with each position change for accuracy
- Zero transducer to atmospheric pressure



4) Demonstrate Actions prior to Catheter Insertion

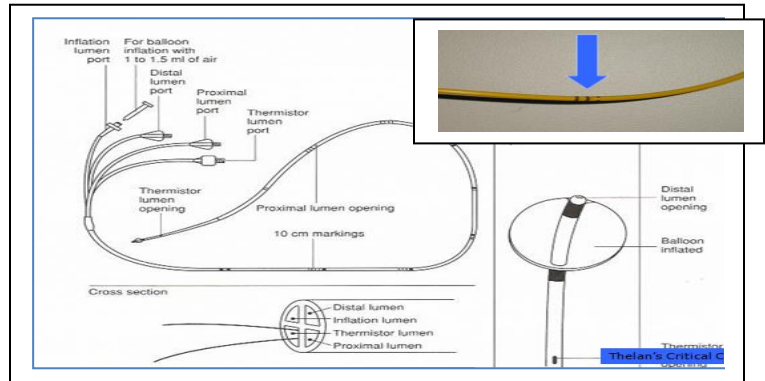
- 1) Place **Steri sleeve** over catheter [by MD]
Hint: place sleeve before checking balloon to avoid damage
- 2) **Inflate balloon once with 1.5 mL air**
Hint: NEVER use saline / water: prevents balloon deflation
Check balloon for leaks and uniformity
- 3) **Connect Transducer / Pressure tubing to catheter**
PA distal [yellow port]
CVP Proximal [blue port]
- 4) **Prime / Flush all ports**
PA distal [yellow port] Fluid will exit at end of catheter
CVP Proximal [blue port] Fluid will exit below 30cm mark
VIP [Venous Infusion Port] [White port] with 10 mL NS syringe
Fluid will exit above 30cm mark
- 5) **Shake** the catheter tip: assess for sharpness of waveform
If waveforms appear damped: keep flushing & shake again



**Disconnect & deflate balloon before & after each use.
Never lock syringe with balloon inflated**

- 5) Identify the markings on the Catheter
 This will identify the depth of catheter
 Each little line = 10 cm
 Each large line = 50 cm

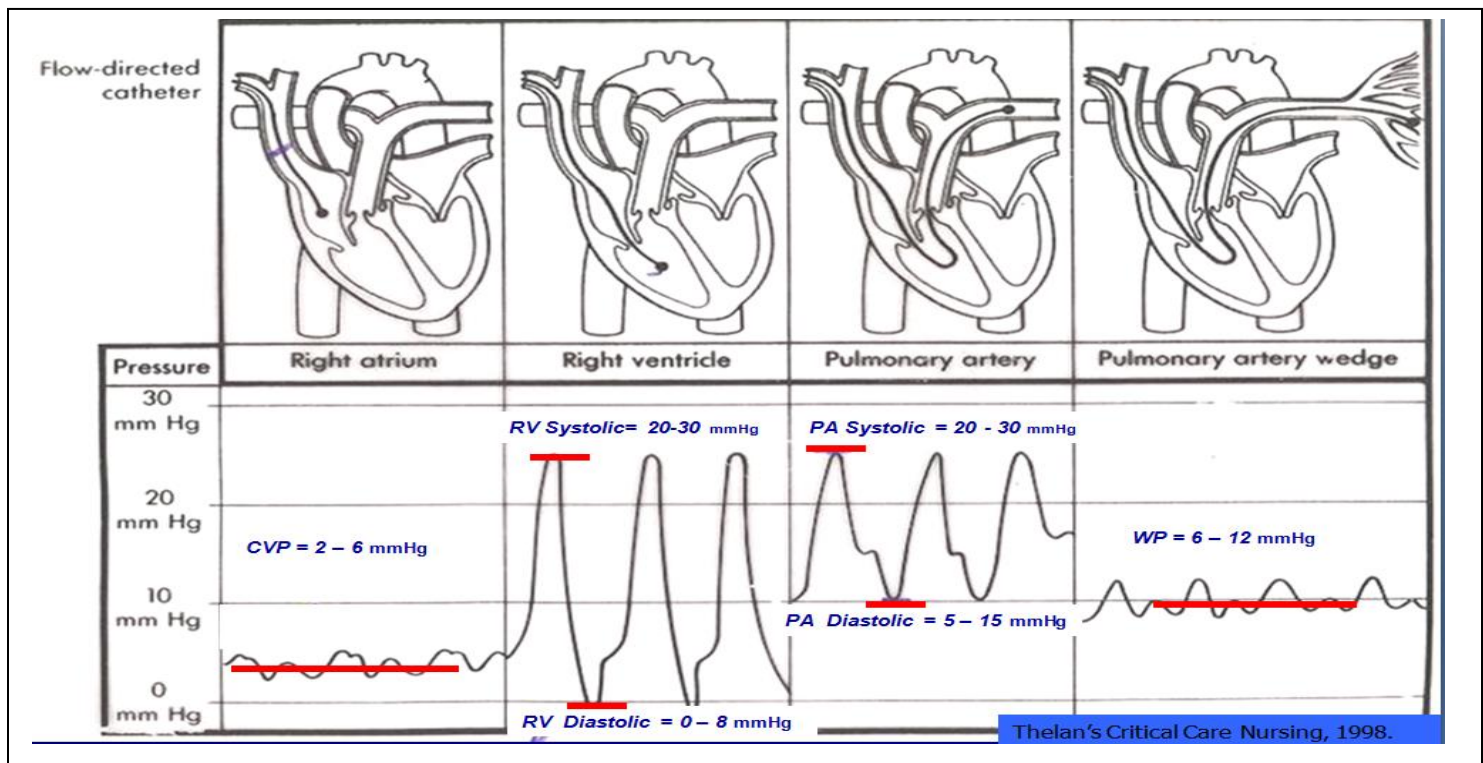
PA distal [yellow port] tip of catheter
CVP Proximal [blue port] below 30cm mark
VIP Port [White port] above 30 cm mark



- 6) Identify Insertion / position technique

- Select PA scales on the GE monitor during insertion to see larger waveform
- MD will insert PA catheter into the introducer to 20 cm mark and Instruct you to inflate the balloon
- **Balloon is INFLATED while advancing [floating forward]**
- **Balloon is DEFLATED while withdrawing [pulling back]**

- 7) Trace the catheter through the heart: Identify waveforms and values on insertion



Hint 1: The balloon will remain inflated during insertion until the WP [wedge waveform is seen] then deflate the balloon to ensure it rests in the Pulmonary Artery: [PAS / PAD waveform]

Re-inflate balloon again to make sure the WP waveform is obtained with 1.5 mL air

Hint 2: While the catheter is passing through the Right Ventricle; PVCs can occur.

Notify MD immediately if they are not in a position to see the waveform.

Hint 3: Before & After every waveform reading: unlock and disconnect balloon syringe: this will release air and prevent balloon rupture from over distention.

Hint 3: Do not lock syringe with balloon inflated: potential for occlusion & pulm infarct

Hint 4: Once catheter is in place: the balloon should never be inflated for more than 15 secs

Hint 5: PA catheters will soften inside a warm body/vessel; this can cause the catheter to Wedge in the capillary without balloon inflation. The catheter must be repositioned



Red line not straight = locked



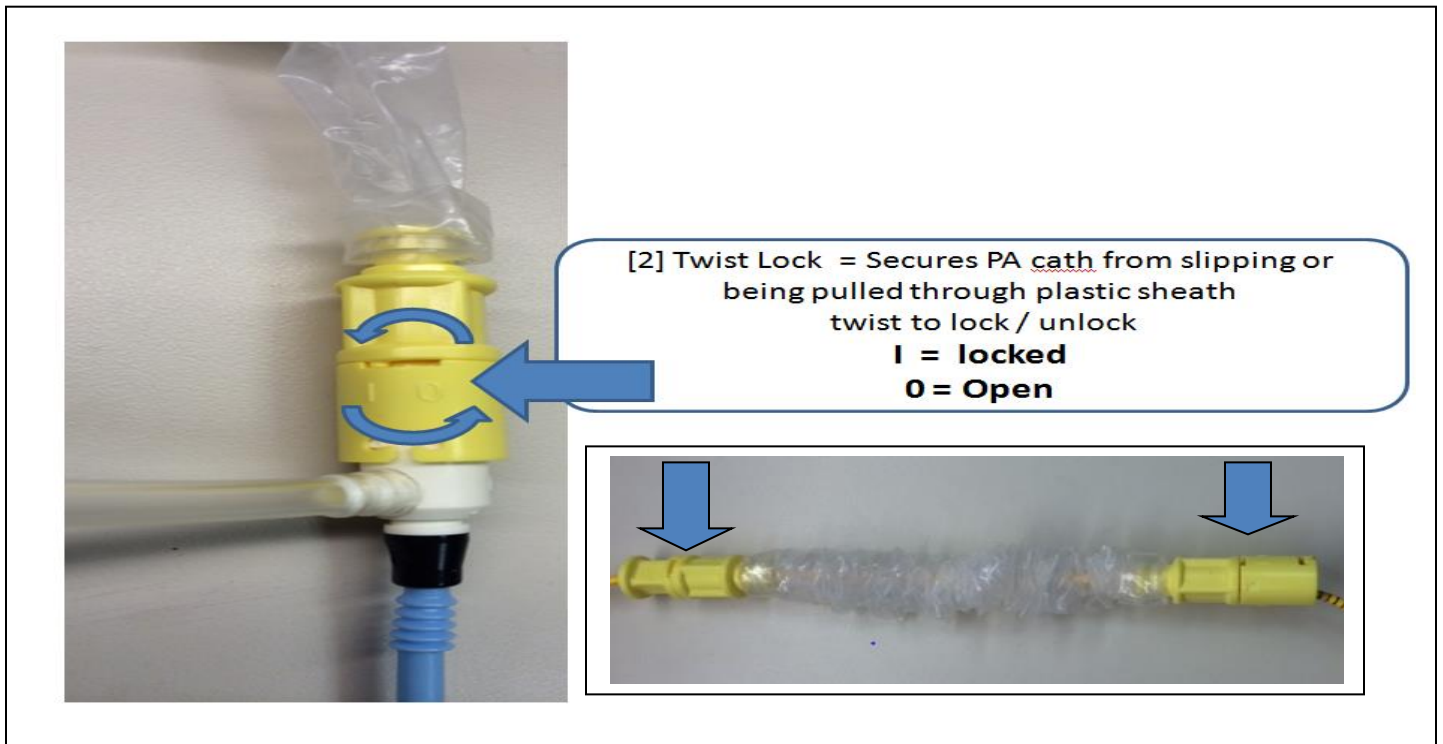
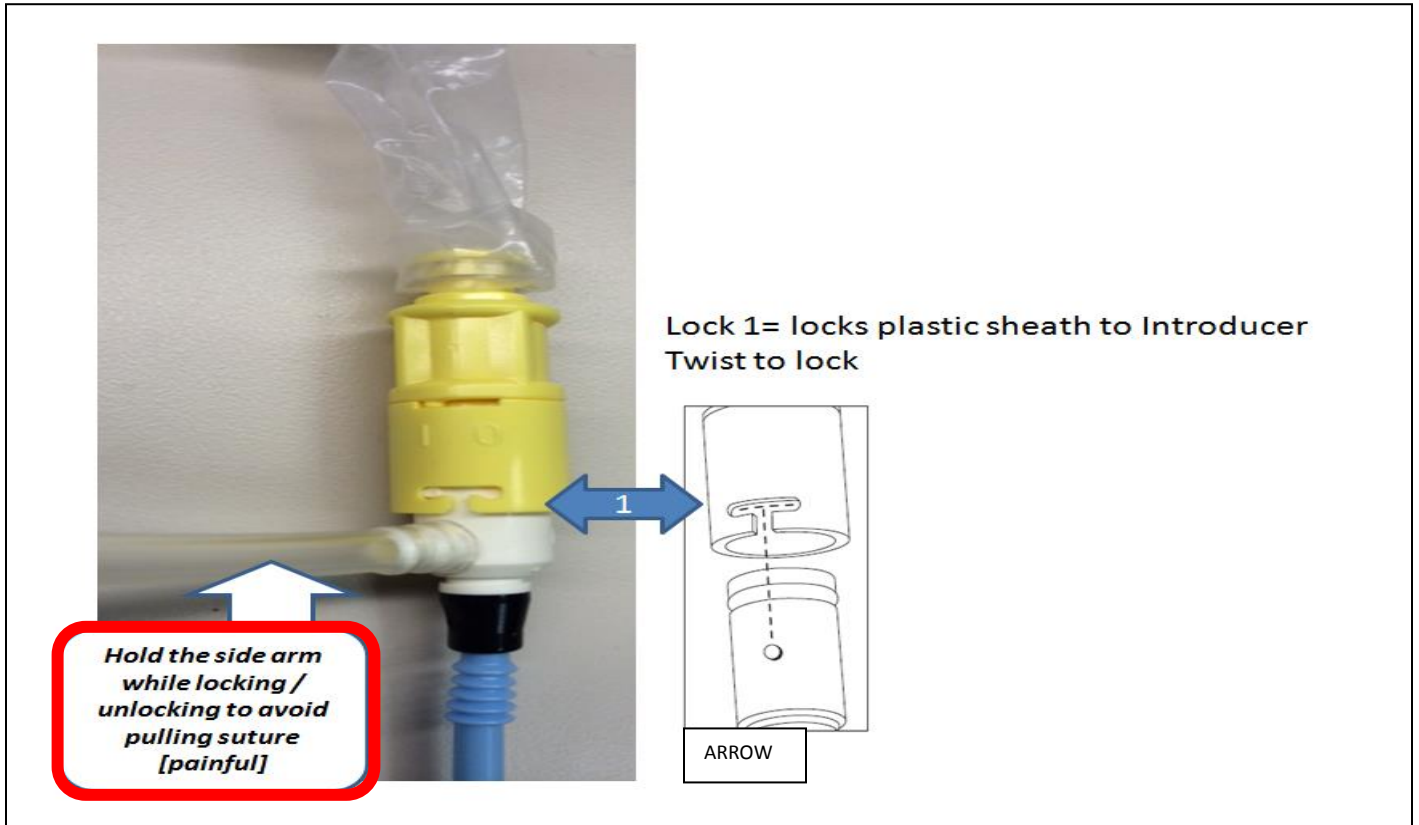
Red line straight = open / unlocked

**Disconnect & deflate balloon before & after each use.
 Never lock syringe with balloon inflated**

8) Demonstrate Plastic Sheath locking mechanism with Introducer and PA Catheter

When Swan is in correct placement in the pulmonary artery advance the plastic sheath over the catheter

- 1) Lock plastic sheath to introducer [twist to lock]
- 2) Lock distal and proximal ends of plastic sheath to PA catheter



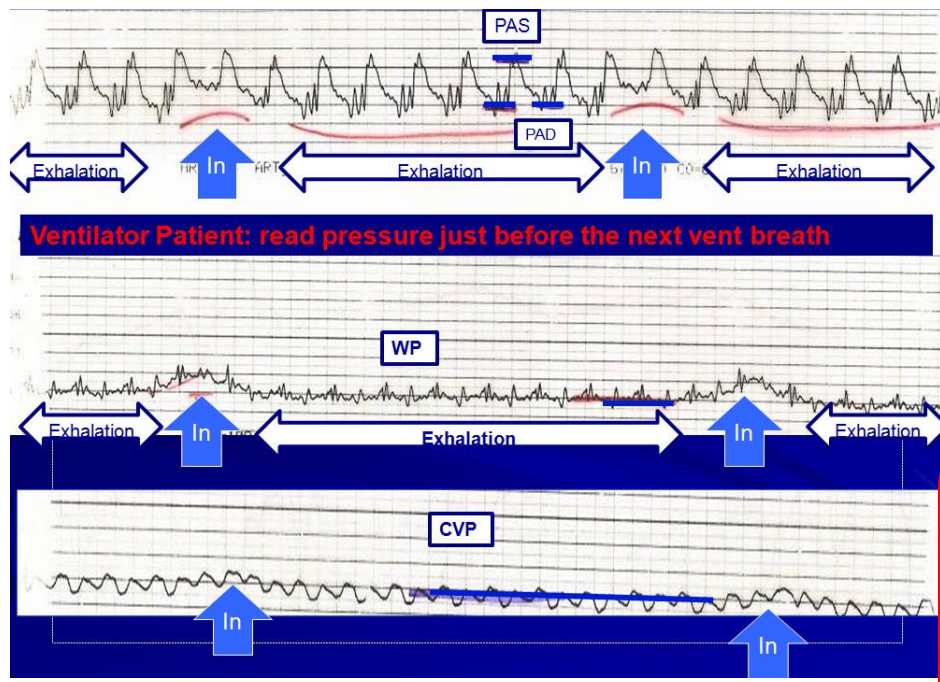
9) Obtain Waveform Readings [Zero & Level transducer]

Before reading waveforms: re-Level & re-Zero

READ ALL WAVEFORMS AT END EXHALATION

Ventilator Controlled Breath: Positive pressure ventilation pushes the thoracic pressure up during inspiration but exhalation is passive [neutral thoracic pressure]

Ventilator patients may pull a negative pressure spontaneous breath if they are air hungry. Always watch the real time waveform to determine end exhalation!

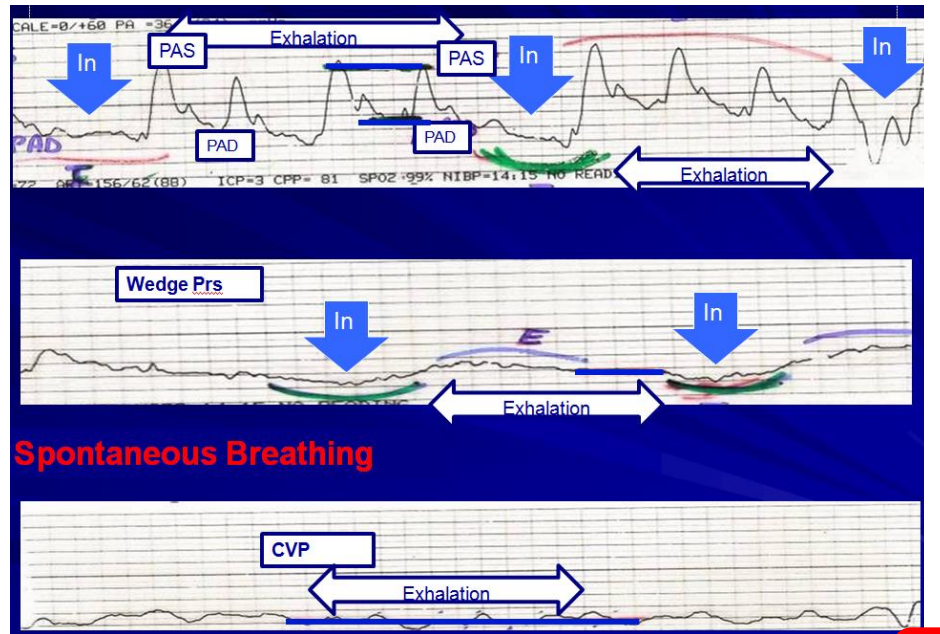


Ventilator Breaths:
 Pressure waveforms will go **UP** during inspiration & **DOWN** during exhalation.
 Read the waveform immediately before the ventilator breath is delivered

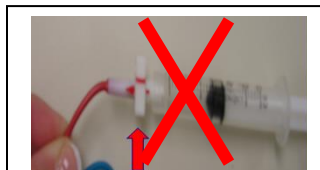
Inflate with 1.5mL: monitor waveform through several respiratory cycles then deflate
 Maximum inflation = 15 sec
 Disconnect syringe to release air after each WP reading
 Never lock inflated balloon

READ ALL WAVEFORMS AT END EXHALATION

Spontaneous Breath: Patient sucks in a **Negative pressure** to pull air into lungs: this pulls the waveform down during inspiration but exhalation is passive [~ neutral thoracic pressure]



Spontaneous Breaths:
 Pressure waveforms will go **DOWN** up during inspiration & **UP** during exhalation.
 Read the waveform immediately before the patient sucks in a negative breath



Never lock syringe with balloon inflated

10) Demonstrate Corrective Actions for the Following

A) Distinguish Dampened waveform vs possible permanent Wedge waveform

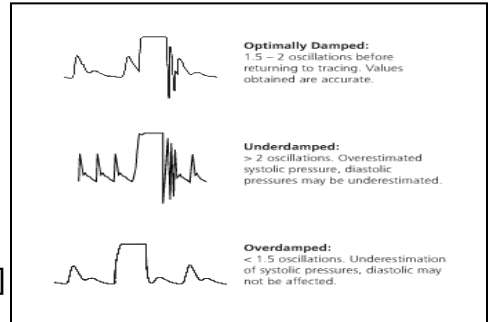
Scenario: Wedge Tracing seen on monitor

- **Unlock & Disconnect syringe to release air**
- If the wedge tracing is probable: Have MD withdraw/ reposition the catheter ASAP
- Have patient cough or rotate neck [may shift catheter out of capillary wedge]
- **NEVER fast flush a WP waveform** [300 mmHg pressure from pressure bag could rupture the pulmonary capillary [pressure normally 6 – 12 mmHg]

Never lock syringe with balloon inflated

Scenario: Dampened PA tracing

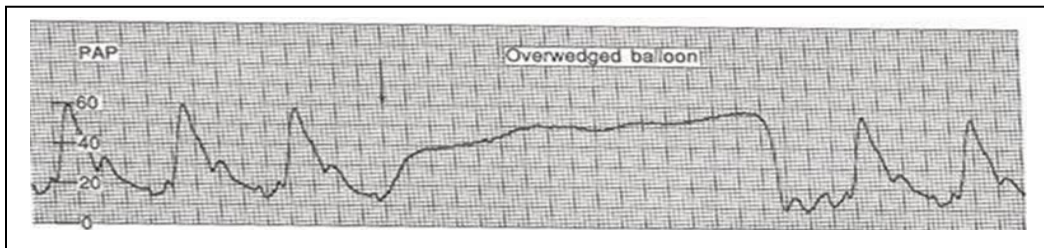
- Re-level & Rezero Check pressure bag = 300mmHg
- Check for air bubbles, clots, kinks
- Check the scale size on the GE monitor
- Fast Flush catheter / check square waveform
- **Hint:** after drawing a mixed venous blood gas: blood may settle in this very small lumen [keep flushing!]
- **Hint:** make sure you are not viewing the CVP waveform!



Edwards Life Sciences 2015

• Over Wedge [superwedge]

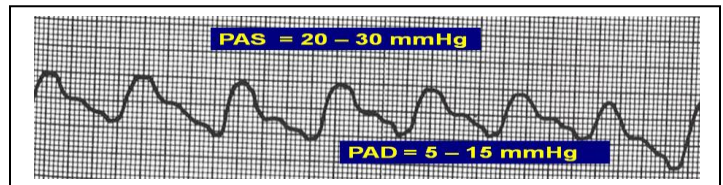
- Balloon should require the full 1.5mL in order to obtain a wedge WP tracing
- If wedge tracing is obtained using **LESS THAN 1.5 mL:** the **catheter is in too far** & too close to capillary **Have MD withdraw / reposition the catheter**
-



B) Distinguish between a catheter that needs to be advanced vs Ruptured balloon

Scenario1: Balloon inflated with 1.5 mL and PAS / PAD waveform still appears

- Release the balloon syringe: the pressure inside the pulmonary artery will deflate the balloon automatically. [i.e. air should come back into the syringe on its own]
- If balloon deflates: the syringe fills with air: **THE BALLOON IS INTACT**
- Check the depth of the catheter: is it still the same marking at the introducer site?
- Attempt to inflate again
- Have MD advance the catheter



Intact
Balloon

Scenario2: Balloon inflated with 1.5 mL and PAS / PAD waveform still appears

- Release balloon syringe: If the syringe does not fill with air: **Suspect Balloon Rupture**
- If there was no resistance to inflation: **Suspect Balloon Rupture**
- If blood pulls back into the syringe upon aspiration: **THE BALLOON HAS RUPTURED**
- THE PA CATHETER MUST BE REMOVED !**

Ruptured
Balloon

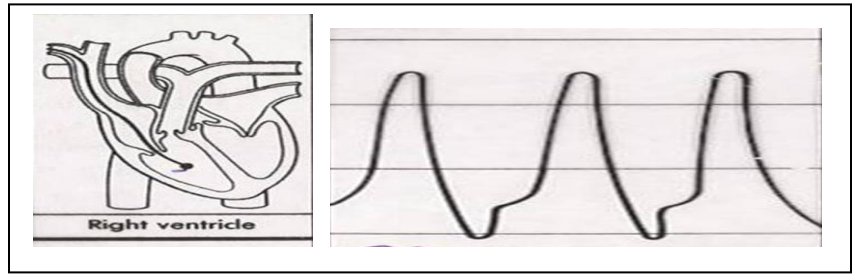
Do Not Leave PA catheter in place to "do the other readings"

A ruptured balloon lumen is full of air / potential for embolism [air or plastic]

Big potential for CLABSI

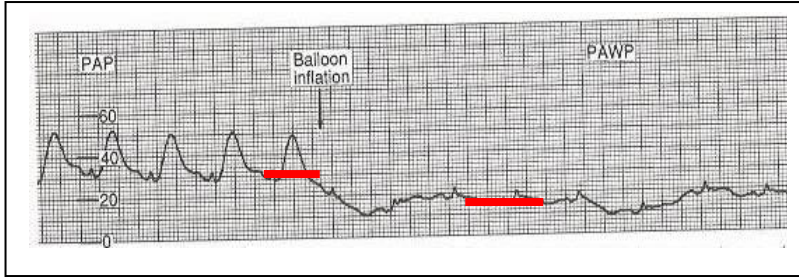
C) Right ventricular waveform

- Should only be seen during insertion
- Warning: PVCs / V Tach
- Inflate the balloon in attempt to float forward into the Pulmonary Artery
- Have MD reposition catheter



D) Recognize Pulmonary Hypertension

- PAD & WP are nearly equal with normal lungs and normal mitral valve
- [PAD 5 – 15 mmHg normally slightly higher than WP 6-12 mmHg]
- **Pulmonary HTN: PAD will be elevated WP will be lower / closer to normal**

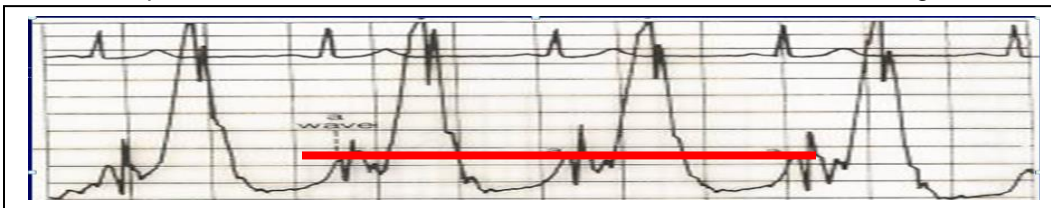


General rule of thumb:
High PAD with normal WP =
THINK PULMONARY etiology

High PAD with High WP =
THINK CARDIAC etiology

E) Recognize Mitral Valve Insufficiency / Regurgitation in the WP Waveform

- PAD & WP are nearly equal with normal lungs and normal mitral valve
- Mitral Insufficiency : During ventricular contraction blood will 'regurg' back toward the lungs causing the waveform to be elevated during ventricular contraction [Large V waves]
- Due to this phenomena the waveform should be read at end exhalation during atrial contraction {a wave}



11) Identify acceptable fluids / medications through the following lumens

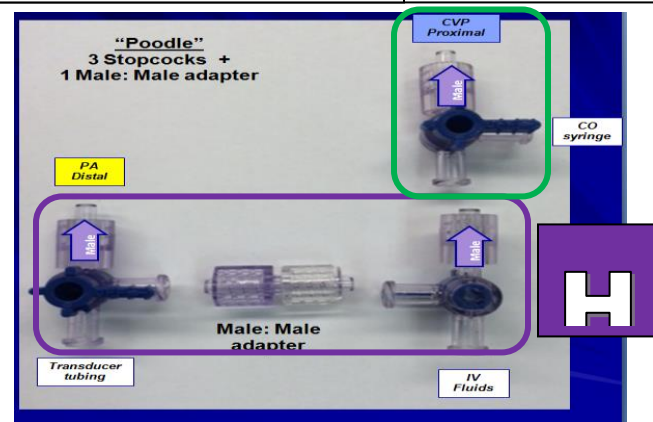
- **Side arm port of introducer:**
 - Continuous medication drips may be infused through the introducer
 - If no continuous med drips are infusing: infuse KVO 0.9% NS at 10mL / hr to prevent catheter occlusion.
- **Distal PA Port [yellow] :** Transducer with NS flush only **NO drips, meds or other fluids ever!**
- **Proximal CVP Port [blue]:** IV Fluids / IV piggybacks / IV push meds
 - **NO Continuous Medication Drips [No Vasoactive / NO Insulin / NO Heparin]**
 - Proximal CVP port will be used to obtain cardiac output readings with 10 mL D5W:
 - Accidental vasoactive or insulin bolus may be very detrimental to patient [DANGER]
- **Venous Infusion Port [white]**
 - Medication drips may be infused through the VIP
- **RV Pacer Port [orange port] rare:** 0.9% NS KVO preferred:
 - Medications in the lumen of the pacer port may be caustic to the pacer wire.
 - Use this port for medications with MD order ONLY

12) Setup and Obtain Cardiac Output [CO] Readings Thermodilution Method

- Equipment: CO tubing & 500mL D5W
- Spike & Burp air from bag
- Prime CO line
- Attach CO syringe
- Attach CO Fluid Temp Probe
- Attach Blood Thermistor [Core temperature probe] Sensor 4cm from tip

Enter patient's Height & Weight in GE monitor for BSA and Index Calculations [patient parameters]

Option 2 Poodle:
Attach 1 transducer to PA port & IV Fluids to CVP port

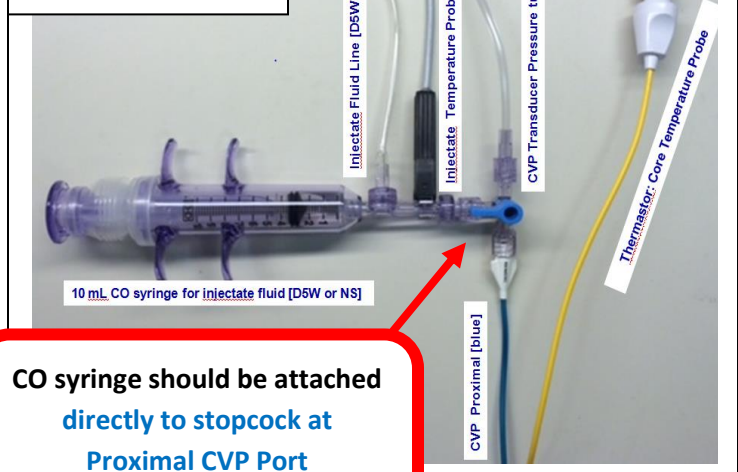


- To build poodle: 1st Make an 'H' with stopcocks
- 1) Attach stopcocks to each side of Male:Male adapter
 - 2) Twist until male ends are pointed in same direction [up]
 - 3) Attach 3rd stopcock to the top of the H

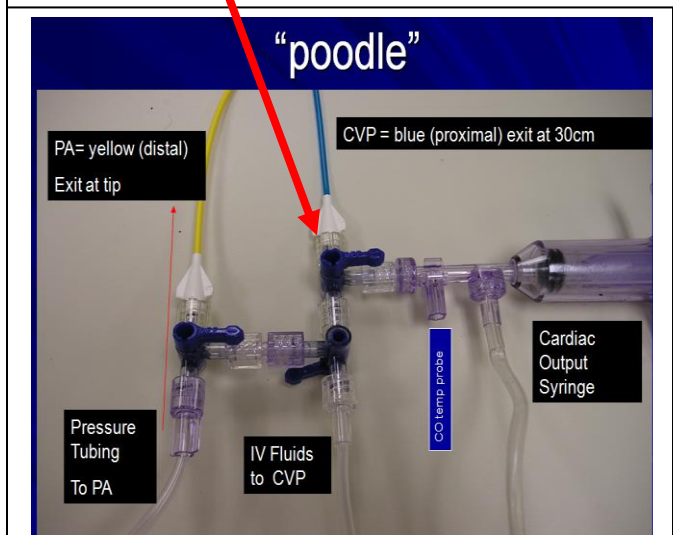
Set monitor to obtain CO reading

- Inject 10 mL D5W
- In less than 4 seconds [steady]
- During End Expiration
- Read washout curve
- Average of 3 CO should be within 20% with similar waveform morphology

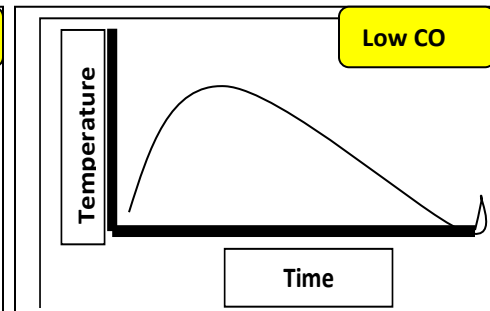
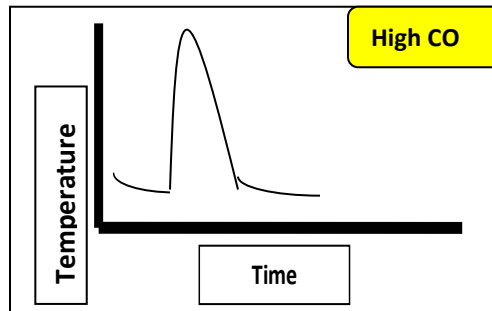
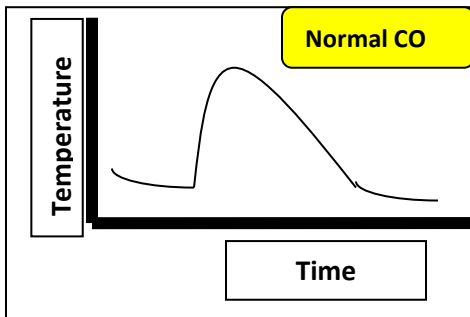
Option 1: PA & CVP with separate transducers



CO syringe should be attached directly to stopcock at Proximal CVP Port
No extension tubing.



Safety Recommendation: disassemble the "poodle":
Connect separate transducers for PA [yellow] and CVP [blue]
Both waveforms continuously on the bedside monitor.



13) Identify calculations & values for the following parameters

Hint: the 4 determinants of Cardiac Output are: HR / Preload / Afterload / Contractility

- Stroke Volume [SV] # mL ejected with each ventricular contraction Normal 60–100 mL/beat/m²
- Stroke Volume Index [SVI] = $\frac{\text{\# mL ejected with each ventricular contraction}}{\text{BSA}}$ Normal 33–47 mL/beat/m²

• Cardiac Output [CO] = Heart Rate x Stroke Volume Normal: 4 – 6 Liters / minute

• Cardiac Index [CI] = Cardiac Output / Body Surface Area [BSA] Normal: 2.4 – 4 Liters / minute

• Systemic Vascular Resistance [SVR] Normal 800 – 1200 dyns/sec/cm⁵

$$\frac{\text{MAP} - \text{CVP} \times 80}{\text{CO}}$$

• Pulmonary Vascular Resistance [PVR] Normal < 250 dyns/sec/cm⁵

$$\frac{\text{MPAP} - \text{WP} \times 80}{\text{CO}}$$

14) Obtain a mixed venous blood gas

- SLOWLY aspirate 3 -5 mL waste from the PA distal [yellow] port Over 60 – 90 seconds
- Using ABG syringe Slowly aspirate 1 mL mixed venous sample
- Hint: Do not place on ice if you are going to utilize iStat hand held analyzer [be sure to include temp & blood source as mixed venous not just venous]
- Hint: Place in ice immediately to send to lab

Mixed Venous vs Central Venous Blood Gas

- [SVO₂] [SCV0₂]
- 60 – 80% ~ 70%

SVO₂ Mixed Venous Blood Gas

The **MOST unoxygenated blood** in the body is immediately before it gets to the lungs i.e. the pulmonary artery [SV0₂]

Hint: A true mixed venous blood gas is blood from the superior and the inferior vena cava ‘mixing’ in the RV & drawn from the **PA distal [yellow] port**

SCV0₂ : Central Venous Blood Gas

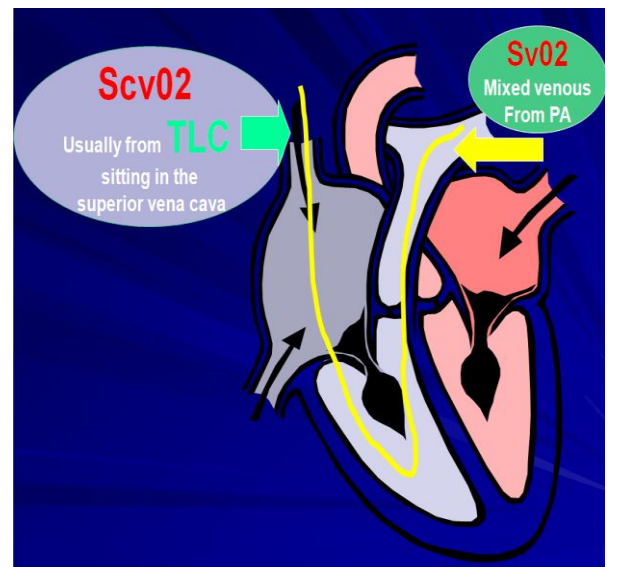
Obtained from **CVP proximal [blue] port** [R Atrium]

Hint: Commonly SCV0₂ is drawn from the Brown Distal Port of a Triple Lumen Catheter sitting in the Right Atrium or Superior Vena Cava

Good approximate value:

This value is approx 2- 3 % higher than SVO₂

More reflective of oxygen consumption in the upper part of the body [brain]



Oximetric Combi Swan with continuous Cardiac Output and SV02 monitoring must be connected to the Vigilance II [see Vigilance II Helpful Hints online]

Vigilance II CCO / SvO2

Continuous Cardiac Output
Average q 3 min of CCO / CCI
Press **Start / Stop** to begin CCO
Reminder: the CCO # will not appear for the first 3 minutes it is connected you will see a Collecting CO Data message on the screen
If time is displayed below the CCO in small letters this indicates the CCO is stopped. Time listed is the last CCO recorded. Press **START**
Press the **Body** button to enter the MAP and CVP to obtain SVR. & to change height or weight
Press the **Body** button again to hide the profile screen.

STAT Boxes every minute CCO
HINT: do not document from the STAT boxes.
If your patient moves or coughs etc. The cardiac output for that minute will be higher.

Troubleshooting CCO
Patency & placement of catheter is most important
Always check your CVP and WP waveforms 1"
Must use 1.25 or 1.5 cc to inflate balloon.
If the PA cath tip is too close to the capillary it can not read the temperature changes necessary to calculate the cardiac output (time and temperature washout curve)
Vig II Helpful Hints Sherri Welch 2010

Scroll to the little box and click to see the STAT boxes or graphics

- Calibrate SV02 daily with am labs
- 1) Rotate and click to highlight the SVO2 box top right
 - 2) Scroll to Select **InVIVO** calibration
 - 3) Connect waste syringe to Yellow PA Distal port
 - 4) Click **DRAW** then immediately draw waste over 60 secs
 - 5) Draw mixed venous sample in ABG syringe [place on ice to send to lab / DO NOT place on ice before iSTAT]
 - 6) When the results are ready: return to the SVO2 calibration screen
Rotate + click to highlight and update SV02 and Hgb / Hct values
 - 7) Scroll down to click **CALIBRATE**
The monitor will count down 25 seconds then update the SV02 reading on the home screen

15) Describe discontinuing pulmonary artery catheter / removal

Hint: PA Catheters and Introducers are only allowed in Critical Care Areas: not on med-surg units

- The PA catheter must be removed
- The introducer must be removed or rewired to a TLC if central venous access is needed prior to transfer to med surg unit.

Ensure labs [coags / plts] are within acceptable ranges

Place patient in Trendelenberg position

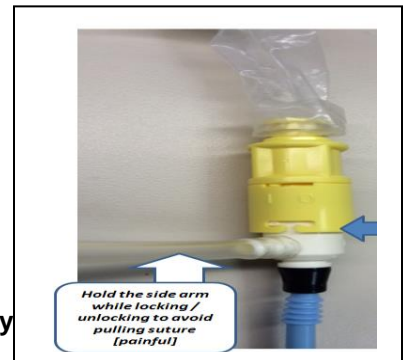
Remove PA catheter after patient inhales and holds breath [to avoid negative pressure pulling in air embolism]

Remove Introducer after patient inhales and holds breath [to avoid negative pressure pulling in air embolism]

Hold pressure 8-10 minutes Reassess for bleeding and hematoma frequently

Discontinuing the PA catheter but keeping the Introducer

- Once PA catheter is removed: a SLIC or Obturator **MUST** be placed **immediately** to prevent air embolism . The valve inside the introducer will not prevent air or fluid movement
Valve must be covered at all times



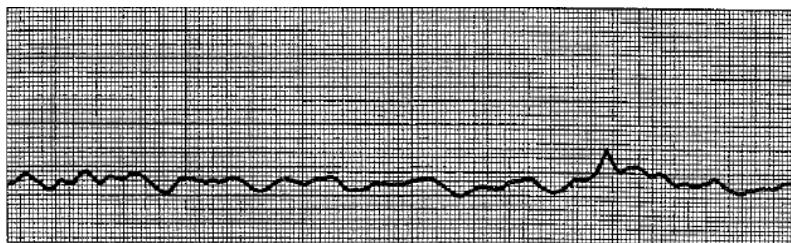
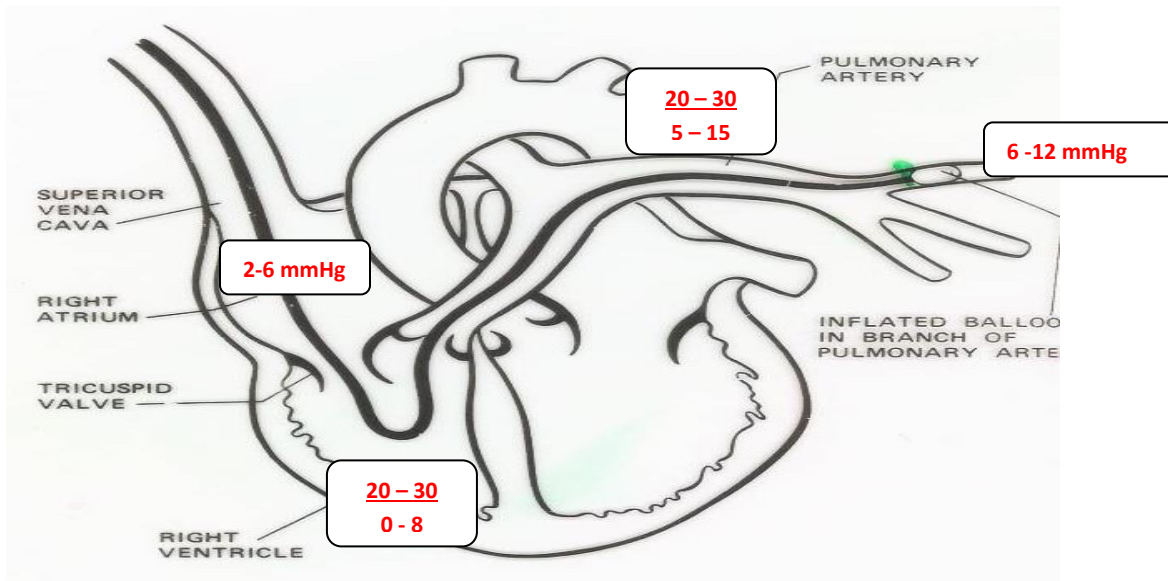
SLIC Single Lumen Infusion Catheter

Connect pressure tubing / transducer [just like an art line] to the tip of SLIC to transduce CVP

Add stopcocks to the side arm to add drips.
Do not clamp introducer
Always have KVO fluid infusing [if no other drips are connected]

Hemostasis Valve Obturator Cap

- i.e. Introducer Dead Ender
- Must be inserted [sterile] to when Swan Catheter or SLIC is not in use [or has been removed]



CVP = 2 – 6 mmHg [R Atrium]

Estimated preload for Right Ventricle
30 cm mark



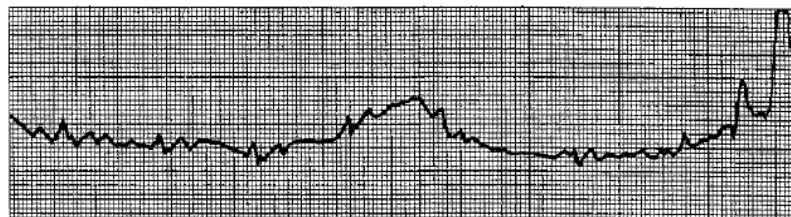
Right Ventricular Waveform

RV Sys 20 – 30 mmHg
RV Diast 0 – 8 mmHg



Pulmonary Artery Waveform

PA S 20 – 30 mmHg
PAD 5 – 15 mmHg



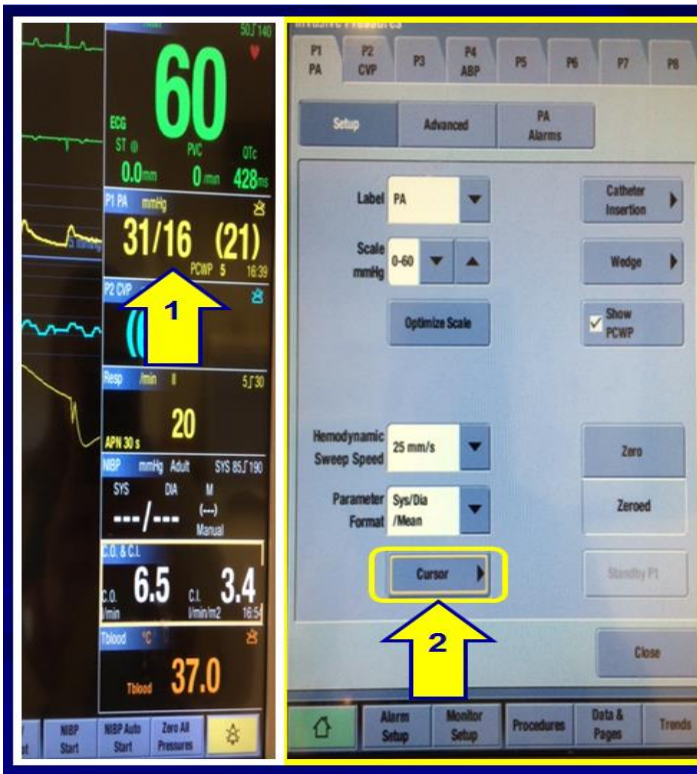
Pulmonary Capillary Wedge Pressure = WP
aka: Pulmonary Capillary Wedge Pressure PCWP
aka: Pulmonary Artery Occlusion Pressure PAOP
WP = 6 – 12 mmHg

Estimated Preload for Left Heart

Atlas of Pathophysiology, Springhouse, 2012
 Clochesy, John, et al. *Critical Care Nursing, 2nd Edition*, W.B. Saunders Company, 1996.
 Marino, P. et al. *The ICU BOOK* Lippincott Williams & Wilkins, 2007
 Thelan, Lynne. Et al. *Critical Care Nursing Diagnosis and Management 3rd Edition*, Mosby Publishing, 1998
 Lynn- McHale et al. *AACN Procedure Manual for Critical Care*, W.B. Saunders Company,

Disconnect & deflate balloon before & after each use.
Never lock syringe with balloon inflated

GE Monitor Screen Shots Helpful Hints



Use PA Cursor to measure PAS / PAD during end exhalation

Use ▲ & ▼ arrows to adjust cursor line

When NO WEDGE is ordered: follow PAD



Use WEDGE mode to measure WP during end exhalation

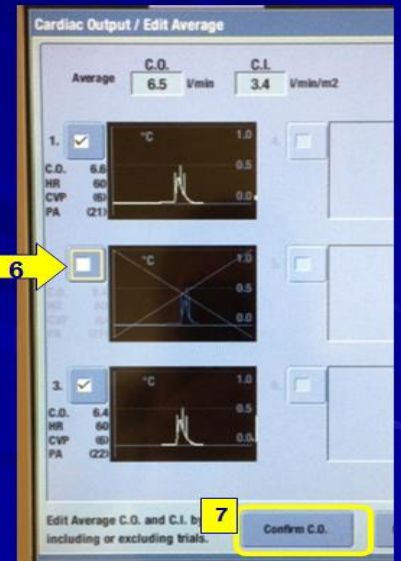
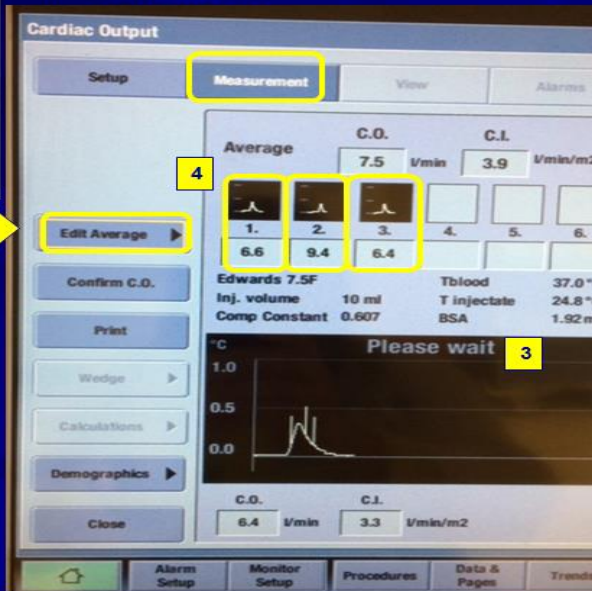
- 1) Inflate 1.5mL balloon
- 2) Continue WP waveform for several breaths
- 3) Press FREEZE WEDGE
- 4) Release syringe
- 5) Use Cursor to determine wave





To Shoot Cardiac Output:

- 1) "Inject when ready" message will appear
- 2) Inject 10mL D5W / steady / in < 4 secs / at End Exhalation
- 3) "Please wait" message during waveform analysis & results
- 4) Compare 2 - 3 waveforms [within 20% of each other]
- 5) Choose "Edit Average" to deselect unwanted waveforms
- 6) Uncheck unwanted waveforms
- 7) Confirm C.O.



Calculations: SVR & PVR

- 1) Select **Edit Input**
- 2) Highlight parameter :Use ^ and v arrows to adjust WP and CVP
- 3) Select **View** to return to calculations
- 4) Select **Save** to add calculations to trends screen.

