Pulmonary Artery Catheter Helpful Hints 2017

Swan Ganz Catheter

1) Gather Equipment

Hint 1: **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

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 Trendelenburg 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*

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

Hint 5: Once catheter is in place; the balloon should never be inflated for more than 15 secs

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

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

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**Lock 1**

Lock plastic sheath to Introducer
Twist to lock

**[2] Twist Lock**

Secures PA cath from slipping or being pulled through plastic sheath
twist to lock / unlock

1 = locked
0 = Open

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*Hold the side arm while locking / unlocking to avoid pulling suture [painful]*
9) Obtain Waveform Readings [Zero & Level transducer]

**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

**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

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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

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Before reading waveforms: re-Level & re-Zero

Never lock syringe with balloon inflated
10) Demonstrate Corrective Actions for the Following

A) Distinguish Dampered 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]

Scenario: Dampered 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!

- 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
  - a. 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]
  - b. If balloon deflates: the syringe fills with air: THE BALLOON IS INTACT
  - c. Check the depth of the catheter: is it still the same marking at the introducer site?
  - d. Attempt to inflate again
  - e. Have MD advance the catheter

Scenario2: Balloon inflated with 1.5 mL and PAS / PAD waveform still appears
  - a. Release balloon syringe: If the syringe does not fills with air: Suspect Balloon Rupture
  - b. If there was no resistance to inflation: Suspect Balloon Rupture
  - c. If blood pulls back into the syringe upon aspiration: THE BALLOON HAS RUPTURED
  - d. THE PA CATHETER MUST BE REMOVED!
    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

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

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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 Thermastor [Core temperature probe]
  Sensor 4cm from tip

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

**Option 1: PA & CVP with separate transducers**

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

**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

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

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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]** \[= \# mL ejected with each ventricular contraction \times \text{BSA}\]  
  Normal 33–47 mL/beat/m²

- **Cardiac Output [CO]**  
  \[= \text{Heart Rate} \times \text{Stroke Volume}\]  
  Normal: 4 – 6 Liters / minute

- **Cardiac Index [CI]**  
  \[= \frac{\text{Cardiac Output}}{\text{Body Surface Area [BSA]}}\]  
  Normal: 2.4 – 4 Liters / minute

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

\[\text{MAP} – \text{CVP} \times 80 \]  
\[\text{CO}\]

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

\[\text{MPAP} – \text{WP} \times 80 \]  
\[\text{CO}\]

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

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### Mixed Venous vs Central Venous Blood Gas

- **[SVO2]**  
  Normal 60 – 80%

- **[SCVO2]**  
  ~ 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 [SVO2]

**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**

**SCVO2** : Central Venous Blood Gas

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

**Hint**: Commonly SCVO2 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]

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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

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

Calibrate SV02 daily with am labs
1) Rotate and click to highlight the SV02 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 SV02 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

Hold the side arm while drawing. SV02 readings may be affected if a large air bubble remains in the line.
CVP = 2 – 6 mmHg [R Atium]
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

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