Winnipeg Regional Health Authority / Office régional de la santé de Winnipeg Caring for Health / À l'écoute de notre santé **CRITICAL CARE CLINICAL PRACTICE GUIDELINE**	**Practice Guideline:** **PULMONARY ARTERY CATHETER (PAC)**	
	Approval Date: *July 3, 2019*	**Pages:** *1 of 29*
	Approval By: *Professional Advisory Committee* *Standards Committee*	**Supercedes:** *N/A*

GUIDELINE STATEMENTS:

1. Performance of the following procedures requires advanced knowledge and skill.

2. The pulmonary artery (PA) catheter is a 7 Fr or 7.5 Fr catheter and may only be inserted through an 8.5 Fr percutaneous sheath introducer.

3. Pulmonary artery catheter waveforms must be continuously monitored while in situ.

4. All transducers must be zeroed upon initial set-up, once per shift and PRN.

5. Transducers are to be re-leveled whenever the patient's position or bed height has changed and prior to obtaining readings.

6. Perform square wave test once per shift and whenever the pattern/tracing appears to be distorted or dampened.

7. Medications should never be infused into the distal port of the pulmonary artery catheter since it is position in the pulmonary artery. **Exception:** A physician may write an order for treatment of pulmonary hypertension to infuse medication directly into the pulmonary artery port.

8. Blood is removed from the PA catheter only to determine mixed venous oxygen saturation (SvO_2) and is not for routine blood sampling.

9. When a pulmonary artery diastolic (PAD) pressure is not adequate for the clinical situation and a pulmonary capillary wedge pressure (PCWP or wedge) is required, an ICU nurse with appropriate experience and comfort on performing PCWP may obtain a measurement. Cardiac patients may more commonly have clinical indications for PCWP measurements and ICU nurses working the Cardiac Sciences Program (CSP) are frequently tasked to provide these measures. To ensure competency nurses working in the CSP will be provided with the theoretical knowledge through the WCCNEP course and unit level education and training for safely obtaining a PCWP. (B. Paunovic, **personal communication**, September 14, 2016; T. Thiele, **personal communication**, March 13, 2018).

10. PCWP is to be obtained using the manufacturers supplied balloon inflation syringe.

11. Do not wedge for greater than 15 seconds or 3 breaths whichever comes first.

12. A physician's order is necessary to perform a PCWP if pulmonary artery (PA) systolic pressures are > 50 mmHg.

13. A physician's order is required to have the patient sitting in a chair at the bedside or ambulating when a PAC is insitu.

14. A physician order is required for PA catheter removal.

15. If the patient has a permanent pacemaker, implantable cardioverter defibrillator (ICD) or temporary transvenous pacing wiring in situ or chest x-ray evidence of a knot in the PA catheter, the PA catheter must be removed by a physician.

PART A: ASSISTING WITH INSERTION OF PAC

Equipment:

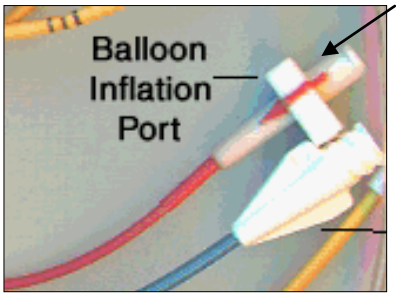
1. Flushed hemodynamic pressure monitoring system including normal saline flush solution, pressure bag, and pressure tubing with transducers (1 dual or 2 single). Refer to NSO Transducer System Setup and Zeroing.
2. Monitor/recorder and pressure monitoring cables.
3. Primed and labelled IV solution set and attached 4-way stopcock for right ventricular (RV) pacing infusion port of the PA catheter (as needed).
4. 2% chlorhexidine gluconate with 70% alcohol swab sticks.
5. Appropriate protective barrier attire (procedure mask, disposable surgical cap, sterile gloves, and sterile gown).
6. 8.5 F percutaneous sheath introducer.
7. Thermodilution 7.0 Fr or 7.5 Fr PA catheter with balloon inflation syringe.
8. Catheter contamination shield (for use with 7.5 and 8 Fr. Catheters).
9. 4 x 4 gauze dressing (as needed).

10. Transparent semi-permeable membrane (TSM) dressing (as needed).
11. Arterial line sticker or label indicating an arterial line.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1. Perform hand hygiene before direct patient contact and subsequently as indicated.	
2. Connect primed hemodynamic pressure monitoring system to the cardiac monitor and zero the system.	Refer to Zeroing the Transducer in NSO's Transducer System Setup and Zeroing.
3. Place monitor in the PA catheter insertion screen mode.	
4. Position patient in supine position with head of bed flat or as requested by physician.	Consider the use of sedation and analgesia for the patient's comfort, prior to the initiation of this procedure as movement of the patient may inhibit insertion of the PA catheter.
5. Level transducer stopcocks to phlebostatic axis.	Phlebostatic axis is the fourth intercostal space mid anterior-posterior diameter. Refer to Leveling the Transducer in NSO's Transducer System Setup and Zeroing.
6. Observe as the physician cleanses the hub of introducer including the hemostasis valve with 2% chlorhexidine and 70% alcohol swab stick using a no touch technique.	
7. Don appropriate maximal protective barrier precautions attire.	Anyone working directly over the sterile field must wear a disposable surgical cap, procedure mask, sterile gloves and sterile gown. Anyone working in the area, but not directly on the sterile field, must wear a disposable surgical cap and procedure mask.

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
8.	Assist the physician as needed with opening the packaging of sterile drapes and subsequent draping of the patient with sterile drapes.	The patient should be fully draped with exposure of only the insertion site.
9.	Open the outer package of the pulmonary artery catheter, allowing the physician to grasp inner package.	Keep outer package containing the lot number, as this number needs to be documented in the procedure note.
10.	Open catheter contamination shield package maintaining sterility and allow physician to grasp.	
11.	Observe as physician inserts the PA catheter through the catheter contamination shield (sterile sleeve) and locks the proximal end of the contamination shield at approximately the 100 cm marker.	Maintains the sterility of the PA catheter and allowing for repositioning of the catheter.
12.	Grasp the proximal end of the PA catheter and balloon inflation syringe from the physician.	
13.	Test the balloon integrity by attaching the supplied volume limited balloon inflation syringe to the balloon port of the PA catheter and instilling 1.5 mL air into the port and passively deflate.	Perform this step PRIOR to insertion to determine balloon integrity and lack of leaks.
14.	Connect the pressurized flush system to the PA proximal (RA/CVP) port and PA distal port of the catheter using aseptic technique and flush the PA proximal and distal ports of air by pulling the flush device until fluid is seen coming from the ports.	Ensure all connections are secure.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
15. Connect flushed IV line with stopcock to RV pacing infusion port of the PA catheter using aseptic technique and flush port until fluid is seen coming from the port.	Ensure all connections are secure.
16. Observe the monitor as the physician gently shakes the PA catheter (creates catheter fling) prior to insertion to verify functioning of catheter.	The movement of the catheter should be seen on the bedside monitor as an erratic pattern. This will verify that the pressure tubing of the PA catheter is being transduced and there are no connection issues or catheter defects before insertion.
17. Once the physician inserts the PA catheter beyond the tip of the introducer, inflate (or deflate) the balloon of the PA catheter as directed by the physician.	The inflated balloon helps to advance the PA catheter into the PA minimizing the chance of endocardial damage. The syringe provided with the PA catheter is designed to only allow 1.5 mL capacity, the same as the balloon capacity. This prevents accidental inflation of more air which could rupture the balloon or pulmonary artery. **Always allow the balloon to passively deflate prior to the PA catheter being pulled back.** **If** the manufacturers supplied balloon inflation syringe is not available use a 3 mL Leur Lock syringe with caution ensuring a maximum of 1.5 ml is used to inflate the balloon.
18. Observe waveform and pressures as the PA catheter is advanced through the right atrium, right ventricle, into the pulmonary artery and into the wedge position.	See Appendix A. Right ventricular pressures are only observed during insertion of the PA catheter.
19. Observe monitor for any cardiac arrhythmias during insertion and notify physician immediately.	

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
20. Verify that the PA catheter tip is in the proper position: a) When the balloon is deflated, the PA waveform is displayed on the monitor. b) When the balloon is inflated, the pulmonary artery wedge pressure waveform is displayed on the monitor.	
21. Remove the balloon syringe from balloon port of the PA catheter ensuring balloon port of PA catheter is not locked in inflation position.	This facilitates passive removal of air from the PA catheter balloon and prevents accidental inflation of balloon. Red line along the lumen tubing of the balloon port is used to indicate if balloon port is locked or unlocked.  A continuous red line indicates the balloon port is unlocked. A broken red line indicates the balloon inflation port is locked.
22. Note the centimeter marking at the hub of the introducer.	Each thin line represents 10 cm; each thick (bold) line represents 50 cm.
23. Observe the physician as the contamination shield is extended over the PA catheter and secure in place.	Provides a sterile environment in the event the PA catheter requires repositioning by the physician.

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
24.	Label the distal PA port with an "Arterial line" sticker.	The distal lumen opens into the pulmonary artery and this port **can never** be used for infusions. **Exception:** A physician may write an order for treatment of pulmonary hypertension to infuse medication directly into the pulmonary artery port.
25.	Anchor PA catheter securely to patient.	
26.	Apply a dressing over introducer insertion site (if necessary).	Follow your site specific guideline or nursing procedure for central venous access device (CVAD) dressing change or care.
27.	Ensure post-procedure chest x-ray is obtained.	A physician must order and subsequently review chest x-ray to confirm the catheter tip is positioned appropriately in the pulmonary artery.

DOCUMENTATION:

Intensive Care Flowsheet or Unit Specific Nursing Documentation Tool:

1. Date and time of PA catheter insertion.
2. External centimeter marking of the PA catheter at the introducer exit site.
3. Patient tolerance and/or any rhythm disturbances or ectopics.

Procedure Note (completed by physician):

1. PA catheter distance, lot number and confirmation of placement.

PART B: CARE AND TROUBLESHOOTING

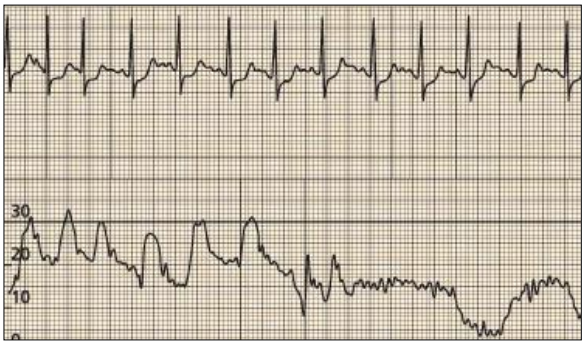
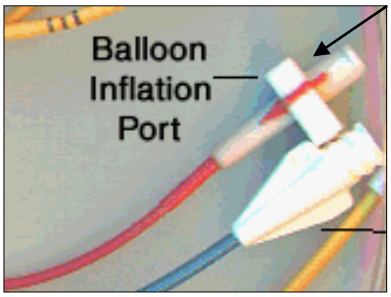
Part B-1: CARE OF

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1.	Assess the position of the PAC every shift and prn by noting the external centimeter measurement or marking on the PAC at the introducer exit site.	Document on clinical record and bedside whiteboards (if applicable).
2.	Ensure that balloon inflation syringe is not left attached to the balloon inflation port.	Prevents accidental balloon inflation.

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
3.	Care of the introducer dressing should follow the general CVAD dressing change procedure. Ensure the TSM dressing does not overlap the sleeve of the contamination shield.	Follow your site specific guideline or nursing procedure for central venous access device (CVAD dressing change or care.
4.	Secure the hub of the PA catheter and any excessive length in tubing from all ports to the patient gown.	This will help to prevent accidental dislodgement or movement of the PA catheter from the introducer.
5.	Prior to mobilizing patient it is essential to assess the catheter for its secure placement.	If dysrhythmias occur while the patient is turning from side to side or the catheter shows significant forward/backward movement, then the patient is an unlikely candidate for out-of-bed activity.

Part B-2: Troubleshooting for Catheter Tip Migration

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1.	Right ventricular (RV) pattern identified on monitor.	Right ventricular pattern is taller than the PA pattern. See Appendix A for RV pattern image. The systolic pressures are similar, but diastolic pressures are lower. RV pattern indicates the catheter has migrated into the right ventricle which may cause irritation and ventricular arrhythmias.
	a) Note the external centimeter marking of the PA catheter at the introducer exit site.	Identifies whether the PA catheter has migrated from the previously documented measurement.
	b) Position patient left side down.	This position can reduce irritation and direct contact with the ventricular wall and may promote advancement of the catheter to the pulmonary artery.
	b) Notify physician immediately as the PA catheter must be repositioned.	The physician may instruct the nurse to slowly inflate the PA balloon port with 1 – 1.5 mL of air to facilitate catheter floatation from the RV into the pulmonary artery.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
2. A persistent pulmonary capillary wedge pattern is observed on the monitor.	This indicates that the PA catheter has migrated into the pulmonary arterial circulation, where the lumen of the artery is equal to the diameter of the catheter. This obstructs blood flow and may compromise blood flow to lung tissue. 
a) Ensure balloon inflation syringe has not inadvertently been left in place.	If so, remove the syringe from the balloon inflation port to allow passive deflation of the balloon.
b) Ensure balloon port of PA catheter is not locked in inflation position.	The red line along the lumen tubing of the balloon port indicates if the balloon port is locked or unlocked.  Unbroken red line indicates the balloon port is not locked in an inflation position. A broken red line would indicate the balloon inflation port is locked in the inflation position.
c) Note the external centimeter marking of the PA catheter at the introducer exit site.	Identifies whether the PA catheter has migrated from the previously documented measurement.

PROCEDURE:	SPECIAL CONSIDERATIONS:
d) Troubleshoot hemodynamic system by: • Assess for loose connections. • Assess for air or clot in the system. • Ensure adequate volume in pressurized bag. • Ensure pressurized bag is at 300 mmHg.	An overdampened system will produce a low amplitude wave form as a result of pressure transmission interference.
e) Assist the patient in changing position or if possible ask the patient to cough.	This may help the PA catheter to float out of the wedged position.
f) Never flush a wedged PA catheter.	Flushing the catheter in the wedged position may lead to PA rupture and hemorrhage.
g) Notify physician immediately if permanent pulmonary capillary wedge tracing persists.	The catheter may require repositioning as quickly as possible to prevent prolonged occlusion leading to PA infarction.

DOCUMENTATION:

Intensive Care Flowsheet or Unit Specific Nursing Documentation Tool:

1. Date and time of any assessment information prior to mobilizing patient, patient tolerance, and/or any dysrhythmias or waveform changes.

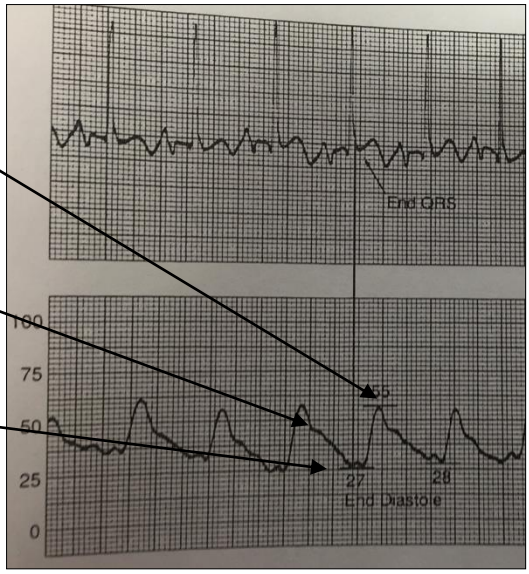
2. Date and time of any troubleshooting actions taken for treatment of PA catheter tip migration.

PART C: OBTAINING PULMONARY ARTERY PRESSURES

EQUIPMENT:

1. Pulmonary Artery Catheter in situ that has hemodynamic pressure monitoring system connected to patient transducer cable and monitor and that has been leveled, zeroed, and square wave test performed as per NSO Transducer System Setup and Zeroing.

PROCEDURE:	SPECIAL CONSIDERATIONS:
1. Perform hand hygiene before direct patient contact and subsequently as clinically indicated.	

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
2. Ensure appropriate patient position.	Values are most accurate when the patient is supine with the head of the bed elevated from 0 to 45 degrees.
3. Ensure pressure transducers are leveled to phlebostatic axis	Phlebostatic axis is at the fourth intercostal space mid anterior-posterior diameter. Level the transducer as follows if side-lying: • **30° lateral position**: level to half the distance from the surface of the bed to the left sternal border. • **90° right lateral position**: level to fourth intercostal space mid sternum • **90° left lateral position**: level to fourth intercostal left parasternal border. See NSO's Transducer System Setup and Zeroing.
4. Identify acceptable pulmonary artery wave form. • Pulmonary Artery Systole (PAS) is caused by ejection of blood from the right ventricle and reflects right ventricular systole. • Dicrotic notch occurs with closure of the pulmonic valve. • Pulmonary Artery Diastole (PAD) is an approximation of left ventricular end diastolic pressure in absence of pulmonary disease or mitral valve disease.	

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
5. Measure the PA pressures at end expiration.	The effects of intrathoracic pressure are minimized at the end expiration phase of the respiratory cycle. Placing hand on patient's chest while observing PA pattern will aid in recognition of end expiration.
6. Measure and/or record the PA systolic pressure at the peak of the systolic waveform on the PA waveform.	Reflects the highest PA systolic pressure. Normal PA systolic pressures are considered 20-30 mmHg.
7. Measure and/or record the PA diastolic pressure at the end of the QRS complex.	The end of the QRS complex correlates with ventricular end-diastolic pressure. This point occurs just before the upstroke of the systolic pressure. Normal PA diastolic pressures are considered 10-15 mmHg.
8. Ensure alarm limits are enabled and set according to diastolic values.	Alarm limits are 10 mm Hg above and 5 mm Hg below the pulmonary systolic and diastolic value unless otherwise indicated.

DOCUMENTATION:

Intensive Care Flowsheet or Unit Specific Nursing Documentation Tool:

1. Record time and pulmonary pressure values obtained.

PART D : OBTAINING PULMONARY CAPILLARY WEDGE PRESSURE (PCWP OR WEDGE PRESSURE)

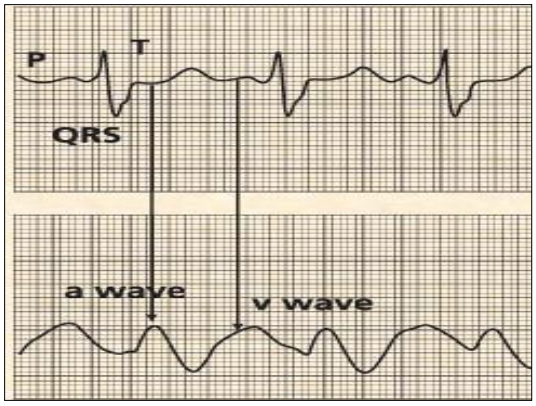
EQUIPMENT:

1. Pulmonary Artery Catheter in situ that has hemodynamic pressure monitoring system connected to patient transducer cable and monitor and that has been leveled, zeroed, and square wave test performed as per NSO's Transducer System Setup and Zeroing.
2. Manufacturer supplied balloon inflation syringe.
3. 3 mL Leur Lock syringe, (if applicable).

PROCEDURE:	**SPECIAL CONSIDERATIONS:**

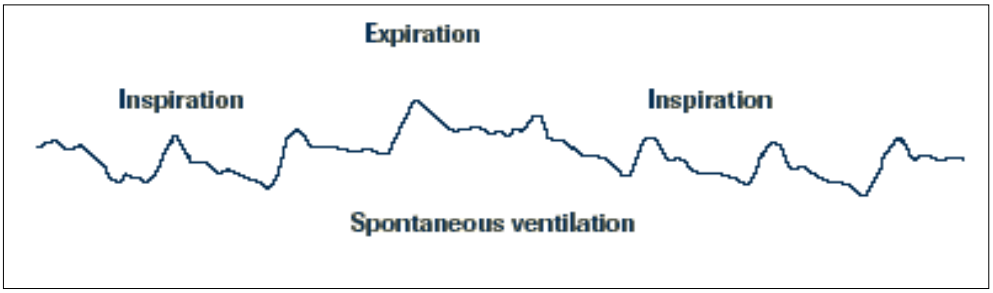
A physician's order is necessary to perform a pulmonary artery wedge pressure (PCWP) if pulmonary artery (PA) systolic pressures are > 50 mmHg. The pulmonary artery diastolic (PAD) pressure can be used in lieu of wedge pressure reading.
Only experienced/competent nurses or a physician can obtain a PCWP – see Guideline statement #9 on page 2 of this document.

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1.	Perform hand hygiene before direct patient contact and subsequently as clinically indicated.	
2.	Ensure appropriate patient position.	Values are most accurate when recorded with the patient in a supine position with the head of the bed elevated 0 to 45 degrees.
3.	Ensure pressure transducers are leveled to phlebostatic axis	Phlebostatic axis is the fourth intercostal space mid anterior-posterior diameter. See NSO's Transducer System Setup and Zeroing.
4.	Set monitor for wedge reading.	
5.	Fill manufacturers' supplied balloon inflation syringe with 1.5 mL of air.	The syringe provided with the PA catheter is designed to only allow 1.5 mL to be drawn back. This will prevent accidental inflation of more air which could rupture the balloon or pulmonary artery. **Note:** If the manufacturers supplied balloon inflation syringe is not available use a 3 mL Leur Lock syringe with caution.
6.	Attach balloon inflation syringe to the PA balloon port.	Ensure the balloon port is open and not in the locked position.

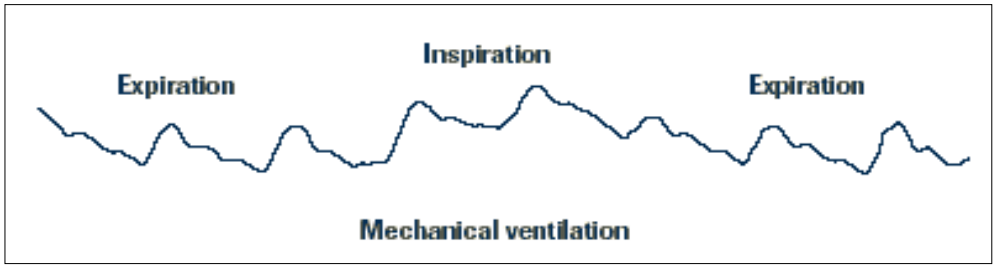
PROCEDURE:	**SPECIAL CONSIDERATIONS:**
7. Slowly inflate PA balloon port until the PA waveform changes to a wedge waveform (use a maximum of 1.5 mL of air).	Avoid over inflation of the balloon because it can cause pulmonary capillary infarction or rupture. A slight resistance is usually felt during balloon inflation. If significant resistance is met, stop injecting air and allow balloon to passively deflate. If no resistance is met during inflation and no air returns into syringe on deflation, notify physician as this could indicate balloon rupture. Notify physician if less than 1 mL of air is required to obtain a wedge pattern as this can indicate migration of PA catheter in small pulmonary artery.
8. Observe for acceptable wedge pattern and hold inflation for 3 breaths or 15 seconds (whichever comes first). • "*a*" wave: occurs with atrial contraction and correlates to the end of the QRS complex and reflects LV filling at end diastole. • "*c*" wave: follows the "a" wave and occurs with closure of the mitral valve. If present, falls in the T wave of the ECG tracing. • "*v*" wave: occurs as a result of passive atrial filling when mitral valve is closed during ventricular systole. Falls well after the T wave on the ECG tracing.	Some monitors will provide an audible prompt to deflate the balloon. This will minimize the risk of pulmonary infarct from occlusion of pulmonary artery for an extended period of time. 

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
9. Place your hand on the patient's chest noting where end expiration is on the wedge pattern.	**Record all pressures at end expiration** when pleural pressures are closest to zero to minimize the respiratory effects on pressure readings.

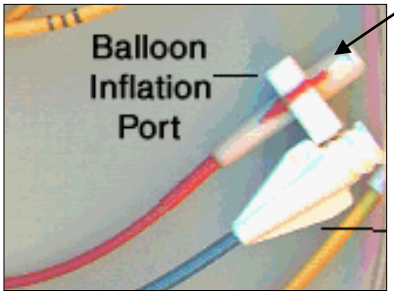
If the patient is breathing spontaneously, the inspiratory phase is the negative group of waveforms.



The opposite is **generally** true if the patient is ventilated with positive pressure ventilation (depending on the amount of positive pressure ventilation).



10. Store/review wedge tracing.	Some monitors have the capability of "freeze framing" waveforms.
11. Release plunger and allow passive deflation of the balloon.	Passive deflation will prevent unnecessary stress on the PA balloon and decrease risk of balloon rupture.
12. Remove syringe from balloon port.	Keep syringe available for repeated use.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
13. Ensure the balloon port is open and not in the locked position.	The red line along the lumen tubing of the balloon port indicates if balloon port is locked or unlocked.  Unbroken red line indicates the balloon port is not locked in an inflation position. A broken red line would indicate the balloon inflation port is locked in the inflation position.
14. Ensure PA wave form has returned.	
15. Edit/review wedge tracing by:	
a) Adjust the horizontal cursor on the monitor to the mean of the "a" waves at end expiratory phase.	
b) If monitor allows, adjust vertical cursor to the point of end expiration.	This is just before wave form changes direction.
16. Save edited wedge value.	Normal wedge is 8-12 mmHg for a healthy individual.
17. Return monitor to main screen.	
18. Compare the PA diastolic with the wedge pressure.	Usually the wedge is approximately 1-4 mmHg less than the PA diastolic pressure. If these two pressures are similar, the PA diastolic pressure may be followed which minimizes the frequency of balloon inflation, decreasing potential for balloon rupture and PA trauma.
19. Re-activate alarms if they had been suspended.	

PROCEDURE: **SPECIAL CONSIDERATIONS:**

DOCUMENTATION:

Intensive Care Flowsheet or Nursing documentation tool for your area:

1. Document the amount of air required for balloon inflation to obtain wedge tracing.
2. Document the PCWP value.
3. Document patient tolerance and any ectopics.

PART E: CARDIAC OUTPUT (CO) SET UP

EQUIPMENT:

1. 500 mL IV Solution Bag as per your facility's practice or as ordered (D5W is a commonly used solution).
2. CO Set (tubing kit)
3. CO monitor module (if needed for specific monitor).
4. CO transducer cable (bifurcated with thermistor connector and injectate probe).
5. "Date to be changed" labels.
6. PA Cath in situ

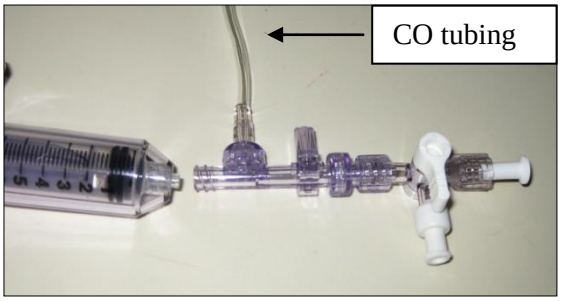
PROCEDURE: **SPECIAL CONSIDERATIONS:**

1. Perform hand hygiene before direct patient contact and subsequently as clinically indicated.

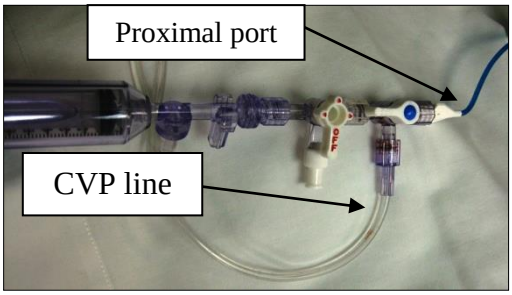
2. Open cardiac output tubing kit and tighten all connections.

3. Using aseptic technique, spike IV solution bag.

4. Attach cardiac output (CO) syringe to the end where the cardiac output tubing enters.



5. Prime the tubing and stopcock using the CO syringe to ensure system is free of air.

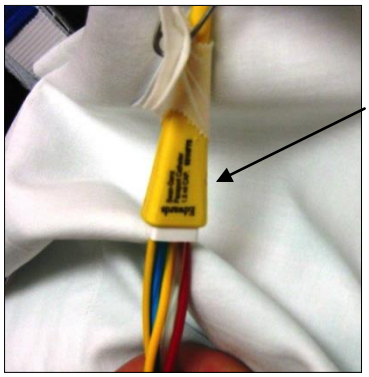
PROCEDURE:	**SPECIAL CONSIDERATIONS:**
6. Maintaining aseptic technique, remove central venous pressure (CVP) line from the proximal port of the PA catheter.	Ensure syringe is attached in a straight line with the PA catheter to facilitate direct injection.
7. Attach distal end of stopcock of CO set-up to proximal port of pulmonary artery (PA) catheter.	
8. Attach the central venous pressure (CVP) line to the side port of the stopcock attached to proximal port of the PA catheter.	
9. Remove cover from the thermistor port on the PA catheter.	
10. Attach thermistor connector probe to the thermistor port on the PA catheter.	Carefully align grooves to avoid bending connecting wires.
11. Label bag and tubing with the "date to be changed" labels.	The entire CO system including the solution must be changed every 96 hours.

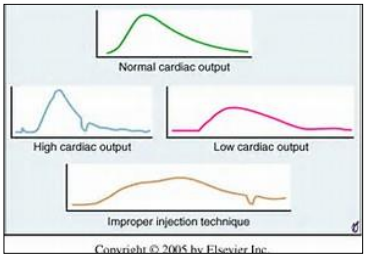
PART F: CARDIAC OUTPUT MEASUREMENT

EQUIPMENT:

1. Cardiac monitor.
2. Attached cardiac output syringe and monitoring system.
3. Pulmonary Artery Catheter in situ that has hemodynamic pressure monitoring system connected to patient transducer cable and monitor and that has been leveled, zeroed, and square wave test performed as per NSO Transducer System Setup and Zeroing.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1. Perform hand hygiene before direct patient contact and subsequently as clinically indicated.	
2. Position the patient supine, with the head of the bed elevated from 0 to 45 degrees.	Position should be documented and communicated since consistent positioning when obtaining CO measurements over time decreases measurement variability.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
3. Verify the position of the PA catheter by assessing both the RA (CVP) and PA waveforms for proper waveform contours.	Proper positioning ensures that the distal thermistor responsible for calculating time-temperature data is located in the PA.
4. Set monitor for CO reading.	
5. Ensure patient's height and weight has been entered into the monitor.	This will ensure accurate calculation of body surface area (BSA) and cardiac index (C.I.).
6. Verify correct computation constant for the type and size of PA catheter has been entered into the monitor.	The standard computation constant is 0.592. See Appendix B. If a non-standard PA catheter is used, obtain model number located directly on the PA catheter and use the computation constant obtained from table in Appendix B.
	 Model number
7. Turn stopcock off to CVP monitoring.	Silence alarm once activated. Do not suspend alarms prior to their activation.
8. Using the CO syringe, slowly withdraw 10 mL of room temperature IV solution.	Ensure there is a minimum of 8-10^{o} Celsius difference between the injectate temperature and the patient's body temperature for the computer to sense a change in temperature over time.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
9. Observe the patient's respiratory pattern and inject fluid rapidly and smoothly at end expiration in 4 seconds or less in a continuous motion.	Some monitors require the injector to wait until the "inject when ready" message appears; other monitors may require a button to be pressed prior to injection. To minimize respiratory effect, values are recorded at end expiratory when plural pressures are closest to zero. Prolonged injection time interferes with time and temperature calculations.
10. Observe for CO curve on monitor.	 A normal curve starts at baseline with a smooth upstroke and a gradual down stroke. A normal CO is 3.5-5.0 L/min.
11. Repeat steps 8-10 until a minimum of 3 acceptable measurements have been obtained.	Measurements must be within 10% of each other to be considered acceptable and provide the most accurate CO value.
12. Turn stopcock off to CO and open to CVP monitoring.	
13. Observe for return of CVP waveform on monitor.	
14. Identify and mark (reject) any unacceptable CO measurements.	
15. Save and average all acceptable CO measurements.	
16. Save CO value (if applicable for monitor).	
17. Access the cardiac calculations menu of the cardiac monitor.	

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
18. Verify hemodynamic numbers.	This will ensure accurate calculation of Systemic Vascular Resistance (SVR), Pulmonary Vascular Resistance (PVR) and Cardiac Index (C.I.). If unable to enter the pulmonary capillary wedge pressure (PCWP), enter the pulmonary artery diastolic (PAD) value in order to calculate pulmonary vascular resistance (PVR).
19. Save calculated values (e.g. CO, C.I. and SVR) as required by your cardiac monitor.	
20. Return monitor to main screen.	
21. Reactivate alarms.	

DOCUMENTATION:

Intensive Care Flowsheet or Unit Specific Nursing Documentation Tool:

1. Record time and values obtained.
2. Record fluid volume used in performing cardiac output measurement.

PART G: BLOOD SAMPLING FOR MIXED VENOUS BLOOD GAS

EQUIPMENT:

1. Non-sterile gloves.
2. 2 x 5 ml syringe (for discard).
3. Blood gas sampling syringe.
4. 2 x 2 cm gauze (clean).
5. Sterile non-vented cap (as needed).
6. Plastic specimen bag (transport bag).
7. Appropriate requisition.
8. PA Cath in situ

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1. Perform hand hygiene before patient contact and subsequently as clinically indicated.	

	PROCEDURE:	**SPECIAL CONSIDERATIONS:**
2.	Don non-sterile gloves.	
3.	Remove non-vented cap from side port of stopcock of distal lumen of PA catheter.	Utilize aseptic technique. Maintain sterility of non-vented cap.
4.	Silence alarms on monitor, as necessary.	
5.	Attach sterile discard syringe to side port of stopcock of distal lumen of PA catheter.	
6.	Turn stopcock off to the flush solution.	
7.	Slowly and gently aspirate the discard volume.	The discard volume includes the dead space from the tip of the distal lumen to the top port of the stopcock and the blood diluted by the flush solution. This is approximately 3.5 – 4 mL.
8.	Turn the stopcock off to the syringe.	Stops blood flow, and prevents blood loss and air embolus.
9.	Remove the syringe and discard.	
10.	Attach blood gas sampling syringe to stopcock of distal lumen of PA catheter.	
11.	Turn the stopcock off the flush system.	
12.	Slowly aspirate the required amount of blood for the blood gas sample.	Slow aspiration is important to prevent contamination of the mixed venous sample with arterial blood from the pulmonary capillaries, which will falsely elevate the SvO_2 value. Typically 0.5 – 1 mL of blood is required for blood gas analysis. If obtaining arterial-venous oxygen difference (AVO2 diff), ensure the venous blood sample is drawn within one minute of an arterial blood sample.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
13. Turn the stopcock off to the syringe.	Stops blood flow and prevents blood loss.
14. Remove the blood gas sample syringe from the stopcock.	
15. Expel any air bubbles from the blood gas sample syringe and cap the syringe.	To expel air, hold the syringe upright, gently tap and push plunger forcing air bubbles present in the syringe out onto gauze, and then cap the syringe.
16. Roll blood gas sample syringe between palms of hand.	
17. Turn the stopcock off to the patient.	
18. Hold gauze beneath the stopcock.	To avoid contamination of the side port of the stopcock and possible catheter-related infection, maintaining sterility of side port at all times.
19. Using the fast flush device, flush blood out of the stopcock until clear.	
20. Cap the stopcock using the existing non-vented cap.	Replace with a new-non-vented cap it sterility of the existing cap is questionable.
21. Turn the stopcock off to the side port of the stopcock.	
22. Using the fast flush device, flush the remaining blood in the PA catheter back into the patient.	Residual blood in the PA lumen dampens the waveform and also increases the chance of catheter-related infections.
23. Observe the monitor for the return of the PA waveform.	
24. Ensure alarms are enabled on the monitor.	
25. Complete lab requisition form.	
26. Place specimen in transport bag with requisition and send to respiratory department for analysis.	

PROCEDURE:	**SPECIAL CONSIDERATIONS:**

DOCUMENTATION:

1. Add specimen to EPR order or unit specific nursing documentation Tool

PART H: REMOVAL OF A PULMONARY ARTERY CATHETER (PAC)

EQUIPMENT:

1. 2 pair – non-sterile gloves.
2. 1 - Hemostasis valve obturator (locking cap).
3. 1 - Disposable absorbent pad.
4. 2 - Chlorhexidine 2% with 70% alcohol swab stick.
5. Sterile scissors and specimen container if catheter tip needs to be cultured.
6. Transparent semi-permeable membrane (TSM) dressing or sterile gauze dressing.
7. PA cath in situ

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
1. Perform hand hygiene before direct patient contact and subsequently as clinically indicated.	
2. Don clean gloves.	
3. Discontinue and transfer all necessary IV solutions/medications from the PA catheter to alternate IV sites leaving stopcocks attached to the PA catheter in an off position.	
4. Place the disposable absorbent pad under the site to collect any blood or body fluids and to act as receptacle for the contaminated catheter.	
5. Place the patient supine with head of bed flat or in a slight Trendelenberg position.	The level of the insertion site should be below the level of the heart to minimize the risk of venous air embolus.
6. Have the patient turn their head away from the insertion site, if the PA catheter is located in the internal jugular or subclavian vein.	To reduce the risk of contamination and ease of access to the catheter.

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
7. Ensure the PA catheter balloon inflation valve is open and the balloon is deflated.	Removal of the PA catheter with the balloon inflated could cause serious damage to the pulmonary or tricuspid valve.
8. If necessary, remove the dressing from the central line insertion site and discard.	
9. Unlock and loosen the PA catheter contamination shield from the introducer.	
10. Ask the patient to take a deep breath and hold it. This may be practiced with the patient prior to removal.	During spontaneous breathing, negative intrathoracic pressures can encourage air to enter the insertion site and cause an air embolism. If the patient is ventilated or unable to cooperate with instructions, remove PA catheter at the end of inspiration.
11. While stabilizing the introducer, gently withdraw the PA catheter using a constant, steady motion.	Observe the ECG monitor for ectopy during removal. If arrhythmia occurs, continue to remove the device. If resistance is met, discontinue the procedure, secure catheter in place with a sterile dressing over insertion site and notify physician immediately.
12. Insert the hemostasis valve obturator into the introducer catheter and lock in position.	The hemostasis valve must be occluded to minimize the risk for air emboli or hemmorhage.
13. Have the patient exhale and resume breathing normally.	
14. Inspect the catheter tip for integrity.	If the catheter is not intact, notify the physician.
15. Discard the PA catheter.	
16. Send catheter tip for culture if ordered.	

PROCEDURE:	**SPECIAL CONSIDERATIONS:**
17. If necessary, apply new dressing over the introducer site.	Follow your site specific guideline or nursing procedure for central venous access device (CVAD) dressing change or care.
18. Discard gloves, and perform hand hygiene after direct patient contact.	

DOCUMENTATION:

Intensive Care Flowsheet or Unit Specific Nursing Documentation Tool:

1. Site of PA Catheter and time of removal.
2. Patient's response to the procedure and presence of any ectopy.
3. If tip was sent for culture.

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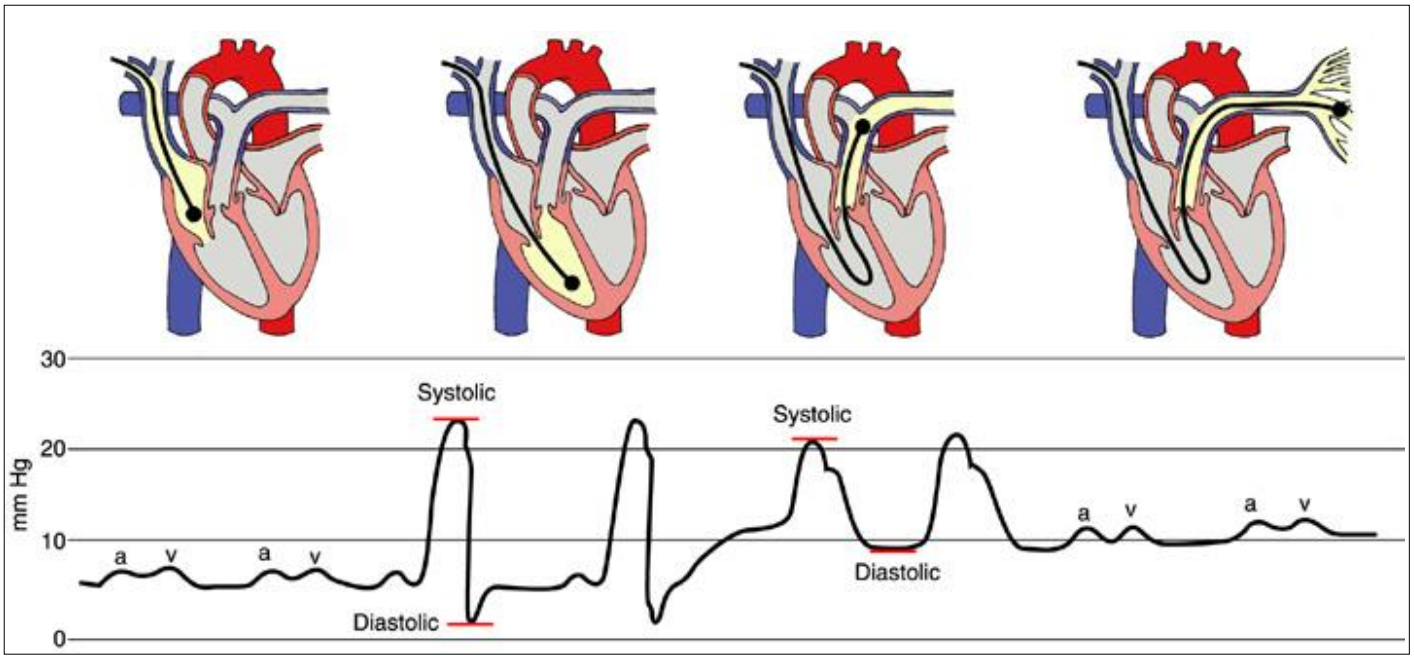
APPENDIX A

WAVES CONFIGURATIONS AND NORMAL VALUES USED AT ST. BONIFACE HOSPITAL FOR PULMONARY ARTERY CATHETER INSERTION



Right Atrial Pressure	Right Ventricular Pressure	Pulmonary Artery Pressure	Pulmonary Artery Wedge Pressure
1 - 6 mm Hg	Systolic: 20-30 mm Hg Diastolic: 1-6 mm Hg	Systolic: 20-30 mmHg Diastolic: 10-15 mm Hg	8-12 mm Hg

APPENDIX B

Computation Constants Edwards CO-Set+ Closed Injectate Delivery System

Edwards Swan-Ganz Catheter Model	Injectable Temperature			
	Cold Injectate		Room Temperature	
	10cc (6-12°C)	5cc (8-16°C)	10cc (18-25°C)	5cc (18-25°C)
096F6	0.558	0.277	0.607	0.301
131HF7	0.561	0.259	0.608	0.301
132F5	--	0.285	--	0.307
141HF7	0.561	0.259	0.608	0.301
143HTF7	0.569	0.266	0.589	0.287
C144H-7F/S 144H-7F	0.570	0.271	0.585	0.287
C145H-6F/S 145H-6F	0.570	0.271	0.585	0.287
151F7	0.561	0.259	0.608	0.301
831HF75	0.578	0.272	0.592	0.290
834HF75	0.574	0.287	0.595	0.298
931HF75	0.578	0.272	0.592	0.290
991HF8	0.553	0.277 (8-12°C)	0.607	0.295

3cc injectate volume not recommended. All computation constants are for the proximal injectate lumen only. For any catheters not listed above call Edwards Lifesciences Technical Support at 800.822.9837.

Edwards
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