Swan Dive into Hemodynamics: A Balloon-Filled Adventure

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Objectives

- Understand indications and technique for RHC
- Recognize key hemodynamic criteria for diagnosing pulmonary hypertension
- Review in-lab testing protocols for PH
- Learn technical aspects of the Swan-Ganz catheter
- Learn indications for RP Impella

Overview of Right Heart Catheterization

- Common indications:
  - Heart failure evaluation
  - Volume status assessment
  - Pulmonary hypertension assessment
  - Shock

- Insertion sites:
  - Internal jugular
  - Brachial
  - Femoral
  - Subclavian

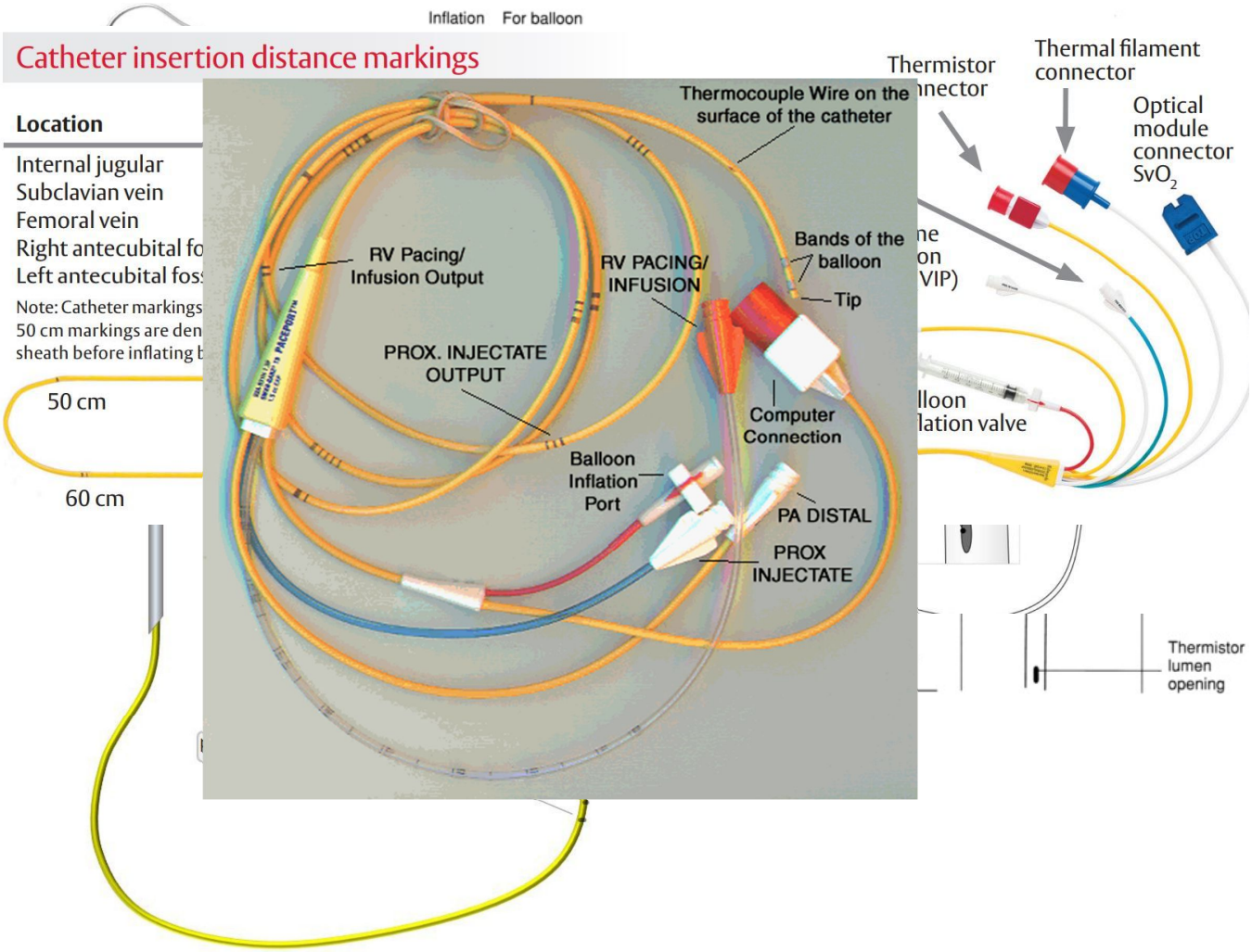
Hemodynamic Measurements

- Right atrial pressure (RAP)
- Right ventricular pressure (RVP)
- Pulmonary artery pressure (PAP)
- Pulmonary capillary wedge pressure (PCWP)
- Cardiac output/index (Fick and/or thermodilution method)
- Oxygen saturations from various chambers

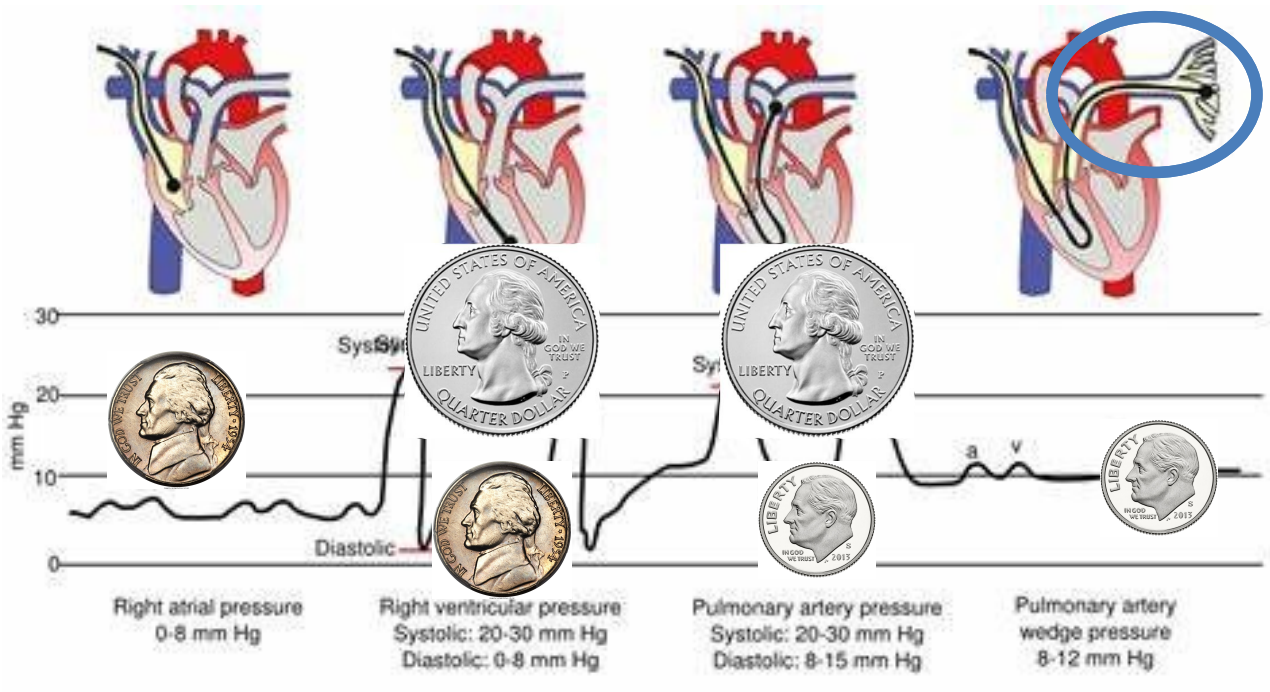
Swan-Ganz Catheter Functions

- Pressure waveforms: RA, RV, PA, PCWP
- Cardiac output via thermodilution
- Mixed venous saturation (SvO2) from PA
- Balloon inflation for wedge pressure
- Optional: Drug delivery, pacing (rare)

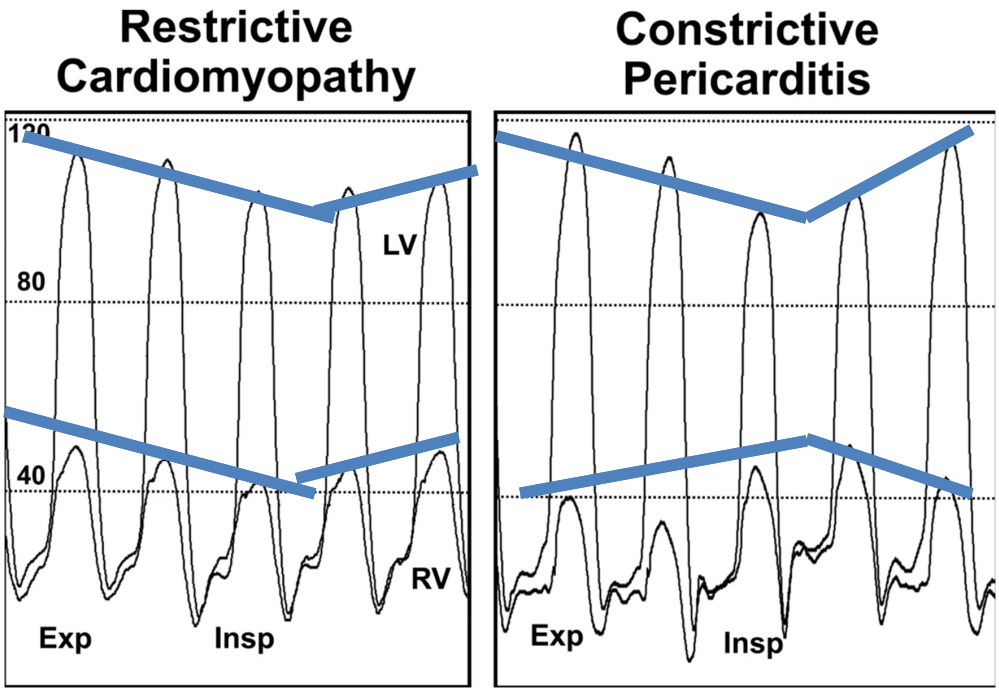
- Proximal injectate hub (blue lumen): The blue lumen, or CVP port, lies 30 cm from the tip of the PA catheter in the right atrium. It is used to assess right atrial pressure and central venous pressure. You can also infuse medications through this lumen, or the injectate for cardiac output studies.
- Volume infusion port (white lumen): The white lumen lies approximately 31 cm from the distal PA catheter tip and is used to infuse medications (dumps into RA/SVC).
- PA distal lumen hub (yellow lumen): The yellow lumen, or PA distal hub, is the distal port of the PA catheter. This lumen measures the pulmonary artery pressure, and may be used to draw a mixed venous sample. Caustic or hyperosmotic solutions must not be infused through the yellow lumen.
- Thermistor connector and Thermal filament connector: These ports include a temperature-sensitive wire that lies in the main pulmonary artery. These connectors allow the measurement of cardiac output via thermodilution.
- Balloon inflation valve (red lumen): The red lumen is the distal balloon port, which connects to a syringe (note that the plunger only withdraws to 1.5ml)


Inflation For balloon
Catheter insertion distance markings
Location
Internal jugular
Subclavian vein
Femoral vein
Right antecubital fo
Left antecubital foss
Note: Catheter markings
50 cm markings are den
sheath before inflating b
50 cm
60 cm
Thermistor
nector
Thermal filament connector
Optical module connector
SvO2
ne
on
VIP)
lloon
lation valve
Thermocouple Wire on the surface of the catheter
RV Pacing/ Infusion Output
RV PACING/ INFUSION
Bands of the balloon
Tip
PROX. INJECTATE OUTPUT
Computer Connection
Balloon Inflation Port
PA DISTAL
PROX INJECTATE
Thermistor lumen opening

Waveforms


30
20
10
0
mm Hg
Diastolic
a
v
Right atrial pressure
0-8 mm Hg
Right ventricular pressure
Systolic: 20-30 mm Hg
Diastolic: 0-8 mm Hg
Pulmonary artery pressure
Systolic: 20-30 mm Hg
Diastolic: 8-15 mm Hg
Pulmonary artery wedge pressure
8-12 mm Hg

Simultaneous LV/RV



Hemodynamics in the Cardiac Catheterization Laboratory of the 21st Century | Circulation

Diagnosis of Pulmonary Hypertension via RHC

- Mean PAP (mPAP) ≥ 20 mmHg
- Pre-capillary PH:
  - PAWP ≤ 15 mmHg
  - PVR ≥ 2 Woods units
- Post-capillary PH:
  - PAWP > 15 mmHg
  - PVR ≤ 2 Woods units

Differentiating PH Types

- Group 1: Pulmonary Arterial Hypertension (PAH)
- Group 2: PH due to left heart disease
- Group 3: PH due to lung disease/hypoxia
- Group 4: CTEPH (chronic thromboembolic)
- Group 5: Multifactorial or unclear mechanisms

Oxygen

- Hypoxia leads to vasoconstriction
- Vasoconstriction leads to blood shunting/re-routing

- 5 mins of O2 therapy to see if PA pressure drops
  - Repeat PA waveform
  - Repeat PA/Ao Sats (Fick CO/CI calculation)

Vasoreactivity Testing

- Performed in idiopathic/heritable PAH cases
- Predicts calcium channel blocker responsiveness
- Agents: Inhaled NO (preferred), IV epoprostenol, adenosine, nitroprusside
- Positive test:
- ↓ mPAP ≥10 mmHg to <40 mmHg
- No decrease in cardiac output

- Once systemic BP drops, or symptoms develop, repeat:
  - PA waveform
  - PA and Ao Sats (Fick CO/CI)

Volume Challenge & Exercise Testing

- Detect occult HFpEF or masked post-capillary PH
- Volume challenge: 500 mL NS over 5–10 min
- PAWP > 18 mmHg post-volume = post-capillary PH
- Exercise RHC: Performed with ergometer/saline bag bicep curls

Troubleshooting and Safety

- Avoid prolonged wedging or RV wedging
- Always deflate balloon before withdrawal
- Recognize abnormal waveforms (whip, overwedge)
- Monitor for arrhythmias, especially in RV
- Infection and thrombosis prevention protocols

Right Heart Failure

- RV Infarct
- AMI-CS
- LV Support (Impella, LVAD)- suction

- Cardiac Index < 2.2 L/min/m2 despite inotropes/pressors
- CVP > 15 mmHJg
- CVP/PCWP > 0.63
- PAPI < 1 ((PA sys-PA dia)/RAP))
- Echo findings- RV hypokinesis, TAPSE < 14 mm, dilated RV

Hemodynamics to consider RV support

- Cardiac Power Output < 0.6 Watts
- Lactic acid > 4
- PAPI < 1.0
- CI < 2.2 l/min/m2 despite inotropic support

Impella RP (FLEX)

- IJ (FLEX)/Femoral access (RP or FLEX)
- Distal parked in main PA
- Inlet/outlet opposite of left sided impella

Questions