

# Interpreting Right Heart Catheterization Findings

## Overview of Right Heart Catheterization

Right heart catheterization (RHC), also known as a pulmonary artery catheterization or Swan-Ganz catheterization, is an invasive procedure used to measure pressures in the heart and lungs and assess cardiac function. A catheter is inserted through a large vein (e.g., internal jugular, femoral, or subclavian) and advanced into the right atrium (RA), right ventricle (RV), pulmonary artery (PA), and finally into a wedged position (pulmonary artery wedge pressure, PAWP) to estimate left atrial pressure. RHC provides critical hemodynamic data to diagnose and manage conditions like heart failure, pulmonary hypertension (PH), shock, and valvular disease. This guide covers the interpretation of RHC findings, their clinical implications, associated diagnoses, management strategies, complications, and includes tables and clinical scenarios for practical application.

## Step-by-Step Guide to Interpreting RHC Findings

### Step 1: Understand Normal Values

RHC measures pressures, cardiac output (CO), and other parameters. Here are the normal ranges:

**Right Atrial Pressure (RAP):** 2-6 mmHg (reflects RV preload).

**Right Ventricular Pressure (RVP):** Systolic 15-30 mmHg, Diastolic 2-8 mmHg.

**Pulmonary Artery Pressure (PAP):** Systolic 15-30 mmHg, Diastolic 4-12 mmHg, Mean 9-18 mmHg.

**Pulmonary Artery Wedge Pressure (PAWP):** 4-12 mmHg (estimates left atrial pressure, reflects LV preload).

**Cardiac Output (CO):** 4-8 L/min (Fick method or thermodilution).

**Cardiac Index (CI):** 2.5-4 L/min/m<sup>2</sup> (CO/BSA, body surface area).

**Pulmonary Vascular Resistance (PVR):** 0.5-2 Wood units (WU) or 40-160 dynes·s/cm<sup>5</sup> (PVR = [Mean PAP - PAWP]/CO).

**Systemic Vascular Resistance (SVR):** 9-20 WU or 800-1200 dynes·s/cm<sup>5</sup> (SVR = [Mean Arterial Pressure - RAP]/CO × 80).

## Step 2: Interpret Pressures

---

- **Elevated RAP (>6 mmHg):**
  - Suggests RV dysfunction, volume overload (e.g., RV failure, tricuspid regurgitation), or increased downstream pressures (e.g., pulmonary hypertension).
- **Elevated RVP (Systolic >30 mmHg):**
  - Indicates RV pressure overload (e.g., pulmonary hypertension, pulmonary embolism, pulmonic stenosis).
- **Elevated PAP (Mean >20 mmHg):**
  - Defines pulmonary hypertension (PH). Classify using WHO groups (see below).
- **Elevated PAWP (>15 mmHg):**
  - Suggests left-sided heart dysfunction (e.g., LV failure, mitral stenosis, volume overload).
- **Low PAWP (<4 mmHg):**
  - Indicates hypovolemia or low LV preload (e.g., dehydration, shock).

## Step 3: Calculate Resistances and Cardiac Output

---

- **PVR:** High PVR (>3 WU) suggests pulmonary vascular disease (e.g., WHO Group 1 PH: pulmonary arterial hypertension [PAH], or Group 3: PH due to lung disease).
- **SVR:** High SVR (>20 WU) indicates systemic vasoconstriction (e.g., cardiogenic shock); low SVR (<9 WU) suggests vasodilation (e.g., septic shock).
- **CO/CI:**
  - **Low CI (<2.2 L/min/m<sup>2</sup>):** Suggests cardiogenic shock, RV failure, or hypovolemia.
  - **High CI (>4 L/min/m<sup>2</sup>):** Suggests hyperdynamic states (e.g., sepsis, anemia), or High output heart failure (HOHF if >6-8 L/min/m<sup>2</sup>)

## Step 4: Assess for Pulmonary Hypertension (PH)

---

- **Definition:** Mean PAP >20 mmHg at rest (2018 ESC/ERS guidelines).
- **Classify PH Using WHO Groups:**
  - **Group 1 (PAH):** High PAP, normal PAWP (≤15 mmHg), high PVR (>3 WU). Causes: Idiopathic PAH, connective tissue disease (e.g., scleroderma).

- **Group 2 (PH due to Left Heart Disease):** High PAP, high PAWP (>15 mmHg). Causes: LV systolic/diastolic dysfunction, mitral/aortic valve disease.
- **Group 3 (PH due to Lung Disease/Hypoxia):** High PAP, normal PAWP, high PVR. Causes: COPD, ILD, sleep apnea.
- **Group 4 (Chronic Thromboembolic PH, CTEPH):** High PAP, normal PAWP, high PVR, history of PE. Diagnose with V/Q scan, pulmonary angiography.
- **Group 5 (Miscellaneous):** High PAP, variable PAWP/PVR. Causes: Sarcoidosis, sickle cell disease.

## Step 5: Evaluate Shock States

---

**Cardiogenic Shock:** Low CI (<2.2 L/min/m<sup>2</sup>), high PAWP (>15 mmHg), high SVR (>20 WU). Causes: Acute MI, decompensated HF.

**Hypovolemic Shock:** Low RAP, low PAWP, low CI, high SVR. Causes: Hemorrhage, dehydration.

**Distributive Shock (e.g., Septic Shock):** Low SVR (<9 WU), high CI (>4 L/min/m<sup>2</sup>), variable PAWP. Causes: Sepsis, anaphylaxis.

**Obstructive Shock:** High RAP, high PAP, normal/low PAWP. Causes: Massive PE, tension pneumothorax.

## Clinical Implications and Associated Diagnoses

**Elevated RAP and PAP, Normal PAWP:** Suggests RV failure, PH (WHO Group 1, 3, 4), or pulmonary embolism.

**Elevated PAWP:** Indicates left-sided heart disease (WHO Group 2 PH), such as LV failure, mitral stenosis, or volume overload.

**Low CO/CI with High SVR:** Suggests cardiogenic shock (e.g., post-MI, RV failure).

**High CO/CI with Low SVR:** Suggests distributive shock (e.g., septic shock, liver failure).

**High PVR with Normal PAWP:** Suggests pulmonary vascular disease (e.g., PAH, CTEPH).

**Mixed Findings:** May indicate combined pathologies (e.g., ARDS with RV failure, or septic shock with underlying HF).

## Hospital Management Based on RHC Findings

- General Principles:
  - **Hemodynamic Monitoring:** Continuous RHC monitoring in ICU for unstable patients (e.g., shock, acute HF).
  - **Tailor Therapy:** Adjust fluids, vasopressors, inotropes, or diuretics based on RHC data.
  - **Address Underlying Cause:** Treat the primary diagnosis (e.g., antibiotics for sepsis, PCI for MI).
- Specific Management:
  - Cardiogenic Shock (Low CI, High PAWP, High SVR):
    - **Inotropes:** Dobutamine 2.5-20 µg/kg/min IV to improve CO.
    - **Vasodilators:** Nitroglycerin 5-20 µg/min IV if MAP allows (reduces preload/afterload).
    - **Diuretics:** Furosemide 20-40 mg IV if volume overload (PAWP >18 mmHg).
    - **Mechanical Support:** IABP or Impella if refractory; consult cardiology.
  - Hypovolemic Shock (Low RAP, Low PAWP, Low CI):
    - **Fluids:** NS/LR 30 mL/kg IV bolus to increase preload (RAP 8-12 mmHg, PAWP 12-15 mmHg).
    - **Blood Products:** PRBCs if hemorrhagic (Hgb <7 g/dL).
  - Septic Shock (Low SVR, High CI):
    - **Vasopressors:** Norepinephrine 5-20 µg/min IV to maintain MAP >65 mmHg.
    - **Fluids:** NS 30 mL/kg IV, titrate to RAP 8-12 mmHg.
    - **Antibiotics:** Broad-spectrum (e.g., piperacillin-tazobactam 4.5 g IV q6h + vancomycin 15 mg/kg IV q12h).
  - Pulmonary Hypertension (High PAP, High PVR):
    - **Group 1 (PAH):** Vasodilators (e.g., epoprostenol 2-4 ng/kg/min IV), consult PH specialist.
    - **Group 2 (Left Heart Disease):** Optimize HF (diuretics, ACEi, beta-blockers).
    - **Group 3 (Lung Disease):** Treat underlying lung disease (e.g., LTOT for COPD, steroids for ILD).
    - **Group 4 (CTEPH):** Pulmonary endarterectomy, consult cardiothoracic surgery.
  - Obstructive Shock (High RAP, High PAP, Normal PAWP):
    - **Pulmonary Embolism:** Heparin 80 units/kg IV bolus, then 18 units/kg/h; thrombolytics (alteplase 100 mg IV) if massive PE.
    - **Tension Pneumothorax:** Immediate chest tube placement.

- Complications of RHC:
  - **Arrhythmias:** 1-3% risk (e.g., VT from catheter in RV); manage with anti-arrhythmics (e.g., amiodarone 150 mg IV bolus).
  - **Infection:** 0.5-2% risk (e.g., catheter-related bloodstream infection); remove catheter, antibiotics.
  - **Pulmonary Artery Rupture:** Rare (<0.1%) but fatal; presents with hemoptysis, hypotension; emergent surgery.
  - **Pneumothorax:** 1-2% risk (if jugular/subclavian access); CXR post-procedure, chest tube if needed.
  - **Bleeding:** Hematoma at access site; apply pressure, monitor Hgb.
  - **Air Embolism:** Rare; presents with hypoxia, hypotension; place patient in Trendelenburg, 100% O<sub>2</sub>.

Table: Normal RHC Values and Clinical Implications

Parameter	Normal Range	Abnormal Finding	Clinical Implication	Associated Diagnoses
RAP	2-6 mmHg	>6 mmHg	RV dysfunction, volume overload	RV failure, tricuspid regurgitation, PH
PAP (Mean)	9-18 mmHg	>20 mmHg	Pulmonary hypertension	PAH, PH from left heart disease, CTEPH
PAWP	4-12 mmHg	>15 mmHg	Left-sided heart dysfunction	LV failure, mitral stenosis, volume overload
		<4 mmHg	Hypovolemia	Dehydration, hemorrhage
CO/CI	CO: 4-8 L/min, CI: 2.5-4 L/min/m <sup>2</sup>	CI <2.2 L/min/m <sup>2</sup>	Cardiogenic shock	Acute MI, RV failure
		CI >4 L/min/m <sup>2</sup>	Hyperdynamic state	Sepsis, anemia
PVR	0.5-2 WU	>3 WU	Pulmonary vascular disease	PAH, CTEPH, PH from lung disease
SVR	9-20 WU	>20 WU	Systemic vasoconstriction	Cardiogenic shock
		<9 WU	Vasodilation	Septic shock, anaphylaxis

Table: Management Based on RHC Findings

Diagnosis	RHC Findings	Management	Monitoring
Cardiogenic Shock	CI <2.2 L/min/m <sup>2</sup> , PAWP >15 mmHg, SVR >20 WU	Dobutamine 2.5-20 µg/kg/min IV, furosemide 20 mg IV	MAP >65 mmHg, CI q4h, ECHO

Diagnosis	RHC Findings	Management	Monitoring
Septic Shock	SVR <9 WU, CI >4 L/min/m <sup>2</sup> , variable PAWP	Norepinephrine 5-20 µg/min IV, NS 30 mL/kg	MAP >65 mmHg, lactate q6h, cultures
PAH (WHO Group 1)	PAP >20 mmHg, PAWP ≤15 mmHg, PVR >3 WU	Epoprostenol 2-4 ng/kg/min IV	6MWT, ECHO, BNP q3 months
Pulmonary Embolism	High RAP, high PAP, normal PAWP	Heparin 80 units/kg IV bolus, thrombolytics if massive	CT pulmonary angiography, RV function
Hypovolemic Shock	Low RAP, low PAWP, low CI	NS 30 mL/kg IV, PRBCs if hemorrhagic	RAP 8-12 mmHg, Hgb q6h

## Clinical Scenarios

### Scenario 1: Elderly Male with Cardiogenic Shock Post-MI

**Presentation:** A 70-year-old male with a recent MI presents with dyspnea, hypotension, and cool extremities. Exam shows T 36.5°C, BP 85/50 mmHg, HR 110 bpm, RR 24/min, SpO<sub>2</sub> 88% on 4 L/min, crackles, JVD.

**RHC Findings:** RAP 12 mmHg, PAP 40/20 mmHg (mean 28 mmHg), PAWP 22 mmHg, CI 1.8 L/min/m<sup>2</sup>, SVR 25 WU.

**Interpretation:** High RAP, PAP, PAWP, low CI, high SVR (cardiogenic shock, WHO Group 2 PH due to LV failure).

**Management:** Admit to ICU (shock). Start dobutamine 5 µg/kg/min IV (CI improves to 2.5 L/min/m<sup>2</sup>). Furosemide 40 mg IV (PAWP decreases to 16 mmHg). Consult cardiology: Urgent PCI for culprit lesion (LAD occlusion). Monitor MAP, CI q4h. After 3 days, BP 110/70 mmHg, discharged with HF meds.

### Scenario 2: Middle-Aged Female with Septic Shock

**Presentation:** A 50-year-old female with fever and hypotension after a UTI. Exam shows T 39°C, BP 90/60 mmHg, HR 120 bpm, RR 22/min, SpO<sub>2</sub> 92% on 2 L/min, warm extremities.

**RHC Findings:** RAP 6 mmHg, PAP 18/10 mmHg (mean 14 mmHg), PAWP 10 mmHg, CI 5.0 L/min/m<sup>2</sup>, SVR 8 WU.

**Interpretation:** Normal RAP, PAP, PAWP, high CI, low SVR (septic shock).

**Management:** Admit to ICU (sepsis). Start norepinephrine 10 µg/min IV (MAP 70 mmHg), NS 30 mL/kg. Antibiotics (piperacillin-tazobactam 4.5 g IV q6h + vancomycin 15 mg/kg IV q12h). Cultures grow E. coli. Monitor lactate (decreases from 3.0 to 1.5 mmol/L). After 2 days, wean vasopressors, discharged on oral antibiotics.

### Scenario 3: Young Female with Idiopathic PAH

---

**Presentation:** A 35-year-old female presents with dyspnea and fatigue. Exam shows T 37°C, BP 110/70 mmHg, HR 90 bpm, RR 20/min, SpO2 90% on room air, RV heave, loud P2.

**RHC Findings:** RAP 8 mmHg, PAP 60/30 mmHg (mean 40 mmHg), PAWP 10 mmHg, CI 2.8 L/min/m<sup>2</sup>, PVR 5 WU.

**Interpretation:** High PAP, normal PAWP, high PVR (WHO Group 1 PH: idiopathic PAH).

**Management:** Admit for evaluation. Consult PH specialist: Start epoprostenol 2 ng/kg/min IV, titrate up. Oxygen 2 L/min (SpO2 94%). ECHO confirms RV dilation. Plan for vasodilator testing (e.g., nitric oxide challenge). Monitor 6MWT, BNP. After 5 days, dyspnea improves, discharged with PH follow-up.

**Visit: [medcheatsheets.com](https://medcheatsheets.com) for more education, fun resources and 10 category 1 AAPA CME credit!**

© Hospital Medicine Cheat Sheets ([medcheatsheets.com](https://medcheatsheets.com)). For educational purposes only. Do not redistribute or sell. Neither the author nor the company is liable for realworld implications. AI was used in development