Cateterismo Derecho.
Indicaciones y Problemas.

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(1998-2012)

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CARDIOLOGIA       NEUMOLOGIA

Activitat assistencial
- 200 malalts amb HAP
- 5 cateterismes setmanals
- Test de vasodilatació aguda
- Hemodinàmica en exercici

Activitat docent/investigadora
- Cursos multidisciplinars de HAP
- Estudis multicèntrics
- Activitat investigadora pròpia:
  3 estudis i 1 assaig clínic
- Corbes P-V de VD
- IVUS i OCT d’artèria pulmonar
Figure. The double lumen balloon flotation catheter and its placement at the bedside without fluoroscopy. Figure courtesy of Dr Peter Ganz, Chief of Cardiology at San Francisco General Hospital, University of California, San Francisco.
The effectiveness of right heart catheterization in the initial care of critically ill patients.

SUPPORT Investigators.


Source
Department of Medicine, Case Western Reserve University at MetroHealth Medical Center, Cleveland, Ohio, USA.

- **DESIGN:**
  - Prospective cohort study.

- **SETTING:**

- **SUBJECTS:**
  - A total of 5735 critically ill adult patients receiving care in an ICU for 1 of 9 prespecified disease categories.

**CONCLUSION:**
In this observational study of critically ill patients, after adjustment for treatment selection bias, RHC was associated with increased mortality and increased utilization of resources. The cause of this apparent lack of benefit is unclear. The results of this analysis should be confirmed in other observational studies.
• The proportion of incorrect answers to some basic items was disturbingly high. For instance, [approximately]50% of the respondents, whether trained or in training, did not correctly identify pulmonary artery occlusion pressure from a clear chart recording.

• Conclusions: Knowledge of right-heart pulmonary artery catheterization is not uniformly good among ICU physicians. Accreditation policies and teaching practices concerning this technique need urgent revision.
The Swan-Ganz Catheters: Past, Present, and Future: A Viewpoint

Kanu Chatterjee

*Circulation.* 2009;119:147-152

- Pulmonary artery catheterization with the use of balloon flotation catheters is an easy and rapid technique for bedside hemodynamic monitoring.
- However, its abuse has been associated with complications that can be avoided if it is used by experienced operators.
- The randomized clinical trials in patients with acute coronary syndrome, noncoronary high-risk patients (including noncardiac surgical patients and patients with sepsis and ARDS), and patients with chronic heart failure have established that its routine use is not necessary and may be associated with increased complications, including death.
- However, it is still necessary in patients with cardiogenic shock, for the differential diagnosis of pulmonary arterial hypertension, and for diagnosis and treatment of uncommon causes and complications of heart failure.
- In patients with severe chronic heart failure requiring inotropic, vasopressor, and vasodilator therapy, hemodynamic monitoring is essential.
- For heart and lung transplantation workup, hemodynamic monitoring is always necessary.
Current Indications for Use of the Swan-Ganz Catheter.
K. ChatterjeeCirculation, 2009;119:147-152

- Not indicated as routine pulmonary artery catheterization in high-risk cardiac and noncardiac patients
- Indicated in patients with cardiogenic shock during supportive therapy
- Indicated in patients with discordant right and left ventricular failure
- Indicated in patients with severe chronic heart failure requiring inotropic, vasopressor, and vasodilator therapy
- Indicated in patients with suspected “pseudosepsis” (high cardiac output, low systemic vascular resistance, elevated right atrial and pulmonary capillary wedge pressures)
- Indicated in some patients with potentially reversible systolic heart failure such as fulminant myocarditis and peripartum cardiomyopathy
- Indicated for the hemodynamic differential diagnosis of pulmonary hypertension
- Indicated to assess response to therapy in patients with precapillary and mixed types of pulmonary hypertension and for the transplantation workup
Cardiac Output - Thermodilution

FIG 1 (Braunwald, 2001): Typical thermodilution curves- temperature on y axis and time on x axis; Cardiac output is inversely proportional to area under the curve

• PITFALLS: - severe tricuspid regurgitation (alters accuracy of measurements in an unpredictable manner),
  - very low cardiac output states (calculated outputs tend to be overestimated as temperature dissipates into surrounding cardiac structures)
Fick cardiac output

PITFALLS: VO2 calculated from a body surface area equation can be quite inaccurate (e.g. 1 MET = 3.5 cc O2/kg/min is often an underestimate of work in the decompensated patient); therefore trending mixed venous saturations to see trends in cardiac output is more useful than looking at the absolute value of the Fick cardiac output itself.
Pulmonary capillary wedge tracing with a and v waves and x and y descents. The mean should be taken at end expiration which is at the peak plateau in a spontaneously breathing patient.
Example of pulmonary artery tracing with dicrotic notch formed by closure of the pulmonary valve marking the end of systole. Note the respirophasic variation in pressures.
Presión Capilar Pulmonar.
Metodología de Obtención.
• **pulmonary capillary wedge pressure**
• **noun** An indirect indication of left atrial pressure obtained by wedging a catheter into a small pulmonary artery tightly enough to block flow from behind and thus to sample the pressure beyond.
INVASIVE HEMODYNAMIC MONITORING

- 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
The proximal lumen, usually blue, typically opens into the right atrium. In addition to measuring right atrial pressure, it delivers the bolus injection that's used to measure cardiac output and functions as a fluid infusion route.

The distal lumen, usually yellow, opens into the pulmonary artery. When attached to a transducer, it allows you to measure PAWP.

The balloon inflation valve serves as the access point for inflating the balloon at the distal tip of the catheter for PAWP measurement.

The inflated balloon wedges in a branch of the pulmonary artery during PAWP measurement.

The thermistor measures core body temperature. When connected to a cardiac output monitor, it measures temperature changes related to cardiac output.
Figure 3: The phlebostatic axis, marked on the patient's chest, is the precise anatomical point of origin of the hemodynamic pressures being measured.
PCP = PAOP

- Pulmonary Vascular Resistance low
- No significant venous resistance

Balloon-tipped, Swan-Ganz catheter for measuring pulmonary capillary wedge pressure (PCWP).
• **Dampened waveform** – can occur with physical defects of the heart or catheter; can be caused by kinks, air bubbles in the system, or clots

  **Solution:** Check your line for kinks & air bubbles, aspirate (not flush) for clots, straighten out tubing or patient as much as possible

• **No waveform** – can occur with non-perfusing arrhythmias or line disconnection

  **Solution:** Check your line for disconnection, check your patient for pulse, could also be wet transducer or broken cable or box
Pulmonary Capillary Wedge Pressure (PCWP)

- Zero the transducer to the patient’s phlebostatic axis.
- Measure the PCWP at end expiration
- PCWP should not be higher than PA diastolic
- PCWP is an indirect measurement of left ventricular end diastolic pressure.
PAOP is less than diastolic PAP
• Tracing compatible with Atrial Pressure Waveform
• Stationary catheter after inflation in fluoro
• Free flow is present within the catheter
• Highly O2 blood is obtained from the distal port

At least 4 out of 5 !

PAOP is the Pulmonary Arterial Catheter Derived Pressure Subject to the Greatest Error in Measurement and Interpretation
RESPIRATORY INFLUENCE ON HEMODYNAMIC WAVEFORMS

In the spontaneously breathing patient, inspiration is the fall in pressure, expiration is the rise in pressure. End expiration occurs just prior to the inspiratory drop in the waveform: this is where the pressure reading should be taken.
PCP – Normal Respiration
PCP – Relaxed Respiratory Pause (10 sec)
• Document PAS, PAD, and PCWP on nursing flowsheet under Hemodynamic Parameters
• PCWP will **rarely** be > PAD (if so, means blood is flowing backwards) If PCWP = PAD, look for tamponade
• Under circumstances where the catheter will not wedge (or should not be), do **not** document any values in the PCWP column on the flowsheet
• If you use the PAD measurement for calculations, it **is** acceptable to write **ONLY**
  “PAD value used for calculations” at the top of your numbers
Table 1—Analysis of Pulmonary Capillary Wedge Pressure as a Test for Pulmonary Arterial Hypertension

<table>
<thead>
<tr>
<th></th>
<th>Positive (LVEDP ≤ 15 mm Hg)</th>
<th>Negative (LVEDP &gt; 15 mm Hg)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive test</td>
<td>270</td>
<td>310</td>
<td>580</td>
</tr>
<tr>
<td>(PCWP ≤ 15 mm Hg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative test</td>
<td>152</td>
<td>3,194</td>
<td>3,346</td>
</tr>
<tr>
<td>(PCWP &gt; 15 mm Hg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>422</td>
<td>3,504</td>
<td>3,926</td>
</tr>
</tbody>
</table>

LVEDP = left ventricular end-diastolic pressure; PCWP = pulmonary capillary wedge pressure.
PCWP / LVEDP.
Chest 2009, Halpern
It is not possible to reliably measure PAOP in PH by using fixed volumes of balloon inflation (Swan, 1970; 0.8 ml).
Ballon Inflation Volume on PAOP
Tonelli, Chest 2010

SO2 89%  SO2 97%  SO2 71%  SO2 99%
R PA  R 1.5 ml  R 0.75 ml  L PA  L 1.5 ml  L 0.75 ml
PAOP
Balloon Volume Inflation

• Safeness of using balloon half inflation: catheter tip NOT fully protected.
• Validity of PAOP in PH varies according to balloon inflation.
• Half balloon inflation is safe, more reproducible and precise.
PCP in HP.
Critical Care 2005, R. Souza
Monoexponential fitting curve

[Graph showing pulmonary artery pressure over time with annotations for Balloon Occlusion and MONO 0, MONO 150]
PCP in HP.
Critical Care 2005, R. Souza
Biexponential fitting curve
At least 1 second after steady state

PCP in HP.
Critical Care 2005, R. Souza
Biexponential fitting curve
PCP is elevated in PH, although its interpretation must take into account the methodological limitations of measurement using the arterial occlusion technique. The time constants of pulmonary artery emptying may differ according to the disease process.

The time constants may be useful for increasing the accuracy of PCP measurement using the arterial occlusion technique.

In PH the arteriolar territory is heterogenously abnormal and longer periods may be required for complete emptying (0.75 seconds for 95% emptying).

In addition venous resistance seems to be increased in PH.
Qué hacemos nosotros?

- Hemodinamista dedicado a la HP y al cateterismo derecho.
- Avanzar el SG hasta el máximo e inflar el balón. Si la curva es morfológicamente correcta, con valor inferior a la PAD, y el balón está estable se acepta como correcta.
- Si la anterior maniobra no es suficiente, desinflar el balón, avanzar más el catéter, insuflar el balón progresivamente hasta lograr una curva correcta. El volumen de inflado puede variar entre pacientes.
- En caso de duda obtener muestra distal de sangre para análisis de saturación.
- Siempre tener presente las limitaciones técnicas de la PAOP para medir la PCP.
Case of acute mitral regurgitation with poor left atrial compliance as manifested by increased PCW pressures and giant v wave; notice that the v wave is transmitted to the PA tracing as well

- Differential for giant v wave includes: any condition that causes LA dilation and noncompliance (e.g. acute ischemia, dilated cardiomyopathy), acute VSD from increased pulmonary blood flow
Case of cardiac tamponade with equalization of RA, PA diastolic and RV diastolic pressures at 15 mm Hg; there is marked attenuation of the y descent on the RA tracing
PCWP / LVEDP.
Chest 2009, Halpern

RHC performed: 12,823 Patients

Excluded due to:
mitral stenosis: 69
tachycardia: 25

Eligible for study: 12,744 Patients

Simultaneous LHC and RHC: 11,523

RHC only: 1,211 patients

mPAP missing: 86

mPAP < 25 mmHg: 7,117
mPAP ≥ 25 mmHg: 4,320

LVEDP missing: 346
PCWP missing: 48

3,926 evaluable patients with pulmonary hypertension

PCWP ≤ 15: 580
PCWP > 15: 3,346

867 evaluable patients with pulmonary hypertension

PCWP ≤ 15: 240
PCWP > 15: 627