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UPDATE IN INTENSIVE CARE MEDICINE: HEMODYNAMIC MONITORIZATION IN THE CRITICAL PATIENT

Techniques available for hemodynamic monitoring. Advantages and limitations☆

M.L. Mateu Campos[a,*], A. Ferrándiz Sellés[a], G. Gruartmoner de Vera[b], J. Mesquida Febrer[b], C. Sabatier Cloarec[b], Y. Poveda Hernández[c], X. García Nogales[b]

[a] *Servicio de Medicina Intensiva, Hospital Universitario General de Castellón, Castellón, Spain*
[b] *Área de Críticos, Hospital de Sabadell, Institut Universitari Parc Taulí, Centro de Investigación Biomédica en Red (CIBER) en Enfermedades Respiratorias, Sabadell, Barcelona, Spain*
[c] *Servicio de Medicina Intensiva, Hospital Santiago Apóstol, Vitoria, Álava, Spain*

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Abstract The pulmonary artery catheter has been a key tool for monitoring hemodynamic status in the intensive care unit for nearly 40 years. During this period of time, it has been the hemodynamic monitoring technique most commonly used for the diagnosis of many clinical situations, allowing clinicians to understand the underlying cardiovascular physiopathology, and helping to guide treatment interventions. However, in recent years, the usefulness of pulmonary artery catheterization has been questioned. Technological advances have introduced new and less invasive hemodynamic monitoring techniques.

This review provides a systematic update on the hemodynamic variables offered by cardiac output monitoring devices, taking into consideration their clinical usefulness and their inherent limitations, with a view to using the supplied information in an efficient way.

PALABRAS CLAVE
Monitorización hemodinámica;
Gasto cardiaco;
Parámetros hemodinámicos

Técnicas disponibles de monitorización hemodinámica. Ventajas y limitaciones

Resumen El catéter de la arteria pulmonar (CAP) ha constituido una herramienta fundamental para la monitorización hemodinámica en las unidades de cuidados intensivos durante los últimos 40 años. Durante este período de tiempo ha sido ampliamente usado en pacientes críticos para el diagnóstico y como guía del tratamiento, ayudando a los clínicos a entender la fisiopatología de muchos procesos hemodinámicos. Sin embargo, en los últimos años la utilidad del CAP ha sido sometida a un intenso debate. Paralelamente, los avances tecnológicos han permitido el desarrollo de nuevas técnicas, menos invasivas, para la monitorización cardiovascular. Esta puesta al día pretende dar a los clínicos una visión de los parámetros hemodinámicos que

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* Corresponding author.
E-mail address: lidonmateu@gmail.com (M.L. Mateu Campos).

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aportan los distintos métodos disponibles, considerando que es fundamental comprender tanto su potencial utilidad clínica como sus limitaciones para un uso eficaz de la información que proporcionan.

Introduction

For the past 40 years, the pulmonary artery catheter (PAC) has been a fundamental tool in the hemodynamic monitorization of patients admitted to the Intensive Care Unit (ICU).[1] During this period of time, it has been widely used in critical patients for diagnostic purposes and as a guide to treatment, helping clinicians to understand the physiopathology of a broad range of hemodynamic processes. However, in recent years the usefulness of the PAC has been the subject of intense debate, fundamentally due to the publication of studies in which its use was not found to be associated with benefits in terms of patient survival.[2–7] In fact, several of these studies reported an increase in mortality associated with the use of the catheter.[2,3] At the same time, technological advances have made it possible to use less invasive procedures for cardiovascular monitorization—reinforcing the idea that the systematic utilization of the PAC may have come to an end. Despite the controversy, however, there is no doubt that the PAC can be used to obtain unique, valuable and useful hemodynamic variables in critically ill patients.[8,9]

In recent years, new methods have come to replace the PAC in the determination of cardiac output (CO). These new technologies are highly diverse, ranging from very invasive to less invasive or even noninvasive, from intermittent to continuous, and involving different basic principles, methods and costs. Some of the methods offer dynamic fluid response indices, which are currently regarded as better predictors of the response to volume expansion, while others allow us to evaluate volumetric preload parameters or afford continuous central venous saturation measurements. All of these variables, together with CO, contribute to improve the hemodynamic monitorization of critical patients.[10] However, to date, none of the mentioned techniques exhibit optimum or ideal characteristics, i.e., noninvasiveness, continuous measurement, reliability, reproducibility, convenience for both the patient and physician, accuracy and minimum side effects.[11,12] Consequently, the utilization of each of them fundamentally depends on their availability and on the knowledge or aptitudes of the professional.

All of these techniques have been evaluated and validated by comparing their results with those of the gold standard, which continues to be intermittent thermodilution of the pulmonary artery.

The present update aims to offer clinicians a vision of the hemodynamic parameters afforded by the different methods which are currently available, considering that it is essential to understand both their potential clinical usefulness and their limitations in order to ensure effective use of the information obtained in each case.

Invasive methods

Pulmonary artery or Swan–Ganz catheter

This catheter was introduced by J.C. Swan and W. Ganz in 1970. It is advanced through a large caliber vein to the right side of the heart and into the pulmonary artery, where its distal tip is positioned in a branch of the artery. The PAC offers information referred to three categories of different variables: measurements of blood flow (CO), intrathoracic intravascular pressures, and oximetric parameters.

Measurements of blood flow

The measurement of CO using this catheter is based on transcardiac thermodilution. After injecting a volume of liquid at a temperature below the temperature of the blood, the thermistor detects the temperature changes over time in the form of a curve. The area under this curve (AUC) is the minute volume. The details referred to the measurement of CO, and the technical limitations involved (tricuspid valve insufficiency, etc.), have been extensively addressed in previous ''Updates in hemodynamic monitorization''.[13]

Measurement of intrathoracic intravascular pressures

The PAC, when correctly positioned, allows us to record pressures in three different locations: right atrium (central venous pressure, CVP), pulmonary artery (pulmonary artery pressure, PAP) and the pulmonary veins (also called pulmonary occlusion or wedge pressure, PWP). Originally, the PAC was developed for the measurement of PWP, which corresponds to the pulmonary venous pressure distal to the pulmonary capillary bed (hence the commonly used term of pulmonary capillary wedge pressure, or PCWP), affording an indirect estimate of left atrial pressure (LAP). In fact, even today PCWP affords the best patient bedside estimate of pulmonary venous pressure, contributing to assess both pulmonary resistances and left atrial preload. To this effect there is no practical alternative to PCWP. Recently, a series of pulmonary venous flow measurements have been proposed, using Doppler echocardiography, for the estimation of PCWP,[14] though the variables obtained using Doppler ultrasound derived from transmitral flow (TMF) and pulmonary venous flow (PVF) are inexact, time consuming to obtain, cannot be recorded in all patients, and require important experience beyond the basic principles of echocardiography.[15] Nevertheless, in recent years new parameters have been developed, based on tissue Doppler ultrasound, which afford increased accuracy. In any case, the usefulness of PCWP in the critical patient requires redefinition. It has been repeatedly and consistently shown that PCWP has low predictive value in the evaluation of volume