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UPDATE IN INTENSIVE CARE: HEMODYNAMIC MONITORING IN THE CRITICALLY ILL PATIENT

Introduction of the ''Up-date'' series. Hemodynamic monitoring in critically ill patient☆

Introducción de la serie «Puesta al día»: Monitorización hemodinámica en el paciente crítico

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Hemodynamic monitorization is a crucial aspect in the care of the hypoperfused patient, offering information on cardiovascular physiopathology that allows us to differentiate among the different causes of hemodynamic instability. In addition, the data obtained can help guide treatment intervention, which ultimately may improve patient prognosis. The main reasons for indicating hemodynamic monitorization are the detection of cardiovascular alterations before multiorgan failure develops, and assistance in monitoring patient response to therapy. It is important to note that hemodynamic monitorization is only a diagnostic tool, and that it therefore cannot improve the prognosis unless it is accompanied by adequate treatment measures capable of improving the clinical course of the patient. In this respect, the determinant factors influencing the outcome of such treatment interventions are correct interpretation of the data obtained, precise timing of treatment, and the patient population involved. The introduction of the pulmonary arterial catheter by Swan and Ganz in 1970 constituted a turning point in monitorization in the intensive care setting, and has been the most widely used hemodynamic monitoring technique in the past decades. The Swan–Ganz catheter has undeniably represented a very important step forward in our knowledge of cardiovascular function in the critically ill patient – allowing the determination of intravascular pressures (pulmonary arterial pressure, right atrial pressure and pulmonary arterial wedge pressure), the calculation of cardiac output via the thermodilution method, and access to mixed venous blood, in the setting of the complex course of the different types of shock. From its introduction, modifications have been made that have further expanded the information provided by the technique; in this context, we can establish the ejection fraction, right ventricle volumes, mixed venous oxygen saturation (SvO_2), and cardiac output on a continuous basis – as well as the possibility of inserting electrocatheters in the right atrium and ventricle.

However, the limitations, indications and usefulness of the pulmonary arterial catheter remain subject to controversy, despite its widespread use. This is largely due to scant knowledge of the bases of pulmonary artery catheterization, error in data interpretation and, consequently, the application of inappropriate therapies. As a result of the above, there has been an intensification of the search for new monitoring methods affording information on cardiovascular function in the critical patient.

Ideal hemodynamic monitorization should be scantly invasive, reliable, precise, easy to perform, continuous and applicable at the patient bedside. No system offering all these features has yet been developed, though the

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technological advances of recent years contribute ''new parameters'' with which to explore the most important aspects of patient hemodynamics, such as preload level, preload dependency, ventricle function or assessment of the objectives or goals of hemodynamic resuscitation. On the other hand, the market now offers ''new technology'' allowing us to obtain the ''old parameters'' (e.g., cardiac output) in a less invasive manner, together with many of the aforementioned ''new parameters'' incorporated to clinical practice.

Within the technological progression of hemodynamic monitorization, special mention should be made of echocardiography. Although this is not a true continuous monitorization system, it can be enormously useful for assessing cardiovascular function in the critical patient, since it offers real-time imaging at the patient bedside in a noninvasive (transthoracic echocardiography, TTE) or minimally invasive manner (transesophageal echocardiography, TEE). The evaluation of cardiocirculatory function in shock conditions is one of the main indications of echocardiography in the ICU. This noninvasive or minimally invasive procedure allows us to quickly establish an etiological diagnosis (cardiac tamponade, acute myocardial infarction and its complications, severe ventricular dysfunction, hypovolemia, etc.), and moreover affords rapid and reliable hemodynamic assessment. Therefore, echocardiography may be very useful as a guide and in the monitorization of treatments in situations of hemodynamic instability.

The multiple applications of echocardiography in the management of critical patients have led it to become increasingly used in the ICU, and many intensive care societies in different countries throughout the world are promoting intensivist familiarization with the technique, proposing basic and goal-directed training in echocardiography for all intensivists, i.e., training destined to resolve specific issues in Intensive Care Medicine. The joint recommendations of the societies in France and the United States regarding competences in ultrasound in the ICU have recently been published. These recommendations specify the skills and competences required for the different levels of knowledge referred to echocardiography in the ICU.

The Cardiological Intensive Care and CPR Working Group *(GTCIC y RCP)* of the Spanish Society of Intensive and Critical Care Medicine and Coronary Units *(Sociedad Española de Medicina Intensiva, Critica y Unidades Coronarias, SEMICYUC)* has developed many teaching and scientific areas related to cardiovascular disease in the critically ill patient, and at present has wished to impulse the development of an update in hemodynamic monitorization, analyzing its fundamental aspects: the objectives or goals of hemodynamic resuscitation (oxygen transport, tissue oxygenation and microcirculation), the estimation of cardiac output (usefulness in clinical practice and available monitorization), the assessment of preload and cardiovascular response to volume replacement, the evaluation of contractility and postload in the critical patient, the techniques available for hemodynamic monitorization (advantages and limitations), the usefulness of echocardiography in hemodynamic resuscitation, and evidence of the usefulness of hemodynamic monitorization. On the other hand, the Working Group aims to develop and publish recommendations in hemodynamic monitorization of critical patients, following completion and publication of the ''Update'' series, based on the contents of the different chapters. The idea is to offer intensivists and residents and training an update to further their knowledge of the different types of monitorization in hemodynamics, with recommendations that are useful in daily clinical practice.

The authors of this ''Update'' series are mostly members of the mentioned Working Group *(GTCIC y RCP)*, though several of the participants belong to other scientific societies also related to hemodynamic monitorization. We would like to thank all these professionals, the Working Group and the coordinators of the series, for their enthusiasm, dedication and commitment to this project. In turn, thanks are also due to the journal *Medicina Intensiva* for offering the opportunity to publish this series, and for its unconditional support of the initiative.

Conflicts of interest

The authors have no conflicts of interest to declare.