Chapter 1

Introductory Chapter: Hemodynamic Management. The Problem of Monitoring Choice

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Additional information is available at the end of the chapter

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1. Introduction

Technology progress has given us the opportunity to monitor almost every aspect of the cardiovascular system down to the level of tissue microcirculation. However, the choice of the right tool is often a challenge, depending both on institutional capabilities (availability of the device) and on operator training. The present chapter consists a short literature review about the subject.

It is more than three centuries that Reverend Stephen Hales have made the first invasive measurement of blood pressure and cardiac output [1]. During that time, there has been a tremendous progress both in hemodynamics physiology and pathophysiology understanding and in modes of cardiovascular monitoring. Today, it is considered basic and essential knowledge for every physician. The paradox: the more we know about cardiovascular circulation, the more we understand our ignorance. The present chapter focuses on some of the problems encountered during hemodynamic monitoring.

2. Describing the challenges

Current technology provides us with a vast range of tools for hemodynamic evaluation. Yet, whether it uses an invasive technique or not, performs one or more calculations provides with discrete or continuous data, seem to have minor importance. As any tool, we need to know its limitations and choose carefully. Vincent et al. [2] attempted to suggest the key principles of hemodynamic monitoring. The most important of them:

1. No hemodynamic monitoring technique can improve outcome by itself.
2. Monitoring requirements may very over time. Moreover, the highly depend on the availability of the devices and the training of the operators.

3. There are no optimal hemodynamic parameters for every patient.
4. We need to combine and integrate variables.
5. Continuous measurements are preferable.
6. Non-invasiveness is not the only issue.
7. Cardiac output is estimated not measured.

Chan and Khan [3] reviewed the problem from a more physiological point of view. They claimed that since there is no hemodynamic monitoring that can provide us data for the "whole" cardiovascular system and that the main role of the latter is oxygen delivery, we need to choose our monitoring according to the target part of the cardiovascular system and to aim at correlation of the data with oxygen delivery. Thus, we might have a better connection between monitoring and outcome.

Another issue brought up by Peter et al. [4, 5], is calibration. There are calibrated and non-calibrated techniques for hemodynamic monitoring. Though calibrated (invasive in the majority of them) methods seem to work better in unstable patients, careful interpretation of the provided data is needed. On the other hand, as new technology is integrated in medical devices, the future seems to belong to non-invasive techniques.

And what about continuity of data and of care? For example, pulmonary artery catheter (PAC), which triggered a boom in hemodynamic monitoring, provides only static variables. A snapshot of patient's status, often not enough to determine the right therapeutic strategy. Along with that if the same patient is admitted to Emergency Department with an A hemodynamic profile derived from arterial pressure wave, transported to ward where he had a B profile measured via suprasternal Doppler and ended in ICU where PAC and bio-impedance measurements are available, do we take in mind the previous profiles (A and B) or not? One option is to reject previous measurements, thus risking loosing valuable data. Another option is to just average measurements. However, plans based on average assumptions, are on average wrong.

The latter is even more valid for the therapeutic strategy that we may choose. If a drug causes on average an increase in cardiac output (CO), how do we know that our patient lies within this average?

The previous problem is perplexed by the fact that different modes of monitoring may provide us with different variables. CO may be a common parameter for various devices, yet extra lung water index, oxygen extraction ration, wedge pulmonary pressure, peak velocity and Doppler driven dp/dt may be harder to combine.

3. Solution

The aforementioned create a puzzle to solve each time a physician decides that hemodynamic monitoring is needed.

Monitoring that combines conditions and advantages of each monitoring technique could be a solution to the problem. Thus, for example CO based on partial CO_2 rebreathing is considered

less reliable in cases of respiratory failure [2, 6], right ventricular failure or tricuspid regurgitation may compromise PAC derived measurement of CO [7], Doppler flow studies focusing on the descending thoracic aorta may not provide a reliable measurement of the total cardiac output (for example, with epidural use), and are invalid in the presence of intra-aortic balloon pumping [6]. CO measurements derived from peripheral arterial pressure waveform have shown luck of accuracy in patients with intracerebral hemorrhage [8], functional hemodynamic parameters like pulse pressure variation or stroke volume variation need regular sinus rhythm, etc.

As a consequence, several reports tried to suggest guidelines for hemodynamic monitoring in specific conditions, like for example, circulatory shock [9], sepsis [10], or patients under thoracic anesthesia [11].

Personalized hemodynamic monitoring concept emerges as the best available option. This is a very difficult task in most cases, as it assumes the existence of a dynamic close loop system with constantly new hemodynamic targets – adjusted to specific patient within a given clinical and time frame [12, 13].

Yet, even though we cannot form an individualized guideline, ongoing research, both clinical, experimental (including computational modeling of cardiovascular system and simulation of different pathological conditions) will help us create and clarify the exact theoretic concept which will direct the management. Along with that, formation of clear institutional policy about both the availability and the training of the personnel of each healthcare facility are needed, in order to standardize and regulate the use of certain medical devices over others (within the institution).

Conflict of interests

The author has no conflict of interest.

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