Noninvasive Hemodynamic Monitoring Devices

New Tools or Just Another Toy?

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In this month’s issue of Anesthesiology, Kim et al. report on a systematic review and meta-analysis of studies assessing the accuracy and precision of continuous noninvasive arterial pressure monitoring devices. The question is of interest and has clinical relevance in view of the growing trend in the area of hemodynamic monitoring to obtain a maximum of information using minimally invasive devices.

This trend has first appeared in the noninvasive (or minimally invasive) assessment of cardiac output and its derived variables. Such new devices have been developed to replace direct measurements obtained via cannulation of arterial and/or central venous vessels. Basically, these devices rely on computer software and algorithms developed by industry to provide an estimation of the different variables. Although successive software versions progressively yielded more reliable data, there are still clinical situations in which data obtained with noninvasive cardiac output measurements not truly reflect the patient’s hemodynamic condition. In the last few years, this trend of noninvasively estimating hemodynamic variables has extended to the assessment of arterial pressures. The reasons for such development are straightforward. On the one hand, patients undergoing high-risk surgery and/or presenting with multiple comorbidities may require close hemodynamic monitoring with beat-to-beat arterial pressure analysis. On the other hand, potential occurrence of mechanical, thrombotic, and infectious complications described with invasive cannulation of an artery may warrant the search for a less invasive approach.

Currently, the continuous noninvasive arterial pressure monitoring systems that are commercially available are Nexfin (BMEYE B.V., Amsterdam, The Netherlands), CNAP (CNSystems, Graz, Austria), and T-line (Tensys Medical Inc., San Diego, CA). The first two are based on the principle of volume clamp already developed in 1973 by Penaz, whereas the latter is based on the principle of arterial tonometry. From the analysis by Kim et al., it seems that the studies published on the commercially available technologies (n = 14) show an overall pooled bias of −1.8 ± 12.4 mmHg for systolic arterial pressure, 6.0 ± 8.6 mmHg for diastolic arterial pressure, and 3.9 ± 8.7 mmHg for mean arterial pressure. These limits do not satisfy the standards that have been established for the validation of automatic arterial pressure monitoring by the Association for the Advancement of Medical Instrumentation. Therefore, it is concluded that both accuracy (closeness of a measurement value to its actual true value) and precision (the degree to which repeated measurements under unchanged conditions show the same results, i.e., reproducibility) may—for the moment—not be sufficient to allow for reliable clinical decision making.

It is to be expected that in the future further development of software and refining of the algorithms used will enhance reliability of the different noninvasive systems for continuous arterial blood pressure measurements. Nevertheless, a number of considerations need to be taken into account when deciding to implement such devices in daily clinical practice.

First, the type of patients who need continuous blood pressure measurements also frequently necessitates regular blood sampling for the assessment of various biochemical variables. The presence of an arterial line greatly facilitates such sampling, and the use of a noninvasive system for continuous blood pressure monitoring will not avoid the necessity for arterial blood sampling in a majority of cases.

Image: J. P. Rathmell.

Perspective: “… both accuracy ... and precision [on noninvasive arterial pressure monitors] ... may—for the moment—not be sufficient to allow for reliable clinical decision making.”

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Second, the analysis of signals processed by the noninvasive continuous arterial pressure measurement systems is based on algorithms and software programs which are developed by the technical staffs of the different manufacturers involved. The clinical anesthesiologist is—at the best—aware of a number of variables that are included in the design of the software but has no knowledge on the exact algorithms used in the different devices. Hence, it is virtually impossible for the random anesthesiologist to have an insight in how the incoming signals are processed and finally result in the number displayed on the screen. This is in sharp contrast to the signals obtained by regular invasive blood pressure analysis, where every anesthesiologist is capable of assessing and appreciating technical pitfalls such as damping and/or oscillations of the signal.7,8 Although it is probably a normal evolution that the design of monitoring tools moves away from the basic understanding of the clinical anesthesiologist, we should realize that we are increasingly using tools that are designed for us and not anymore by us.

Third, despite the general feeling that especially the very sick patient may benefit from continuous extensive hemodynamic monitoring, there are little data showing that such monitoring substantially improves patient outcome.2 Nevertheless, integrating information of several monitoring tools may help in better guiding therapeutic interventions. Recently, Wax et al. demonstrated that invasive and noninvasive (cuff) blood pressure measurements may yield differential results, especially during periods of hypotension and hypertension. Noninvasively measured blood pressure tended to be higher than radial artery blood pressure during periods of hypotension and lower during periods of hypertension. Interestingly, the use of noninvasive blood pressure measurement to supplement arterial blood pressure measurements was associated with a decreased use of blood transfusions, vasopressor or inotrope infusions, and antihypertensive medications compared with the use of arterial blood pressure measurement alone.9 It remains to be established whether data from continuous noninvasive blood pressure monitoring are indeed capable of replacing direct arterial blood pressure measurement or whether they simply will provide additional information that may help in tailoring therapeutic interventions.

It is therefore essential that parallel to the further design of noninvasive monitoring tools, the impact of data from such systems on clinical decision making and ultimately the impact on patients’ outcome are evaluated. In the end, it is not the availability of a multitude of numbers, coming from different monitoring tools that will improve clinical management and outcome of the patient, but the correct interpretation of these data integrated in the entire clinical picture of the particular patient.

Competing Interests

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