The continued search for the ideal hemodynamic monitoring tool continues. Over time, the medical community has endeavored to identify correlates of hemodynamic status and resultant responses to volume expansion. Historically, we have pursued the use of physical examination alone (jugular height and arm vein collapse), to invasive measurements (central venous pressure [CVP] and pulmonary artery catheters [PAC]), to less invasive physician-interpreted measures (transesophageal and transthoracic echocardiography [TTE, TEE]), and to the proprietary black box evaluation of physiological parameters (arterial waveform contour analysis, transthoracic bioimpedance, etc.,). Still, there is no universal answer as to the ideal monitor of hemodynamic status and volume expansion. In this issue, Power et al. and Lanspa et al. address the important topics of predicting hemodynamic states/responses through monitoring devices in the perioperative period of cardiac surgery patients and volume expansion in critically ill patients in a shock state, respectively.

Both research groups focused on using invasive and noninvasive devices/techniques of monitoring in addressing hemodynamic status and volume expansion in a prospective fashion. Power et al. compared TTE/TEE, PAC, and the noninvasive FloTrac-Vigileo (FV) methods in evaluating hemodynamic status during and after cardiac surgery, whereas Lanspa et al. compared the efficacy of CVP, vena cava collapsibility, passive leg raise, stroke volume variation, aortic velocity, and pulse pressure variation in regard to how well a response to volume expansion could be predicted. While Power’s group actually compared the abovementioned methods, the Lanspa group looked at their potential methods of measurement using an a priori definition in regard to each technique of volume expansion prediction strictly on the feasibility of use, but they did not actually perform the measurements.

What is of clinical concern, and should serve as a cautionary note to those who care for critically ill patients, is that (1) in comparing TTE/TEE with the easier and more common methods of FV and PAC, there was very poor correlation between the measurements (during the perioperative period in cardiac surgery patients) and (2) in the population of critically ill shock patients requiring volume expansion, the use of many techniques available to those authors was essentially not feasible because of the emergent need for the immediate clinical intervention or particular patient-associated anatomic hindrances preventing their performance. In other words, what these authors have demonstrated to us (within the limitations of these two bodies of work) is that drawing a clinical conclusion from anything other than a TTE or TEE (which involves a skilled examiner and physician interpretation) could lead to an unnecessary, although probably not injurious, intervention. However, the authors did not evaluate patients with an ejection fraction <20% separately, and no assessment of the right heart function was performed. It may be that a measurement made with one particular monitoring tool, in times of physiological peril to a patient, does not provide physicians or other health-care providers with an acceptable level of clinical decision support. In addition, any argument for the use of TTE/TEE as the “gold standard” is problematic for several reasons. First, it must be recognized, as mentioned above, that there is a level of physician interpretation in TTE/TEE and not all physicians who care for seriously ill patients are certified or capable of performing these examinations. Furthermore, echocardiography is not available at all times and in all facilities, and the costs of purchasing additional TTE/TEE devices is considerable, let alone the need for additional training or hiring of personnel. Furthermore, other methods (as described in the studies) have been developed and approved by medical, research, and government entities and are used throughout the medical world with a modicum of success in some situations, especially when those measurements are done serially. CVP, for instance, despite receiving a lot of negative press, continues to demonstrate a great deal of utility, or at least little harm, in select environments, such as cardiac surgery, as shown by its use by Power et al. at their home institution.

Perhaps, we should not concentrate on our failures, but our successes. Perhaps, there is no universal tool for these measurements. Perhaps, our questions should be
posed as, “In which population is this measurement form appropriate?” CVPs and PACs, for instance, obviously do not work universally in the intensive care unit (ICU). Studies to date have been weighted heavily in patients with septic shock (a familiar ICU denizen).\cite{6,7} The solution to the problem may be the fitting of the proper tool to the appropriate situation/patient rather than a universal diagnostic aid. As Lanspa et al. pointed out, newer techniques other that CVP may be superior,\cite{8-12} but may only be of use in certain patient populations and may not function effectively in all physiologic states.\cite{9,11,13,14} If these methods of monitoring hemodynamic status and volume expansion are also disparate in their results and reproducibility, then there is much more work to be done in the evaluations of these methods regarding the physiologic information and clinical assistance these devices actually provide.

While the answer to which is the best single tool to measure fluid responsiveness in critically ill patients may remain unresolved for many years, the authors here have keyed in on two crucial aspects that help frame the conversation: feasibility and decision support. In the same way that laryngeal mask airways (LMAs) will never replace endotracheal intubation as the standard in definitive airway management, noninvasive hemodynamic monitoring may never fully eclipse TEE/TTE. However, just as the LMA has become a quick and easy tool for use until a more definitive airway can be established, so too can these noninvasive monitoring techniques provide a feasible alternative until a more global hemodynamic assessment is warranted or available, as suggested by Power et al. In the meantime, the various methods explored by the authors, as suggested by Power et al., may be well used as triggers for the use of echocardiography in the assessment of hemodynamic states and volume expansion.

The studies’ authors also point out that the past reliance on mortality as the endpoint of outcome in similar studies is a blunt tool for the measurement of success and does not answer all of our questions. Some of these tools used for measurement did not improve mortality in the ICU, nor did they worsen it. Mortality may be too harsh of an outcome to evaluate a measurement/monitoring tool’s utility in populations with significant rate of death. Perhaps, we should narrow our focus to other “smaller” outcomes, such as ventilator hours or days, length of ICU stay, length of hospital stay, or discharge disposition. Or ask, as Power et al. did, if any of these tools aid in the diagnosis of a hemodynamic state, or a change in a hemodynamic state, at one time or another in the ICU.

Then again, perhaps the problem is simply one of complexity. Hemodynamics is an idea that describes the manifestations of a natural system; and that system in its completeness, like most natural systems, is beyond the limits of man’s understanding – at least at present. Each of the tested modalities reveals an aspect of the system, but none see the system in its whole. Seen in this way, each monitoring system may in a given circumstance give us insight or mislead us. To learn that no one monitor exists that always delineates the hemodynamics is disappointing, but probably to be expected. The answer, for now, is to do what physicians have always done: gather all the evidence they can use their training to assign significance or not to any result based on the patient; the circumstances, experience, and the current level of knowledge; and then, to choose the most likely beneficial treatment. In other words: use as many feasible, cost-effective, and appropriate monitors for each patient rather than rely on any single technology.

Although it is true that both investigative groups addressed different populations of patients, the inability to obtain a feasible, accurate, reproducible, and comparable result (except for TTE and TEE in the cardiac surgery patients) in both of these populations was striking. It leaves us with controversy regarding these conclusions and a necessary call for more studies regarding the use of the various monitoring methods addressed by the studies in this current issue in larger and various homogeneous populations of similar illnesses or surgical procedures.

We who work and perform in the critical care arena, who strive to give the very best care to our patients, and who do err (as do our measurements and monitoring tools), and who do come up short on occasion\cite{15} should encourage our colleagues to continue to evaluate current tools and create new ones with an eye toward varied endpoints beyond mortality, and to pursue the evaluation of specific tools for specific populations in specific clinical situations.

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