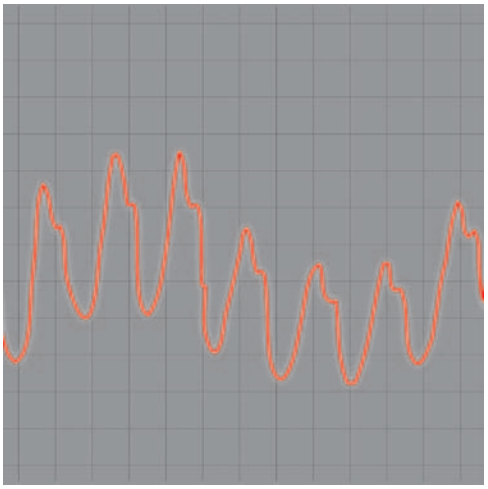
Do We Need to Monitor Cardiac Output during Major Surgery?

THERE is strong evidence that optimizing stroke volume or cardiac output during major surgical procedures is associated with better outcomes.[1–3] With this approach, interventions, consisting primarily of fluid administration, are given until there is no further increase in stroke volume, that is, when the Frank-Starling relation reaches a plateau. In this issue of ANESTHESIOLOGY, Dr. Le Manach *et al.*[4] evaluate a new technique to assess changes in cardiac output during fluid administration in the surgical patient. In this context, it is interesting to return to the first measurements of cardiac output during surgery more than 50 yr ago[5]; the method used, based on dye-dilution techniques (fig. 1), revealed unsuspected changes, including a 20% decrease in cardiac output, during induction of anesthesia.

So is monitoring cardiac output necessary to assess the response to fluids in this situation? It is widely appreciated that changes in arterial pressure do not reliably reflect changes in cardiac output, because the body employs mechanisms to preserve tissue perfusion pressure when stroke volume falls. However, predicting response to fluid administration could be facilitated by examining changes in pulse pressure during the respiratory cycle, because cyclic changes in intrathoracic pressure may influence ventricular filling when stroke volume is preload dependent.[6] The operative period, when patients are anesthetized, paralyzed and managed with volume-predetermined ventilation, is ideally suited for monitoring this pulse pressure variation (PPV). The presence of significant arrhythmia, atrial fibrillation in particular, is the most obvious limitation to this approach during surgery. The major problem with using PPV to predict fluid responsiveness is the area of uncertainty surrounding middle-range values, as these values can indicate other scenarios than just fluid responsiveness, making a specific diagnosis difficult. A fluid challenge is, thus, still required in many cases.



"They now report that [changes in pulse pressure variation] during the fluid challenge reflected better the changes in cardiac output, with a smaller gray zone."

Dr. Le Manach *et al.*,[4] in the study published in this issue of ANESTHESIOLOGY, went one step further than simply monitoring PPV and evaluated the *change in PPV* (dPPV) during administration of 400 ml of colloids. This technique involved a real fluid challenge, because the response was uncertain, and indeed only half the patients responded with an increase in cardiac output. As expected, although there were some changes in arterial pressure, these did not reliably reflect the changes in cardiac output. The authors have already reported that evaluation of PPV could be useful in some patients, but one quarter of the patients remained in a "gray zone" with values between 9 and 13%.[7] They now report that dPPV during the fluid challenge reflected better the changes in cardiac output, with a smaller gray zone. A decrease in PPV of 3% or more during the fluid challenge reflected an increase of more than 15% in cardiac output with a sensitivity of 90% and a specificity of 77%. Importantly, the gray zone, which was for a dPPV between 2.2 and 4.7%, concerned only one in seven patients (14%).

Study of the arterial pressure tracing can, thus, serve not only to predict but also to assess the response during a fluid challenge. The analysis was well performed by these experts, and the strengths of the study include its large size, involving 400 patients from four centers. It is hoped that automatic measurements of PPV and dPPV will soon be obtained routinely, and integrated into current monitoring systems with a continuous display on the monitor. We will be able to set alarms for PPV and dPPV limits and be able to evaluate the likelihood of a response to fluid PPV and the actual cardiac output response (dPPV). The next step will then clearly

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Fig. 1. First measurements of cardiac output during surgery (from Heilbrunn and Allbritten[5] with permission).

be to determine whether monitoring these values can help improve outcomes.

So, do we now need to routinely measure cardiac output during surgery? Fifty years after Heilbrunn and Allbritten's publication,[5] the answer must surely be "no." After all, it is difficult to interpret absolute cardiac output values in conditions of low oxygen demand; changes in stroke volume or cardiac output are much more informative, particularly to appreciate the response to fluids, still the major intervention used to optimize stroke volume during surgery. PPV is already a valuable screening tool, as is stroke volume variation, which can also be assessed using simple tools,[8,9] including transesophageal Doppler.[10] The use of transesophageal echography can also help to assess cardiac function.[9] The study by Dr. Le Manach *et al.*[4] adds an extra-simple analysis of arterial pressure waveforms to our tools for optimizing fluid administration and ensuring the patient is on the flat portion of the Frank-Starling relation.

Although cardiac output should not be monitored routinely during all surgical cases, this does not mean it should be abandoned. The main reason why reliable cardiac output monitoring can be useful during surgery is to be able to establish a baseline for high-risk patients in whom complications, such as hypoxemia, tachycardia or oliguria, arise after the immediate postoperative period, and therapeutic interventions become more complex. Some would argue that there is still time to introduce a cardiac output device at this point, but most would agree that it is preferable to be able to make a trend evaluation when such a problem occurs.

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