Continuous cardiac output monitoring by blood pressure analysis

Johannes J. van Lieshout1 and Jos R. C. Jansen2

1Medium Care Unit, Department of Internal Medicine, Academic Medical Center, University of Amsterdam, Amsterdam; and 2Department of Intensive Care, University Medical Center, Leiden, The Netherlands

TO THE EDITOR: Monitoring of continuous cardiac output (CO) allows for the detection of rapid changes in systemic flow that would otherwise be unnoticed by the recording of arterial pressure and heart rate. Continuous tracking of changes in stroke volume (SV) can be obtained by arterial pulse wave analysis. Lu and Mukkamala (5) describe an attractive novel technique for continuous monitoring of relative CO changes. They propose that changes in CO are monitored from blood pressure variations more accurately when using time intervals larger than a cardiac cycle, i.e., up to a clinically difficult to accept time of 6 min. Previously, pulse contour methods were linear and integrated the systolic area of the arterial pulse wave, sometimes with a correction for heart rate. The elastic behavior of the thoracic human aorta, however, varies nonlinearly with the changing arterial pressure, and therefore the Modelflow method (7) computes an aortic flow waveform from either finger or intra-arterial pressure by simulating a nonlinear three-element model of the aortic input impedance. Lu and Mukkamala suggest that pulse wave contour techniques that analyze single heartbeats may suffer from wave reflection phenomena that impair the derivation of reliable stroke volume estimates. We demonstrated that the amplification of reflex vasoconstriction during 1-h passive head-up tilt does not influence the offset of intrabeat-determined SV (1). Also, the finding that a single calibration of the model appears sufficient to monitor CO continuously in an intensive care setting over a 2-day period with a bias of $-0.1 \pm 0.8$ l/min (4) refutes that CO delivered by intrabeat technique is too inaccurate for clinical use.

We agree with Lu and Mukkamala (5) on their notion that future studies should be conducted to compare their technique with existing intrabeat techniques and preferably against a gold standard. Ventilatory-induced changes in arterial pressure, as shown in their Figs. 2 and 4, allow a word of caution regarding the reference method used. Four quickly repeated thermodilution estimates of CO may differ more than 1 l/min (2). In such circumstances, an average of a small number of random injections does not give a true estimate of CO. When injections are synchronized with ventilation, not by a fixed but by a systematically varied phase equally spread over the ventilatory cycle, the mean of the estimates is within 5% of true mean CO. Precise timing of the injection requires a trigger synchronized with ventilation and the use of an automatic injector in combination with a closed injectate delivery system, improving consistency in injected volume and linearity of injection rate (3, 4). Assuming pulse contour CO to have an accuracy of 5%, two determinations need to differ by at least 7% before it is accepted that a change in CO has taken place (6). In future studies, the reference CO used as a standard should satisfy rigorous criteria before any comparison can be made.

REFERENCES