Xavier Monnet
Daniel Lahner

Can the “FloTrac” really track flow in septic patients?

Received: 10 September 2010
Accepted: 25 September 2010
Published online: 10 December 2010
© Copyright jointly held by Springer and ESICM 2010

This editorial refers to the article available at:
doi:[10.1007/s00134-010-2098-8](https://doi.org/10.1007/s00134-010-2098-8).

X. Monnet (✉)
Medical Intensive Care Unit, Bicêtre Hospital,
Assistance publique-Hôpitaux de Paris, EA 4046,
Paris-11 University, Paris, France
e-mail: xavier.monnet@bct.aphp.fr
Tel.: +33-1-45213539
Fax: +33-1-45213061

D. Lahner
Department of Anaesthesia,
General Intensive Care and Pain Management,
Medical University of Vienna, Vienna, Austria
Tel.: +43-1-404004100
Fax: +43-1-404004104

Monitoring cardiac output (CO) is part of the general care of patients with (or at risk of) haemodynamic instability, because the sole arterial pressure may obviously fail to reflect changes in stroke volume. Forty years after the emergence of the pulmonary artery catheter, several alternative devices have been developed for measuring CO. In search of the “gold nugget”, this (very competitive) technologic research aims to find the least invasive, most informative, most cost-effective and easiest-to-use device.

Among alternatives to the pulmonary artery catheter for measuring CO, techniques inferring CO from the analysis of the arterial pressure waveform are particularly

attractive because they allow a continuous, beat-by-beat estimation of CO and because they have the advantage of simplicity. Another important advantage is that they have a good reproducibility [1, 2] (i.e. with small dispersion of repeated CO values), allowing one to precisely assess short-term small changes in CO as induced by diagnostic interventions [2].

Arterial pressure waveform analysis is based upon the principle that the waveform of the arterial pressure curve is related to stroke volume, even though it also physiologically depends upon arterial compliance and arterial tone. Technically, the key issue is to estimate arterial compliance. The devices that are commercially available today differ concerning the way they solve this pivotal problem. Some devices, such as the LidCOPlus and PiCCO device, calibrate the pulse waveform-derived estimation of CO with a transpulmonary dilution measure. This has the advantage of resetting the pulse contour-derived estimation of CO to a reliable value at each time calibration is performed, but calibration requires a specific dilution device (thermodilution for the PiCCO, lithium dilution for the LidCO) and must be frequently repeated [1]. By contrast, some devices such as the LidCORapid and the FloTrac/Vigileo devices are not calibrated by any “external” measure of CO. In particular, the FloTrac estimates the arterial compliance from some biometric data and from a complex analysis of the arterial curve geometry. This estimation has been validated in a human database.

The capacity of the uncalibrated FloTrac to estimate CO has been well established in surgical patients but has been seriously questioned by some studies in vasoplegic states [3–6]. For instance, the FloTrac did not allow tracking of the trends in CO in whom arterial pressure was modified by norepinephrine administration [6]. This suggested that the FloTrac estimation of CO was “disorientated” by large changes in arterial compliance and vasomotor tone, which might be problematic for septic

shock patients and, more generally, for use in the intensive care unit. However, all these previous studies were performed with the first or second versions of the FloTrac software.

In their contribution to this issue of *Intensive Care Medicine*, Dr. De Backer et al. [7] timely investigated the third version of the FloTrac software. This software has been implemented for a better evaluation of arterial compliance and vasomotor tone in case of vasoplegia. In particular, the database that serves for estimating arterial compliance has been enlarged, including a greater proportion of vasoplegic patients than the previous one. Dr. De Backer et al. compared the second and third versions of the FloTrac software with reference to the measure of CO made by pulmonary thermodilution. The precision of the two software versions was similar (the percentage error was 30% for the third-generation software and 29% for the second version, both below or equal the “magic” 30% cut-off [8]). Nevertheless, the accuracy was improved for the third version: the mean (95% CI) bias of CO dropped from -0.8 (-1.1 to -0.4) L/min (second version) to 0 (-0.3 to 0.3) L/min (third version). More importantly, it seems that the third-generation software was also less sensitive to systemic vascular resistance, because the difference between CO measured by thermodilution and by the third version of the FloTrac was very weakly correlated with the total vascular resistance, unlike the second version. These results are positive and tend to allow utilization of the FloTrac in the intensive care unit.

Beside precision and accuracy, two important points should be kept in mind when choosing a device for haemodynamic monitoring of a critically ill patient. First, one must consider its ability to provide additional information beyond CO for guiding the therapeutic decision. In this regard, the FloTrac usefully measures and displays the respiratory variation of stroke volume, giving information

about fluid responsiveness. In case of spontaneous breathing activity or arrhythmias, when this index is not valuable anymore, the FloTrac allows assessment via a passive leg raising test [9]. In some other complex situations like cardiac failure or acute respiratory distress syndrome, one might be interested in some other information like the left cardiac filling pressures or the lung water and permeability. The devices required for the last two variables are more invasive, but the least invasive is not always the best for complex cases [10]. In other words, these different devices have a different degree of invasiveness and provide a different panel of haemodynamic information that might fit different clinical situations.

Second, the choice of the device might be also guided by its ability to track trends in CO induced by spontaneous evolution of the disease or by therapy, because one is more interested in changes in CO rather than in a given CO value. In this regard, the study by Dr. De Backer et al. [7] showed that the third version of the FloTrac device was able to detect changes in CO of more than 15% occurring during the study period. Of note, this tracking ability was not found to be better than with the second FloTrac version. More importantly, the serial data varied little and the study was not designed for testing the ability of the third version to systematically evaluate some planned CO trends, in particular when total systemic vascular resistance changes by a large extent, as can occur when changing the dose of vasopressors [6]. Hence, although this study clearly suggests that the accuracy of the FloTrac device has been improved and that it might be suitable for septic shock patients, it is to speculate that further studies will investigate whether this improved accuracy is resistant to large changes in arterial compliance and vascular tone, continuing the laborious search for the “gold nugget”...

References

1. Hamzaoui O, Monnet X, Richard C, Osman D, Chemla D, Teboul JL (2008) Effects of changes in vascular tone on the agreement between pulse contour and transpulmonary thermodilution cardiac output measurements within an up to 6-hour calibration-free period. *Crit Care Med* 36:434–440
2. Monnet X, Osman D, Ridet C, Lamia B, Richard C, Teboul JL (2009) Predicting volume responsiveness by using the end-expiratory occlusion in mechanically ventilated intensive care unit patients. *Crit Care Med* 37:951–956
3. Biais M, Nouette-Gaulain K, Cottenceau V, Vallet A, Cochard JF, Revel P, Sztrak F (2008) Cardiac output measurement in patients undergoing liver transplantation: pulmonary artery catheter versus uncalibrated arterial pressure waveform analysis. *Anesth Analg* 106:1480–1486 (table of contents)
4. Biancofiore G, Critchley LA, Lee A, Bindi L, Bisa M, Esposito M, Meacci L, Mozzo R, DeSimone P, Urbani L, Filipponi F (2009) Evaluation of an uncalibrated arterial pulse contour cardiac output monitoring system in cirrhotic patients undergoing liver surgery. *Br J Anaesth* 102:47–54
5. Della Rocca G, Costa MG, Chiarandini P, Bertossi G, Lugano M, Pompei L, Coccia C, Sainz-Barriga M, Pietropaoli P (2008) Arterial pulse cardiac output agreement with thermodilution in patients in hyperdynamic conditions. *J Cardiothorac Vasc Anesth* 22:681–687
6. Monnet X, Anguel N, Naudin B, Jabot J, Richard C, Teboul JL (2010) Arterial pressure-based cardiac output in septic patients: different accuracy of pulse contour and uncalibrated pressure waveform devices. *Crit Care* 14:R109

-
7. De Backer D, Marx G, Tan A, Junker C, Van Nuffelen M, Hüter L, Ching W, Michard F, Vincent J-L (2010) Arterial pressure-based cardiac output monitoring: a multicenter validation of the third-generation software in septic patients. *Intensive Care Med.* doi: [10.1007/s00134-010-2098-8](https://doi.org/10.1007/s00134-010-2098-8)
 8. Critchley LA, Critchley JA (1999) A meta-analysis of studies using bias and precision statistics to compare cardiac output measurement techniques. *J Clin Monit Comput* 15:85–91
 9. Biais M, Vidil L, Sarabay P, Cottenceau V, Revel P, Sztark F (2009) Changes in stroke volume induced by passive leg raising in spontaneously breathing patients: comparison between echocardiography and Vigileo/FloTrac device. *Crit Care* 13:R195
 10. Vincent JL, De Backer D (2002) Cardiac output measurement: is least invasive always the best? *Crit Care Med* 30:2380–2382