

## Comparison of Cardiac Output Measurement by Arterial Waveform Analysis and Pulmonary Artery Catheter in Mitral Stenosis

### Dear Editor,

Cardiac output (CO) is a vital measurement that influences clinical decision-making. Although thermodilution via a pulmonary artery catheter (PAC) is considered the gold standard for CO monitoring, the use of the PAC is no longer routine given its associated complications and lack of efficacy data.<sup>1</sup> The Vigileo system uses an arterial pressure waveform sensor (FloTrac™, Edwards Lifesciences, Irvine, CA) to calculate the CO.<sup>2-4</sup> The FloTrac™, although non-invasive, has not been validated in patients with severe valvular disease. In this study, we compared the FloTrac™ system against PAC thermodilution in a patient with severe mitral valve stenosis.

### Case Report

A 51-year-old Indian female patient with end stage renal disease, a known history of severe mitral valve stenosis and moderate tricuspid regurgitation was admitted for hypotension during haemodialysis although she felt asymptomatic and was afebrile. Similarly, her white blood cell counts and CRP were not raised.

Written informed consent was obtained from the patient for participation in this study and IRB ethics clearance was obtained.

Transthoracic echocardiography by a cardiologist demonstrated severe mitral valve stenosis with moderate tricuspid regurgitation.

APAC was inserted via the right internal jugular vein. Mean CO and corresponding cardiac index (CI) measurements were obtained via thermodilution with injections of 10 mL of ice-cold 0.9% saline at 8 hourly intervals for 3 days and each measurement was repeated at least 3 times. Corresponding CO and CI measurements were recorded on the FloTrac™ system, which was connected to a femoral arterial catheter. A radial artery catheter was not considered as the patient had a left working radiocephalic arterial-venous (AV) fistula and a non-functioning right radiocephalic AV-fistula. All measurements were done in sinus rhythm and intravascular pressure measurements were referenced to the supine mid-

chest level. The FloTrac™ and PAC readings were taken simultaneously to ensure uniformity of the haemodynamic status for both methods and the readings were taken when the patient was comfortable and at rest and not undergoing haemodialysis. Other standard haemodynamic data were recorded from both the PAC and the FloTrac™ system.

Statistical analysis was performed using SPSS version 14.0 (SPSS Inc, Chicago, IL). The CIs as measured by the PAC and the FloTrac™ system were compared using the Student's paired *t*-test for means  $\pm$  standard deviations (SD), as well as by linear regression. A Bland-Altman analysis was used to calculate the bias, precision and percentage error for CI as measured by these methods.

We obtained 9 measurements over the course of treatment, both with and without dopamine (Fig. 1a).

The bias was 1.17 and precision was 2.08 liter  $\text{min}^{-1}\text{m}^{-2}$  (95% limits of agreement -0.92, 3.25) for all CI data pairs. The calculated percentage error [(2SD of bias)/mean CI] was 60.9% (Fig. 1b) and the percentage bias was 40%.

Although there was a moderate correlation between CI measurements using the two methods ( $r^2 = 0.527$ ,  $P = 0.03$ ), FloTrac™ measurements were higher than PAC measurements:  $4.08 \pm 1.36$  versus  $2.91 \pm 0.52$  litre  $\text{min}^{-1}\text{m}^{-2}$  ( $P = 0.01$ ).

Changes in CI measurements between time points were concordant (i.e. in the same direction) for the FloTrac™ system and the PAC for only 37.5% of the time (Fig. 1c). The binary accuracy was 50%.

### Discussion

We attempted to evaluate the continuous non-invasive monitoring of cardiac index in a patient with valvular heart disease. We made multiple cardiac index measurements using arterial pressure waveform analysis via the FloTrac™ system (Edwards Lifesciences, Irvine CA, USA) and compared it against intermittent thermodilution via a pulmonary artery catheter (PAC) in a patient with severe mitral valve stenosis.

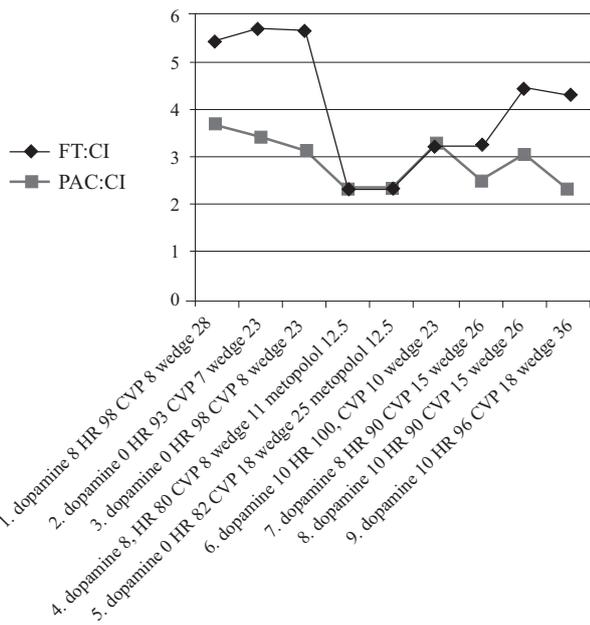


Fig. 1a. Cardiac index : FloTrac™ (FT) vs. pulmonary artery catheter (PAC). Dopamine : amount of dopamine support in µg/kg/min HR : heart rate/minute CVP : central venous pressure in cm H2O Wedge : pulmonary capillary wedge pressure in mmHg

Although the bulk of the literature on the utility of the FloTrac™ system for CI measurements involved patients undergoing cardiac surgery, most studies focused on cardiopulmonary bypass grafting and not valvular disease.<sup>2,3</sup> The studies which included a small number of patients undergoing mitral valve surgery commenced their FloTrac™ measurements intraoperatively only.<sup>3,4</sup> To the best of our knowledge, no study has evaluated the use of the FloTrac™ system in preoperative severe mitral valve stenosis.

Our results show that in the presence of severe mitral valve stenosis, the FloTrac™ system and the PAC show great disparity in CI measurements. The bias derived was 1.17 litre min<sup>-1</sup> m<sup>-2</sup> with a percentage error of 60.9%. Critchley and Critchley<sup>5</sup> had demonstrated in a meta-analysis that a percentage error of greater than 30% is clinically unacceptable. Similarly CI measurements moved in the same direction using the two methods for only 37.5% of the time when the haemodynamic status changed.

This case study has obvious limitations. The surrogate gold-standard marker, thermodilution via PAC, has in itself an inherent bias of 10% to 20%.<sup>5</sup> In patients with tricuspid regurgitation (which our patient has), CI measured by thermodilution is often under measured, moreover the CI and CO in our study were not measured by echocardiography but by thermodilution.<sup>6</sup> The FloTrac™ system also makes an assumption that the systemic vascular resistance (SVR)

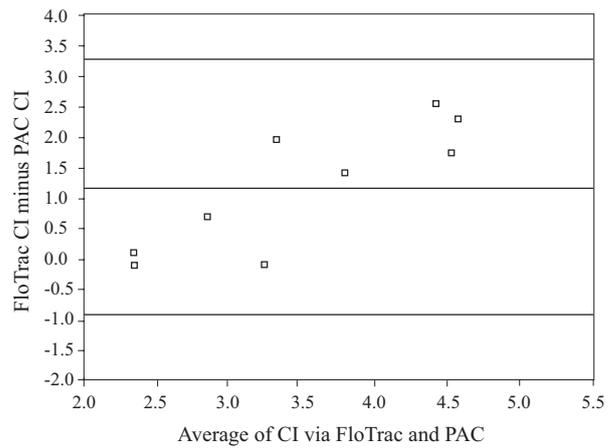


Fig. 1b. Bland-Altman plot of Cardiac index (CI), FloTrac™ (FT) vs pulmonary artery catheter (PAC).

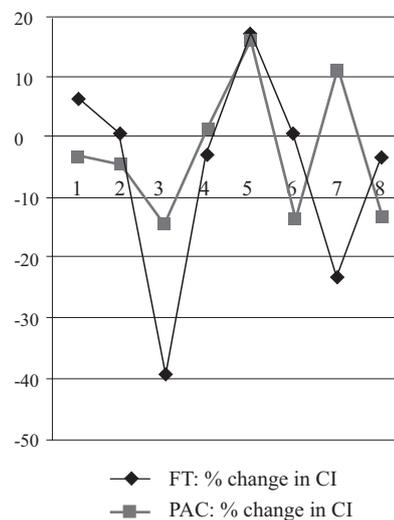


Fig. 1c. Percentage change in cardiac index (CI): FloTrac™ (FT) vs pulmonary artery catheter (PAC). Defined as difference in CI at 2 time points divided by the mean CI at the 2 points.

is constant. However, the treatment with vasopressors may cause the SVR to fluctuate;<sup>7</sup> several studies have already demonstrated this variability and the inaccuracy of the FloTrac™ system in haemodynamically unstable patients.<sup>8-10</sup>

As depicted in Figure 1c, correlation between the FloTrac™ and PAC measurements improved when the patient was on beta-blockers. We hypothesise that this was due to a reduction in the heart rate, which in turn reduced the mitral valve gradient, the left atrial pressure and the tricuspid regurgitation.

These limitations notwithstanding, our single study suggests that the FloTrac™ system does not provide clinically useful measurements in patients with severe mitral valve stenosis. This should be borne in mind when contemplating haemodynamic monitoring in mitral valve stenosis patients. Nonetheless, a larger series will be required

to validate our findings.

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