

LETTER

Use of minimally invasive hemodynamic monitoring to assess dynamic changes in cardiac output at the bedside

Michael R Pinsky*

See related research by Hadian *et al.*, <http://ccforum.com/content/14/6/R212>, and related commentary by Critchley, <http://ccforum.com/content/15/1/106>

I read with dismay the Commentary by Lester Critchley [1] on our recent pulse contour analysis study [2]. We disagree with his statement that, based on our data, one cannot use arterial pulse contour to assess changes in cardiac output (CO). We compared several commercially available arterial pulse contour methods of measuring CO with themselves and pulmonary artery catheter (PAC)-derived bolus thermodilution (COtd) and continuous CO (CCO) modes. We showed that none of these devices trended CO changes well when compared to the others, either separately or compared to a pooled CO value of all the devices. Thus, clinical trials using CO trending data from one device cannot be extrapolated to similar outcomes using other devices. Dr Critchley concluded that none of the pulse contour devices accurately trend CO changes. If that logic were true, then one could also not use PAC CO trending either, as it fared worse than the rest when compared to pooled CO values. Lack of proof of CO trending correlation amongst devices does not equate to lack of ability to trend CO by a device. His argument is based on four lines of reasoning that we dispute.

First, he argued that we pooled PAC COtd and CCO measures. However, we also reported separate Bland-Altman analyses for COtd and CCO and the relations were unchanged. Second, we then restricted our analysis to low flow states and all devices markedly improved their CO estimates, but the concordance remained poor compared to PAC. Furthermore, his study [3] as a reference used COtd as cardiac index (CItd) 'giving concordance across devices of 90-95% when exclusion criteria of 0.5-1.0 l/min/m² are applied.' We set our exclusion limits at 0.25 l/minute/m², but if we set it at 1 l/minute/m² the PiCCO, LiDCO and FloTrac concordance would increase to 83%, 88% and 74% in line with that reported by de Wilde and colleagues [4] using a more accurate PAC COtd reference method. Third, the FloTrac algorithm we used would remain the same even in the newer version of their software. Finally, he correctly says that the site of measure may affect reflected arterial pressure waves. But all measures with all devices for a given subject were made from the same site. So this is a non-issue. Accordingly, the conclusion that these devices are inaccurate cannot be made from our study.

Author's response

Lester AH Critchley

My recent commentary published in *Critical Care* [1] is a fair reflection of Hadian and colleagues' paper [2], but also the current status of pulse contour monitoring technology. However, Dr Pinsky's group should receive due credit for attempting to show something that is very

difficult clinically, and also presenting their far from simple data clearly. However, even with my trained eye I still find it hard to draw any positive conclusions other than LiDCO against PAC has the least error. I also fail to find any convincing evidence that trending exists.

Dr Pinsky defends his corner with a number of arguments about misinterpretation of their data analysis. The use of CCO rather than single COtd as the reference standard was mentioned in my commentary because it is creeping into validation studies. In Squara and colleagues' recent and excellent review on 'tracking changes in

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cardiac output' they discuss at length the problems of response time when using the continuous method [5]. Dr Pinsky refers in his letter to a paper by de Wilde and colleagues [4], which has a particularly interesting figure and Table 3 that compares five pulse contour algorithms to COtd. The two best performers are model flow and the Hemac. These methods' concordance rates were both 96%, indicating good trending ability, unlike the LiDCO and PiCCO cohorts, which were 88% and 84%, respectively. Thus, there are better algorithms around for modeling peripheral circulatory changes, so why are they not being used?

Abbreviations

CCO, continuous cardiac output; CO, cardiac output; COtd, bolus thermodilution cardiac output; PAC, pulmonary artery catheter.

Competing interests

MRP has received funding from Edwards LifeSciences, Inc, and LiDCO, Ltd, and has shares with LiDCO, Ltd. MRP is also inventor of a University of Pittsburgh-owned patent on the "Use of aortic pulse pressure and flow in bedside hemodynamic management".

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