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CRITICAL CARE

COMMENTARY

Pulse contour analysis: Is it able to reliably detect changes in cardiac output in the haemodynamically unstable patient?

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See related research by Hadian *et al.*, http://ccforum.com/content/14/6/R212

Abstract

Three pulse contour systems for monitoring cardiac output – LiDCO Plus™, PiCCO Plus™ and FloTrac™ – were compared in postcardiac surgery patients. None of the three methods demonstrated good trending ability according to concordance analysis. Pulse contour systems remain unreliable in the haemodynamically unstable patient.

In the previous issue of *Critical Care* Hadian and colleagues compare the performances of the three best known examples of pulse contour systems – LiDCO Plus™, PiCCO Plus™ and FloTrac™ – against thermodilution [1]. An experimental design was used based on cardiac surgery patients in the first 4 hours after surgery, in which cardiac output was managed using four different therapeutic interventions – fluid bolus, vasoconstrictor, vasodilator and inotrope – which should have provided a vigorous test of trending ability when compared with the alternative of sampling at regular time intervals. The authors used a standard and now well-established statistical approach of Bland and Altman analysis [2], determining percentage errors [3] and concordance trend analysis that included an exclusion zone (changes <0.5 l/minute) [4]. The results show that only the LiDCO Plus™ system provided an acceptable level of agreement with thermodilution (percentage limits <30% benchmark), and that the FloTrac™ system performed the worst [3]. None of the three systems provided satisfactory trending, however, with concordance rates (74%, 72% and 59%) well below the required 90 to 95% for good trending [4]. The reliability of the pulse contour method is known to be susceptible to changes in peripheral resistance and the study protocol involved vasoconstrictor and vasodilator drugs, which may explain these poor trending results [4,5].

This study helps to confirm what is already suspected about the reliability of pulse contour devices; that these devices do not track changes in cardiac output reliably. Although there are many recent published studies evaluating pulse contour devices, the present one provides a very exacting examination and also compares the three main brands of pulse contour monitor. The study could be faulted, however, because a now out of date FloTrac™/Vigileo software version was used. The FloTrac™ has been criticised for failing to compensate for low peripheral resistance states [4,5]. In response, Edwards LifeSciences (Irvine, CA, USA) produced a new third-generation software version (for example, version 3.02) known as Dynamic Tone Technology to overcome this limitation. The authors also used continuous cardiac output readings as their reference standard if a heated wire pulmonary artery catheter was *in situ*. Validation should ideally be based on readings from single bolus thermodilution cardiac output measurements as these are said to be the most reliable. There are several studies that show continuous cardiac output to be as accurate as single bolus thermodilution [6,7]. Continuous cardiac output takes several minutes to stabilise and provide a valid reading, however, which makes it less reliable when measuring trends [8]. One must therefore be cautious interpreting data from this study, as the Bland and Altman analyses and the concordance analyses may use reference data that have a wider spread than usual and thus wider acceptance criteria [3,4].

The paper is made much harder to comprehend due to the many cross-comparisons, in the form of Bland and Altman and four-quadrant concordance plots, which show agreement between the three pulse contour methods. These comparisons do, however, suggest that these three pulse contour methods are not interchangeable. The reason given by the authors is the use of

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different proprietary algorithms, which measure different aspects of the pulse contour waveform – which is an interesting point.

Pulse contour cardiac output relies on a good quality of arterial trace. Overdamping or underdamping can lead to unreliable cardiac output measurements. The authors have not verified in their protocol whether acceptable arterial traces were used. Furthermore, nine out of 17 patients had femoral rather than radial arterial lines inserted. There is growing evidence that the site of puncture affects the shape of the arterial trace and thus pulse contour measurements. The more distal the puncture site, the greater the influence of acoustic reflections from vessel branching, and the extent of wave reflection also varies quite dramatically with blood vessel constriction and dilatation [9]. The puncture site thus seems to be an important determinant of the success of pulse contour measurements and should be paid more attention.

So what does this paper by Hadian and colleagues add to scientific knowledge? It is one of several recent clinical studies that show the pulse contour does not reliably reflect changes in cardiac output in haemodynamically unstable patients [4,5]. Excuses can be made that the thermodilution reference method is less reliable than the quoted ±20% precision error, but that is another story [10]. The study, however, does provide a rigorous test of the technology, does compare the performance of the three main pulse contour methods, albeit with now out of date FloTrac™ software, and does add to the growing evidence that the pulse contour method is not the solution to providing reliable cardiac output monitoring at the bedside.

Competing interests

The author declares that he has no competing interests.

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