this patient population was not suitable to assess any effects of intraoperative β-blockers on immune function. In both groups, intraoperative doses of metoprolol were administered to blunt tachycardia unresponsive to top-up doses of anaesthetics, but the use of β-blockers did not differ between the groups. Hence the concept that intraoperative β-blockade may have contributed to the inhibition of the proinflammatory response is not supported by our results. A more detailed description of the cardiovascular effects of S-(−)-ketamine in comparison with sufentanil as the main analgesic in a similar patient group has been published before. Our study was not designed to show differences in outcome. The clinical significance of the anti-inflammatory effects of S-(−)-ketamine during and after adult cardiopulmonary bypass remains to be elucidated. Therefore, further research is needed to fully evaluate the specific influence of ketamine on immune response and outcome after cardiac surgery. We conclude that based on our results, the use of ketamine in cardiac anaesthesia is safe and is potentially associated with a beneficial immunologic profile.

Conflict of interest

None declared.

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Pressure recording analytical method to measure cardiac output after cardiac surgery: some practical considerations

Editor—We read with interest the paper ‘Lack of agreement between pulmonary arterial thermodilution cardiac output and the pressure recording analytical method in postoperative cardiac surgery patients’. The study aimed to determine the reliability of pressure recording analytical method (PRAM)-derived cardiac output (PRAM-CO) in comparison with thermodilution-derived CO (ThD-CO) in a heterogeneous group of patients after cardiac surgery. Large differences between PRAM-CO and ThD-CO were found and the authors concluded that PRAM-CO could not replace ThD-CO in such patients.

The authors sought explanations for the discrepancies between their work and previous studies showing the accuracy of PRAM to measure CO when compared with ThD-CO. We wish to share some considerations that may help to clarify this issue.

First, pressure artifacts are a common phenomenon that must be addressed whenever using pulse contour methods (PCMs) to estimate CO. In fact, different catheter–transducer systems for arterial waveform transmission could give different results in terms of measured pressures. PRAM analyses the arterial signal using a sampling frequency of 1000 Hz. The high-frequency sampling permits a better precision, which is of primary importance for the calculation of the arterial impedance and the correct measurement of pressures. Indeed, in case of an eventual resonance effect of the catheter–transducer system, the device allows to adapt its setting to maximize the signal-to-noise ratio. A pressure waveform altered by under-damping might affect both the amplitude and morphology of the signal evaluated by PRAM. If resonance occurs, dp/dtmax provided by PRAM is abnormally high, reflecting the poor quality of the arterial trace. In this situation, PRAM could likely overestimate systolic arterial pressure and stroke volume. Conversely, there could be under-estimation in the case of over-damped signals. Indeed, PRAM is more sensitive to artifacts than other PCMs as its algorithm is exclusively based on the analysis of the pressure wave morphology and not on external (e.g. bolus dilution) or internal pre-estimated parameters. In their article, the authors have not provided sufficient information concerning pressure signal quality, stroke volume, and systolic arterial pressure values, which could help to evaluate whether these confounding factors may have influenced CO measurement.

Secondly, when comparing a PCM with bolus thermodilution, for each determination of ThD-CO, a corresponding value for PCM must be obtained by averaging the CO obtained by individual beats over the time needed for the reference method estimation. In their study, the average of three 1 min continuous registrations with 1 min intervals was taken (5 min total period) for PRAM, but the authors did not explain how the average of individual beats within 1 min intervals was calculated (i.e. Visually? Downloading the data by the transfer-card?). Also, ThD-CO was calculated as the mean of at least three separate measurements obtained over a total period of 3 min. It appears that the time interval used for PRAM-CO measurement did not match the interval for ThD-CO calculation. Although this may be acceptable for extremely stable patients, it is a methodological limitation of the study.
Thirdly, the characteristics of the arterial tree, such as pathological changes in the ascending aorta, and aortic valve disease might alter the shape of the arterial pressure wave and influence the accuracy of a PCM. Even though the unreliability of PRAM in such patients has still to be demonstrated, these conditions were considered as exclusion criteria in the previous studies with PRAM. Conversely, 11 of 27 patients (41%) with such pathologies were enrolled.¹

Fourthly, the disagreement between the two techniques at extreme CO values is difficult to understand, as there are divergences between the CO ranges reported in the text (2.6–9.2 litre min⁻¹ for ThD-CO and 2.4–12 litre min⁻¹ for PRAM) and those showed in figures. In fact, ThD-CO values above 7 litre min⁻¹ or below 3.5 litre min⁻¹ are not displayed in the graphs.

PRAM has shown good reliability to estimate CO in several clinical situations, including cardiac surgery. When this device is used for scientific research, investigators should take into appropriate account the possible pitfalls and limitations, as it happens for all the other technologies. We believe that statements concerning the quality of the arterial pressure signal, and interventions to improve it, should be clearly described in studies validating PCMs. This is often missing in the literature and, inappropriately, also in our previous studies. Therefore, we strongly recommend providing this information in future research on PCMs.

Conflict of interest
S.S. has received honoraria for educational lectures and consultancy from Vygon and Vytech, Padua, Italy.

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Reply from the authors
Editor—We thank Dr Scolletta and colleagues for their interest in our study comparing the agreement between the cardiac output (CO) measurements by the pressure recording analytical method (PRAM) and pulmonary artery catheter thermodilution (ThD-CO) in postoperative cardiac surgery patients.¹ The authors raised several concerns regarding the methodology of our study.

First, according to the instruction manual, the PRAM-CO MostCare monitoring set (Vygon GmbH & Co. KG, Aachen, Germany) can be used with commercially available catheters connected to a standard haemodynamic monitor. We used radial arterial catheters (LEADER-CATH; Vygon GmbH & Co. KG) and out standard pressure transducers (DPT-600; Codan Pvb Critical Care GmbH, Forstinning, Germany) connected to a Drager, Infinity monitoring system (Drager, Lubeck, Germany). We are of course aware that an optimal pressure curve is a prerequisite to get reliable results by a pulse-contour analysis and took care that only optimal pressure curves were used for the analyses. To achieve this, all arterial lines were flushed by 5 ml of saline immediately before the measurements. Thus, the lack of agreement of the PRAM system with thermodilution CO measurements cannot be explained by poor quality of the arterial pressure readings. We also acknowledge the fact that the quality of the transducer influences the quality of the pressure recordings and that either overdamping or resonance phenomena may reduce the reliability of these measurements. Unfortunately, to our knowledge, neither a recommendation for a specific transducer type is given in the instructions of this device, nor is it realistic, that a user will change the established pressure transducers in his hospital simply to improve the quality of a new haemodynamic monitoring device. It is of note that we did not find any information on which type of transducer and which arterial catheter were used in a recent publication of Dr Scolletta’s group.²

Dr Scolletta and colleagues criticize that we ‘did not provide sufficient information concerning pressure signal quality, nor stroke volume and systolic arterial pressure values, which could help to evaluate whether the aforementioned confounding factors may have influenced CO measurements’.³ We have to admit that we did not present individual details on stroke volume and arterial pressure. However, we note that these details also cannot be derived from their own publications² ³ and that this might be helpful to explore the reliability of a pulse-contour measurement.

They suggest that ‘the time interval used for PRAM-CO measurement did not match the interval for ThD-CO