Arterial Blood Pressure Waveform Based Cardiac Output Analysis Corelates with Continuous Pulmonary Artery Thermodilution In Post Cardiac Surgery Intensive Care Unit Patients Including Those With Arrhythmia

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Introduction

Cardiac output estimation is a critical component of monitoring critically ill patients after cardiac surgery. We sought to assess the agreement between a traditional continuous pulmonary artery catheter-guided thermodilution method and cardiac output estimation using a novel method that performs an analyses of multiple beats of the arterial blood pressure waveform.

Methods

After institutional review board approval, we prospectively enrolled adult cardiac surgical patients recovering post-operatively in the cardiovascular surgical intensive care unit of our tertiary care university hospital. Eligible patients had a functioning pulmonary artery catheter (PAC) and a radial artery line. Continuous thermodilution cardiac output measurements (CO-CTD) obtained via the PAC were recorded once every minute. The arterial blood pressure waveform was fed via a reusable cable connected to the bedside patient monitor into a device that utilizes the novel BP waveform analysis method. The device analyzes multiple beats of an arterial line BP waveform over longer time intervals (20 s) and provides continuous CO estimates (CO-LTI). Both CO-CTD and CO-LTI were averaged over 1 hour, in order to compare hemodynamically stable periods and to reduce the influence of delayed responses to hemodynamic changes[1].

Correlation between paired values of CO-CTD and CO-LTI was computed within subjects, taking repeated observations into account and removing the between-subject variability[2]. Agreement between CO-CTD and CO-LTI was assessed via Bland-Altman analysis, accounting for multiple observations within patients[3]. BP waveform segments were visually inspected by two anesthesiologists blinded to cardiac output measurements to determine persistent arrhythmia or extrasystoles. These data segments constituted the arrhythmia subgroup. Similar analyses were performed on data segments containing arrhythmia or extrasystoles (arrhythmia subgroup).

Results

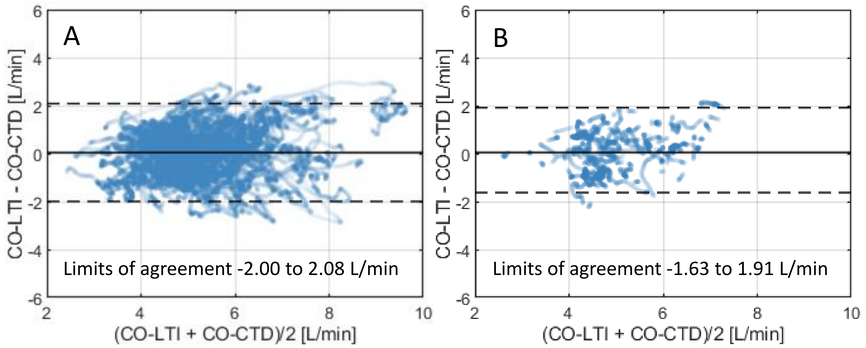

Fig. 1. Bland-Altman (BA) plots showing agreement between CO-CTD and CO-LTI. Bold horizontal line indicates bias, and dashed lines indicate 95% limits of agreement. A) BA plots for all data; B) BA plots for arrhythmia the subgroup

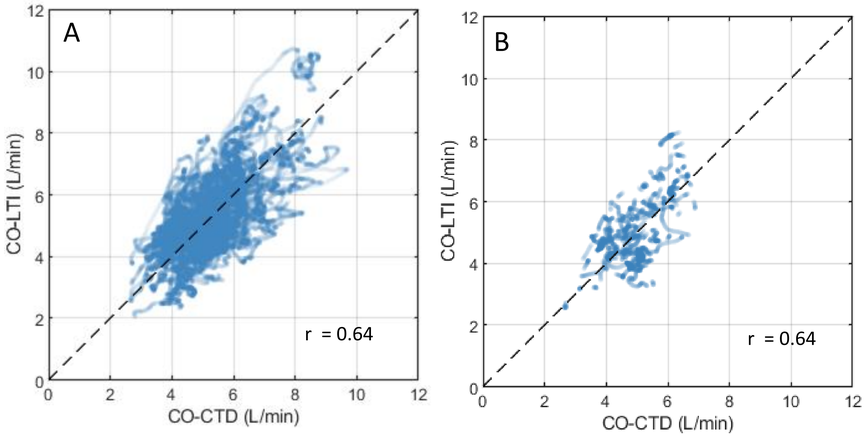

Fig. 2. Correlation plot between CO-CTD and CO-LTI. A) Correlation plot for all data; B) Correlation plots for the arrhythmia subgroup

One hundred patients were enrolled, of which 11 were excluded due to unavailability of simultaneous CO-CTD and CO-LTI readings. Ten patients were further excluded due to underdamped arterial BP waveforms evident via square wave tests, dP/dt max and waveform inspection[4]. After exclusions, 927 hours of data from 79 patients was analyzed.

Mean CO-CTD was 5.29 ± 1.14 L/min and mean CO-LTI was 5.36 ± 1.33 L/min. Bland-Altman analysis showed a mean difference of 0.04 ± 1.04 L/min (bias ± precision), with 95% limits of agreement from -2.00 to 2.08 L/min (Fig. 1A), and a **percentage error of 38.2%**. Paired observations showed a moderate correlation (r= 0.64, Fig. 2A).

In the arrhythmia subgroup, consisting of data from 26 patients, mean value of CO-CTD across all subjects was 4.95 ± 0.80 L/min. Mean CO-LTI was 5.04 ± 1.07 L/min. Bias ± precision analysis was 0.14 ± 0.90 L/min. Limits of agreement were -1.63 to 1.91 L/min (Fig. 1B). **The percentage error for the arrhythmia subgroup was 35.4%**. Correlation between CO-CTD and CO-LTI was moderate (r = 0.64, Fig. 2B).

Conclusion

Cardiac output measurements using a novel multi-beat analysis of radial artery pressure waveform are reasonably correlated with the traditional more-invasive pulmonary artery thermodilution guided cardiac output measurements. Our results agree with a previous validation of the LTI method in 31 post-cardiac surgery patients in the ICU, where a percentage error of 40.7% was reported[5]. Importantly, results were similar in the arrhythmia subgroup, indicating that the agreement of CO-LTI to CO-CTD is not affected by arrhythmia. Intensivists and anesthesiologists have the option of using a relatively non-invasive, easy to use method of cardiac output estimation in post cardiac surgery patients where arrhythmia is common.

References

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