Noninvasive cardiac output measurement using the volume clamp method in cardiosurgical intensive care unit patients: A comparison with the pulmonary artery catheter

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Introduction: The CNAP technology (CNSystems Medizintechnik AG, Graz, Austria) provides noninvasive continuous recording of the arterial pressure waveform based on the volume clamp method (Fig. 1). Recently, an algorithm for measuring cardiac output (CO) using pulse contour analysis of the CNAP-derived arterial waveform became available. In this study, we compared CO measurements and trending capability of the novel CNAP-CO (CNCO) with intermittent invasive CO measurements derived from the pulmonary artery catheter (PAC; PAC-CO) in cardiosurgical intensive care unit patients.

Methods: In this interim analysis, we analyzed simultaneously obtained CNCO and PAC-CO measurements in 41 patients during the first hours after off pump coronary artery bypass surgery. We performed 3 independent sets of 5 consecutive thermodilution measurements each per patient. The average of the 3 closest of the 5 PAC-CO measurements was used for comparison with the average of the corresponding CNCO values.
Four pairs of measurements were excluded due to artifacts resulting in 119 paired measurements for analysis. In addition, we analyzed 27 cardiac output–modifying maneuvers to evaluate trending ability. We conducted 2 separate comparative analyses: 1) CNCO calibrated to the first simultaneously measured PAC-CO value ($CNCO_{cal}$) vs. PAC-CO and 2) CNCO auto-calibrated to biometric patient data ($CNCO_{bio}$) vs. PAC-CO.
Agreement between the two methods was statistically assessed by Bland-Altman analysis and by calculating the percentage error (PE). For evaluating trending ability, we calculated the concordance rate (CCR; exclusion zone 0.5 L/min).

Results: For $CNCO_{cal}$, the Bland-Altman analysis revealed a mean difference of -0.2 L/min, a standard deviation of ±0.5 L/min and limits of agreement of -1.1 to +0.8 L/min (Fig. 2). The PE and CCR were 19% and 100%, respectively. For $CNCO_{bio}$, the Bland-Altman analysis showed a mean difference of +0.6 L/min, a standard deviation of ±1.1 L/min and limits of agreement of -1.6 to +2.8 L/min. The PE and CCR were 45% and 94%, respectively.

Conclusion: In this clinical study in cardiosurgical intensive care unit patients, $CNCO_{cal}$ showed good agreement (PE 19%) and good trending capability (CCR 100%) when compared with intermittent pulmonary artery thermodilution. For $CNCO_{bio}$, we observed a higher PE (45%) but acceptable trending capability (CCR 94%).

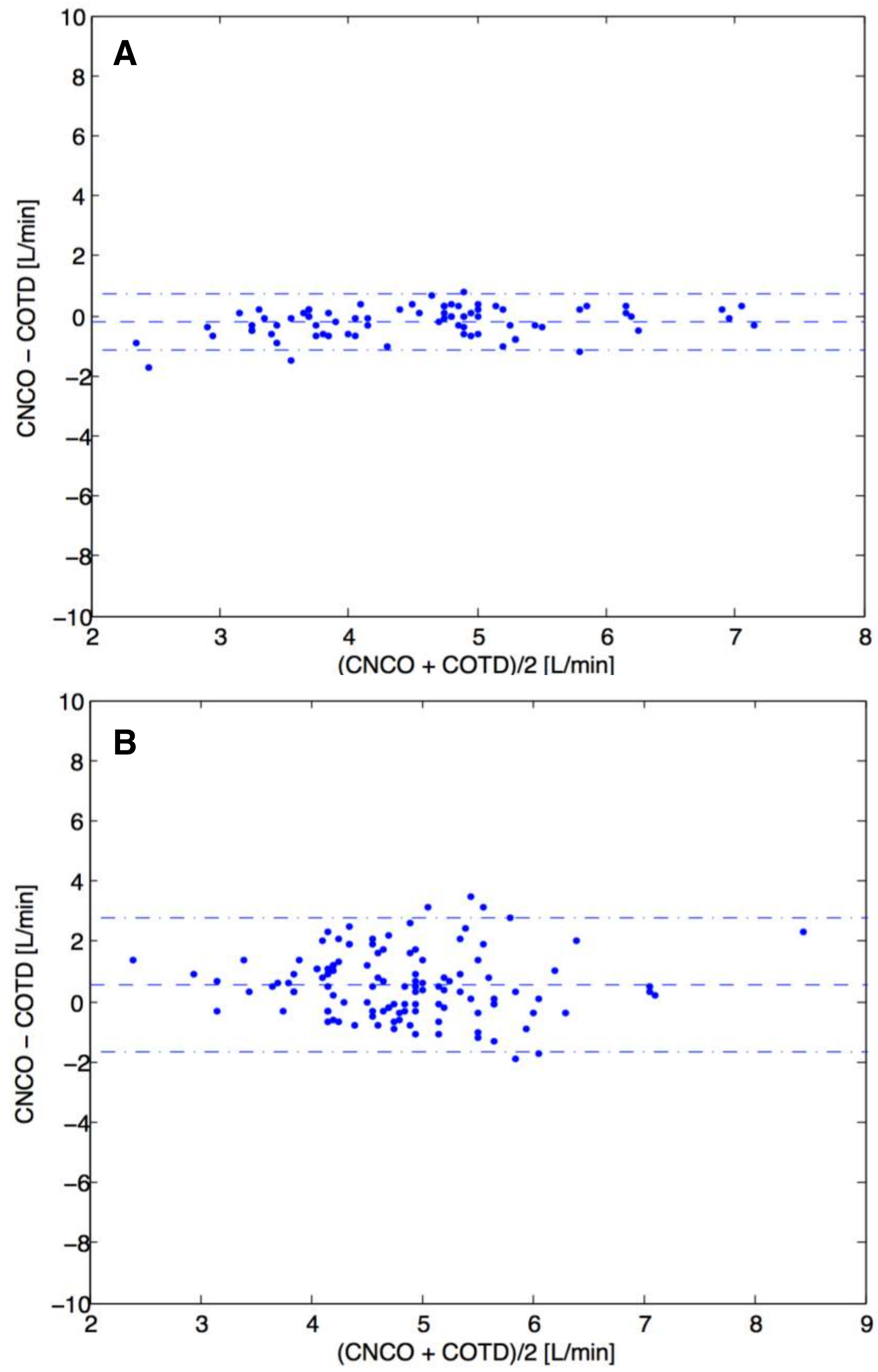

Fig. 2. Bland-Altman analysis for CNCO calibrated to the first simultaneously measured PAC-CO value (A) and auto-calibrated to biometric patient data (B) in 41 patients.

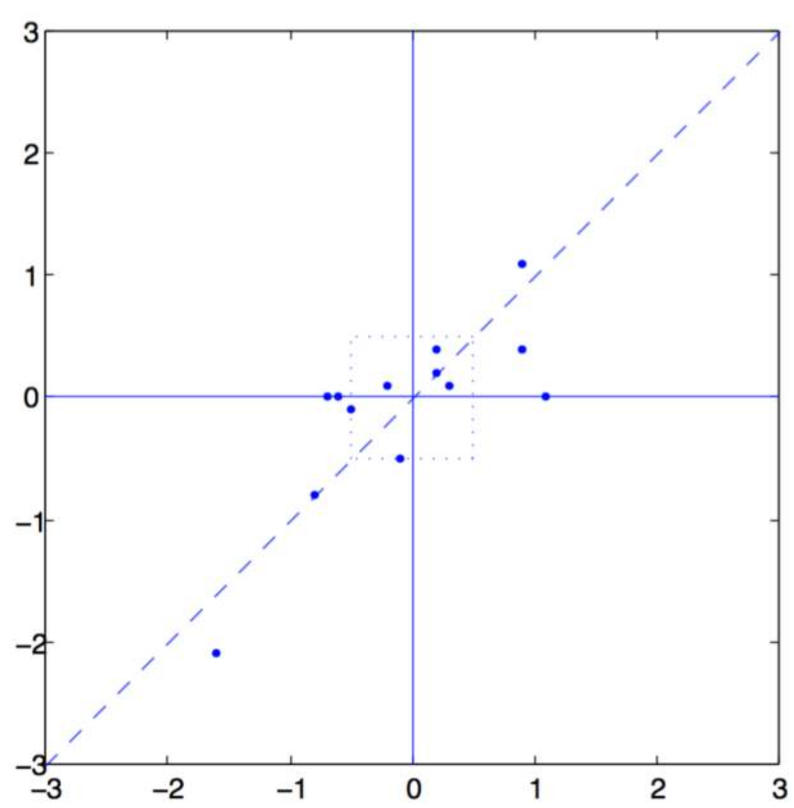

Fig. 3. Four-quadrant plot with a 0.5 L/min exclusion zone.

Fig. 1. The CNAP technology (source: CNSystems Medizintechnik AG, Graz, Austria)

Conflicts of interest:
JYW and BS received refunds of travel expenses and BS received lecture fees from CNSystems Medizintechnik AG (Graz, Austria). For all other authors there is no conflict of interest to disclose

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