

# Evaluation of the agreement of minimally-invasive cardiac output monitors before and after cardiopulmonary bypass

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## Introduction

Cardiac output (CO) monitoring is an important tool for hemodynamic optimization.<sup>[1]</sup> Bolus thermodilution (BTD) with a pulmonary artery catheter (PAC) remains the gold standard for CO measurement, but is invasive and has been associated with complications.<sup>[2]</sup> This study evaluates the level of agreement of CO values measured from multiple minimally-invasive CO monitor systems before and after cardiopulmonary bypass (CPB).

More Invasive		Less Invasive	
CCO	LiDCO Rapid	FloTrac	
Modified thermodilution (heating coil) technology	Radial arterial blood pressure waveform from arterial line	Radial arterial pulse contour from arterial line	
Non Invasive			
Cheetah	CNAP	ClearSight	
Based on thoracic bioreactance (Phase shifts of electrical currents)	Reconstructs arterial pressure waveform from finger arterial pressure	Reconstructs arterial pressure waveform from finger arterial pressure	

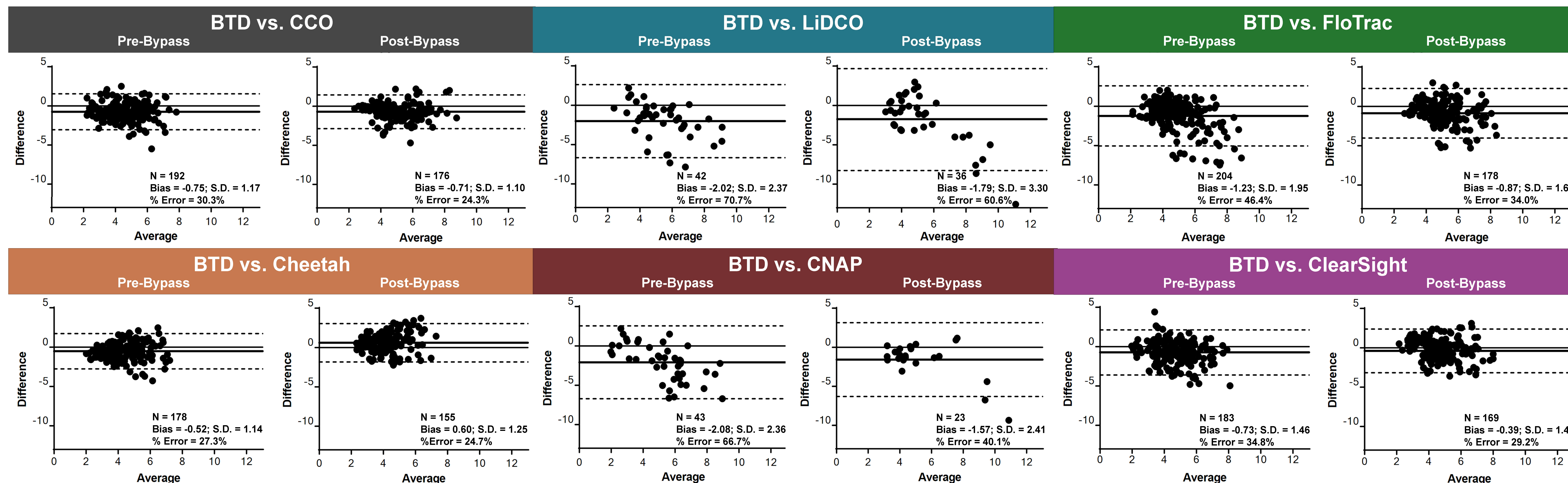
## Methods

The IRB reviewed and approved this quality improvement study. CO values from BTD and minimally-invasive CO monitors were simultaneously collected at various time points before and after cardiopulmonary bypass in cardiac surgeries. CO values were compared using Bland-Altman analysis to evaluate for agreement.

## Results

CO values of 60 patients underwent cardiac surgeries at UC Davis Medical Center were collected for this study. 8 patients were excluded due to missing BTD measurements. CO value measurements from the remaining 52 patients were evaluated using Bland-Altman analysis (Figure 1 – 6) below. Here is a table of result summary.

Types	CO Monitors	Pre-bypass			Post-bypass			Two-tail t-test p-values
		Bias	S.D.	% error	Bias	S.D.	% error	
More Invasive	CCO	-0.75	1.17	30.3%	-0.71	1.10	24.3%	0.058
Less Invasive	LiDCO Rapid	-2.02	2.37	70.7%	-1.79	3.30	60.6%	0.057
	FloTrac	-1.23	1.95	46.4%	-0.87	1.61	34.0%	0.029
Non Invasive	Cheetah	-0.52	1.14	27.3%	0.60	1.25	24.7%	0.238
	CNAP	-2.08	2.36	66.7%	-1.57	2.41	40.1%	0.041
	ClearSight	-0.73	1.46	34.8%	-0.39	1.41	29.2%	0.119



## Conclusions

Differences in CO value measurements Pre-bypass and Post-bypass were NOT statistically significant in most of the minimally-invasive CO monitors (except FloTrac and CNAP).

Based on studies in the past, percent error < 30% is considered acceptable.<sup>[3,4]</sup> Only Cheetah had percent error < 30% for both pre-bypass and post-bypass. However, electrocautery in surgeries might interfere with the reading of Cheetah monitors. So, more in-depth study is recommended.

### Reference:

- [1] Hamilton MA, Cecconi M: A systematic review and meta-analysis on use of preemptive hemodynamic intervention to improve postoperative outcomes in moderate and high-risk surgical patients. *Anesth Analg* 112:1392-1402, 2011
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- [3] Critchley LA, Critchley JA: A meta-analysis of studies using bias and precision statistics to compare cardiac output measurement techniques. *J Clin Monit Comput*. 1999 Feb;15(2):85-91.
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