Minimally Invasive Measurement of Cardiac Output During Surgery and Critical Care: A Meta-
Analysis of Accuracy and Precision.

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Background: When assessing the accuracy and precision of a new technique for cardiac output
measurement, the commonly accepted criterion for acceptability of agreement with a reference standard
is that the percentage error (95% limits of agreement/mean cardiac output) should be 30% or less \(^1\). We
reviewed published data on four different minimally invasive methods adapted for use during surgery and
critical care: pulse contour techniques, esophageal Doppler, partial carbon dioxide rebreathing, and
transthoracic bio-impedance, to assess their bias and percentage error in agreement with thermodilution.

Methods: An English language literature search identified published papers since 2000 which examined
the agreement in adult patients between bolus thermodilution and each method, using bias and precision
statistics. 92 publications were identified. For each method a meta-analysis was done using only studies
in which the first discrete independent measurement for each patient could be identified, to obtain a
pooled mean bias and percentage error weighted according to the number of measurements in each
study.

Results: 46 studies were identified as suitable for inclusion in the pooled weighted meta-analysis: \(N\)
studies, \(n\) measurements: mean weighted bias [percentage error] were: pulse contour \(N = 4, n = 714\): -0.0
L/min [41.3%]; esophageal Doppler \(N = 2, n = 57\): -0.8 L/min [42.1 %]; partial CO\(_2\) rebreathing \(N = 7, n =
145\): 0.0 L/min [43.6%]; transthoracic bio-impedance \(N = 13, n = 435\): -0.1 L/min [42.9%]. The
distributions of percentage error among the studies included in the pooled weighted meta-analysis closely
resembled those of all the studies identified for each method, suggesting that the results of the meta-
analysis are representative of the performance of each method across all studies done over the last
decade.

Conclusion: No method has achieved agreement with bolus thermodilution which meets the expected
30% limits. The relevance in clinical practice of these arbitrary limits should be reassessed. A more
realistic empirical criterion for acceptance would be a percentage error of \(\pm 45\%\).

References: 1. Critchley LAH, Critchley JA: A Meta-Analysis of Studies Using Bias and Precision