Comparison of Noninvasive Measurement of Cardiac Output, Electrical Velocimetry with Thermodilution Measurement of Cardiac Output in Children

David S Spar[1], Julie A Vincent[1], Alejandro Torres[1], William E Hellenbrand[1], Marc E Richmond[1], Ganga Krishnamurthy[2]
[1]Division of Pediatric Cardiology, Columbia University, New York, NY
[2]Division of Neonatology, Columbia University, New York, NY

Columbia University Medical Center
Department of Pediatrics

Morgan Stanley Children's Hospital of NewYork-Presbyterian
Columbia University Medical Center

INTRODUCTION

•The primary function of the cardiovascular system is to meet the metabolic demands of the body and is dependent on cardiac output (1).
•Thermodilution (TD), a measure of cardiac output, is an invasive technique requiring catheterization of the pulmonary artery.
•The use of TD in children is not uniformly favored as it offers uncertain risk-benefit ratio (2).
•Electrical Velocimetry (EV) is a novel method of noninvasive cardiac output assessment.
•EV interprets the maximum change in thoracic electrical bioimpedance as the ohmic equivalent of the mean aortic blood flow acceleration and further transforms it into an equivalent of mean aortic blood flow velocity. Stroke volume and cardiac output are then calculated (3).
•This method has been minimally studied in children (4,5).

OBJECTIVES

•The objective of this study was to compare cardiac output measurements by the non-invasively measured Electrical Velocimetry with pulmonary artery Thermodilution in children with normal cardiac anatomy and function.

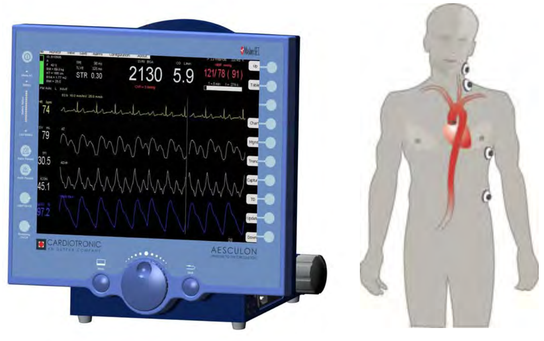

Figure 1: Model of the Aesculon® EV-CO monitor and location of the four standard ECG electrodes.

MATERIALS AND METHODS

•A prospective study was conducted in children (<18 years) who previously underwent cardiac transplantation and were undergoing routine cardiac catheterization at Morgan Stanley Children's Hospital from October 2009 to October 2010.
•Subjects with intra or extracardiac shunts, abnormal cardiac function, moderate or severe tricuspid regurgitation or hematocrit less then 30% were excluded from the study.
•Paired measurements of thermodilution cardiac output (TD-CO) by pulmonary artery catheter thermodilution and Electrical Velocimetry cardiac output (EV-CO) by Electrical Velocimetry were recorded.
•TD-CO was measured with a balloon tipped pulmonary artery thermodilution catheter (Arrow International, Reading, PA, USA) inserted via a sheath within the femoral vein or internal jugular vein and directed to the pulmonary artery under fluoroscopy. CO was obtained by pulmonary artery catheterization with bolus injection of 5ml or 10ml saline depending on the size of the patient.
•EV-CO was measured by placing four standard ECG electrodes, two placed on the left side of patient's neck and two placed on the left anterior axillary line at level of xiphoid process. The electrodes were attached to the Aesculon® monitor (Figure 1).
•TD-CO and EV-CO measurements were compared with the student t test, analyzed for correlation, and measured by the Bland-Altman plot for bias and precision.
•An *a priori* definition of acceptable limits of agreement was set at ± 30%.
•Bias represents the mean difference between the actual TD-CO measured by pulmonary artery TD and the EV-CO measured by Electrical Velocimetry.
•Precision was represented by two standard deviations of the bias.

RESULTS

•Forty-four children were enrolled in the study.
•Median age: 10 years (Range 0.8 -17) (see Table).
•Males: 26 (59%) and females: 18 (41%)
•Mean TD-CO: 3.66 ± 1.71 liter min^{-1}
Mean EV-CO: 3.44 ± 1.71 liter min^{-1} p=NS
•There was a significant correlation between TD-CO and EV-CO, r=0.89, p<0.001 (Figure 2).
•Bland-Altman analysis of TD-CO and EV-CO demonstrated a bias of 0.22 liter min^{-1} with a precision of ± 1.55 liter min^{-1} (Figure 3).
•The mean percentage error was 7.7 ± 18.7 (±1SD).

	Median (Range)
Age (years)	10 (0.8 – 17)
Weight (kg)	33.3 (8-110)
Height (cm)	129.5 (70 – 178)
Body Surface Area (m^2)	1.04 (0.38 – 2.2)

Table: Patient related data

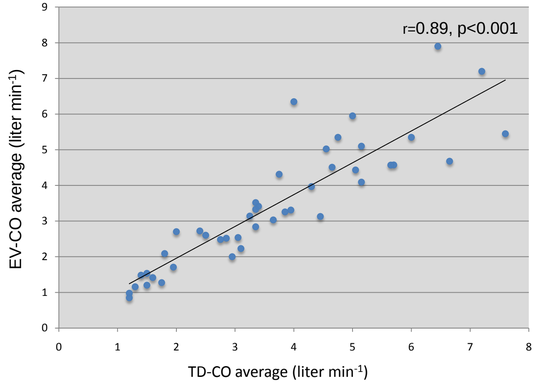

Figure 2. Correlation analysis of TD-CO and EV-CO measurements.

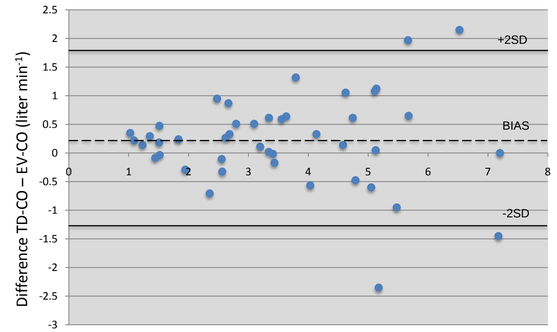

Figure 3. Bland-Altman analysis to compare TD-CO and EV-CO values. The plot shows 2 SD of differences (± 2 SD; precision) and the mean difference (Bias).

CONCLUSIONS

•Noninvasive EV-CO differs from TD-CO measurements by an average of 7.7 ± 18.7% and exceeds the *a priori* set acceptable limits of agreement in children with normal intracardiac anatomy and function.
•There was significant correlation between TD-CO and EV-CO (r= 0.89).
•The application of EV-CO monitoring as a trend monitor in outpatient or critical care settings requires further investigation.

REFERENCES

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DISCLOSURE STATEMENT

The equipment was provided by Cardiotronic Inc.