Validation of a novel capodynamic method (COEPBF) for cardiac output (CO) monitoring against suprasternal trans thoracic Doppler in anesthetized mechanically ventilated children

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Background

Perioperative cardiac output (CO) measurement is of considerable interest for hemodynamic management. Current available methods are generally not applicable in small children. The aim of this study was to validate a novel CO monitoring system, Dynamic Capnography (DC) against 2D trans thoracic Doppler. DC appears as a promising new option to monitor and guide intraoperative hemodynamics in children undergoing general anesthesia. The principle behind dynamic capnography can be described using the formula;

$$\text{ELV} \cdot (\text{FACO}_2^n - \text{FACO}_2^{n-1}) = \text{EPBF} \cdot \Delta t \cdot (\text{CvCO}_2 - \text{CcCO}_2^n) - \text{VTCO}_2^n.$$

The left side reflects the difference in CO2 content in the lung between two breaths and the first term on the right side describes the circulatory supply of CO2 in the alveolar compartment between two breaths.

Equation 1. Calculating effective pulmonary blood flow using mole balance

DC has been developed based on CO2 elimination (VCO2) by the lungs in ventilated patients and use the Differential Fick’s principle (1). By continuously six breaths with normal I:E relationship and three breaths with 2 seconds expiratory pause, variations in FACO2 are created. These variations are proportional to pulmonary blood flow (Equation 1). This provides continuous breath-by-breath cardiac output monitoring, which calculates the effective pulmonary blood flow (EPBF) which in the absence of significant intrapulmonary or cardiac shunt is equal to CO.

Methods

Prospective observational study in 15 children undergoing correction of cleft lip and palate repair. Patients were 6-65 months (median 9 months) and weighing 6-22 kg, (median 8.3 kg). After induction and before the surgical procedure, patients were subjected to controlled hemodynamic changes using PEEP and iv atropine according to Fig 2. Supra sternal transthoracic 2D echo and pulsed Doppler was used to determine aortic diameter and VTI (velocity time integral) and CO was then calculated using the formula below. The Doppler measurements were done by a senior pediatric cardiologist with more than 25 years experience in pediatric cardiac ultrasound and was blinded to recorded EPBF values.

$$\text{CO} = \text{Aortic diameter} \times \text{VTI} \times \text{heart rate}$$

Results

EPBF and CO showed moderate agreement during baseline and hemodynamic interventions (Fig 2). Values are presented as mean +/-SEM. Mean percentage error overall was 47%, bias 0.05L/min and correlation coefficient 0.76. Base line precision of reference method: +/- 26%, EPBF +/-12%.

Conclusion

DC appears as a promising new option to monitor and guide intraoperative hemodynamics in children undergoing general anesthesia. It shows agreement with trans thoracic Doppler. The mean percentage error in this study was higher than normally tolerated for novel CO-devices. Since DC can be used in any intubated and mechanically ventilated child and considering the lack of easy-accessible and minimal invasive CO monitors in small children, we still believe that the DC deserves attention and further analysis against reference methods with higher precision.

References