Effect of changes in tidal volume on plethysmographic variability in pediatric patients

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Introduction

The pulse oximeter is widely used as a standard for intraoperative monitoring of oxygenation during anesthesia. Studies have looked into expanding its utility by using the respiratory induced variation of the photoplethysmography (PPG) waveform as a dynamic index of preload (1,2). It has also been shown that different respiratory patterns can affect the waveform variability. In adults, a tidal volume of at least 8cc/kg is necessary to cause significant circulatory changes (4).

Reviews of studies done in children have been equivocal with regard to the use of respiratory-induced PPG variation to predict preload conditions (5). None of the studies standardized the ventilator settings used. Additionally, compared to adults, children have higher chest wall compliance and more compliant arterial vasculature. The aim of this study is to investigate whether or not pediatric patients require higher than 8cc/kg tidal volume to induce respiratory induced variations due to their physiology.

Methods

We included patients age 0 day to 17 years, ASA classification 1 and 2 who were intubated with positive pressure ventilation. They were grouped according to the NICHD Pediatric terminology. In these results, we included 12 patients age 1 month - 1 year (Group 1), 22 patients age 1-6 years (Group 2). Tidal volume was maintained at baseline, altered to 25% above then 25% below baseline while respiratory rate held constant for 5-minute intervals. Vital signs and basic hemodynamic data were recorded, in addition to continuous recording of the PPG and airway pressure waveforms at 100Hz. Waveforms were analyzed using frequency domain analysis at baseline tidal volume, and at 25% below and 25% above baseline. PPG waveform measurements were divided by their respective cardiac pulse amplitude to generate normalized DC% and AC% values. Results are presented as median and inter-quartile range (IQR). Friedman ANOVA and Wilcoxon tests were used, p < 0.05 is considered statistically significant.

Results

In Group 1 there was a statistically significant difference in the PPG DC% between baseline tidal volume of 8cc/kg and 25% above (p = 0.02) and in the PPG AC% between baseline and 25% above (p = 0.03). In Group 2, there was statistically significant difference in the PPG DC% between baseline and 25% below (p = 0.017).

Conclusion/Discussion

Statistically significant changes were seen in PPG waveform parameters in Group 1 between the baseline tidal volume of 8cc/kg and 25% above (10cc/kg), but not between baseline and 25% below. This suggests that within that age group, at least 10cc/kg is required to induce circulatory changes that would produce respiration-induced variability in the PPG waveform. In Group 2, however, there was a significant difference between baseline tidal volume and 25% below; this suggests that in that age group, 8cc/kg is adequate.

References