



Original contribution

Age-related incidence of desaturation events and the cardiac responses on stroke index, cardiac index, and heart rate measured by continuous bioimpedance noninvasive cardiac output monitoring in infants and children undergoing general anesthesia[☆]



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Abstract

Study objective: To assess the effects of desaturation on stroke index (SI), cardiac index (CI), and heart rate (HR) using the ICON continuous noninvasive cardiac output monitor in children undergoing general anesthesia.

Design: Retrospective analysis of a prospectively collected data set.

Setting: Pediatric operating rooms in a tertiary academic medical center.

Patients: Children younger than 20 years who experienced desaturation while undergoing general anesthesia.

Intervention: All records were retrospectively searched for desaturation events defined as a recorded SpO₂ ≤ 90%. We compared the data from the prior 4 minutes (baseline) with mild, moderate, and severe levels of desaturation.

Measurements: The relationship between SpO₂ and percent change in SI, CI, and HR from baseline was assessed using a generalized linear model with repeated measures and the least-squares method.

Main results: Data from 446 patients were reviewed; 38 events were eligible for analysis after exclusions. There were significant decreases in SI at all saturation ranges below 95%: -6.5% ($P < .001$) for 85%-95%, -8.9% ($P = .002$) for 71%-84%, and -11% ($P < .001$) for ≤ 70%. Based on the result from the regression, SpO₂ was associated with change in SI with borderline significance ($P = .053$) but not that of HR and CI. There was a strong relationship to desaturation events with young age ($P < .001$), particularly infants younger than 6 months.

[☆] Conflicts of Interest: Charles J. Coté serves on the editorial board of the *Journal of Clinical Anesthesia*.

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Conclusion: Events associated with desaturation in children under general anesthesia were significantly associated with decreased SI with a greater effect with lower saturation nadirs. It is unclear if other concurrent events could have also contributed to adverse hemodynamic responses during desaturation. In most children, a compensatory increase in HR generally offsets concurrent decreases in CI. It would appear that bradycardia is a late manifestation of hypoxemia.

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1. Introduction

Electrical Cardiometry noninvasively measures changes in thoracic bioimpedance to estimate cardiac parameters including cardiac output (CO), stroke index (SI), cardiac index (CI), and heart rate (HR). The ICON (Cardiotronic/Osypka Medical, Inc, La Jolla, CA) monitor measures the rate of change of impedance during peak aortic blood flow via 4 skin electrodes, using the change of orientation of red blood cells between the systole (low impedance and aligned orientation) and diastole (high impedance and random orientation) to estimate cardiac function [1,2].

We previously reported a pilot study evaluating the ICON monitor for clinical usefulness in anesthetized children [3] and have continued to enroll patients at our institution. During the pilot study, which involved >400 children, we observed a dramatic decrease in CI and SI in 1 infant during a clinically important desaturation event (Fig. 1). Given this observation and the fact that respiratory events are commonly associated with adverse cardiovascular responses during anesthesia in children [4], we performed a post hoc analysis on all prospectively collected desaturation events in order to characterize the relationship between desaturation events and cardiac function. We hypothesized that desaturation events would lead to measurable impairment of CI and SI, with the magnitude of the

decrease in these parameters proportional to the degree of desaturation.

2. Materials and methods

2.1. Pilot study and data collection

This was a retrospective analysis of a prospectively collected data set from a convenience sample of children undergoing general anesthesia; the results of that study involving 402 children are reported elsewhere [3]. An additional 44 children were enrolled under the same protocol designed to determine the value of this monitor in the operating room. The study was institutional review board approved and registered with the Food and Drug Administration Amendments Act (Trial Registry NCT01499615); informed verbal consent was obtained. Four electrodes were placed per manufacturer instructions [1], with monitoring initiated prior to induction when allowed by the anesthesia team and/or patient anxiety and agitation levels. Standard monitors including a blood pressure cuff, electrocardiogram leads, and a pulse oximeter were applied, and the presence of a quality pulse oximetry waveform was confirmed before recording study data. SpO₂ was monitored using a Masimo pulse oximeter model LNCSF Neo,

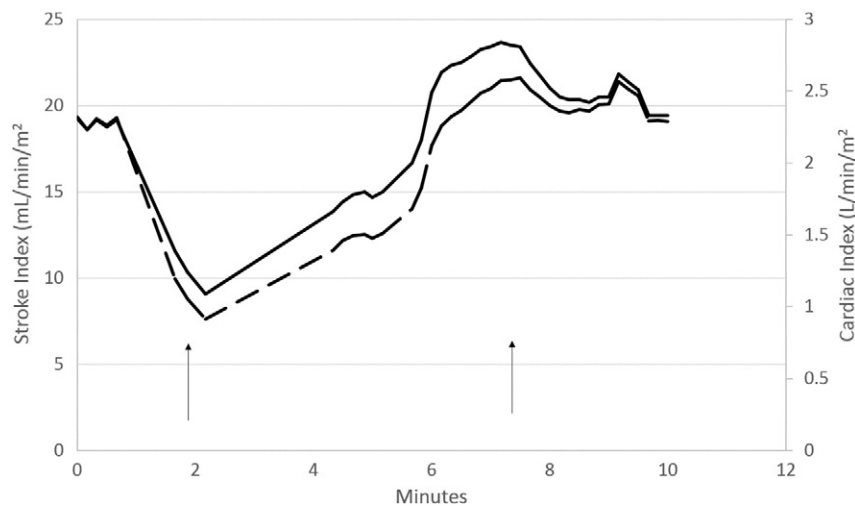


Fig. 1 Trends of cardiac index (dotted line) and stroke index (solid line) over the course of one of the desaturation events, a case of bronchospasm at extubation that resulted in a ~60% decrease in cardiac index and a ~50% decrease in stroke index. The first arrow marks the first recorded SpO₂ ≤ 90%, whereas the second arrow marks the recovery of the SpO₂ to >90%. Heart rate remained relatively stable between 120 and 140 beats/min during the entire event.

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