NON-INVASIVE ASSESSMENT OF CHANGES IN CARDIAC OUTPUT IN INFANTS HOSPITALIZED WITH BRONCHIOLITIS

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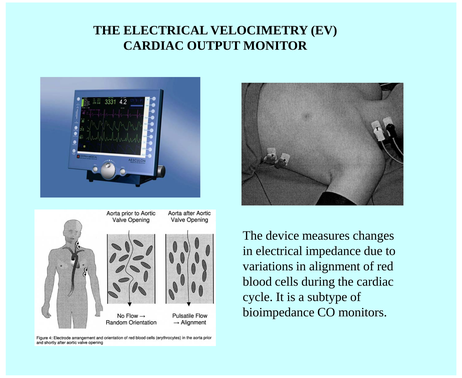
INTRODUCTION

Hemodynamic monitoring, including measurement of cardiac output (CO), is important in pediatric critical care medicine. However, measuring CO traditionally requires invasive techniques that are difficult in many patients, especially non-sedated infants. New non-invasive physiologic monitors may be able to detect hemodynamic changes including CO in awake infants. If so, non-invasive CO monitoring could facilitate hemodynamic profiling and guide medical interventions in these patients.

PURPOSE

Our objective is to characterize hemodynamic trends in non-sedated infants with bronchiolitis as measured by a non-invasive cardiac output (CO) monitor.

METHODS



The device measures changes in electrical impedance due to variations in alignment of red blood cells during the cardiac cycle. It is a subtype of bioimpedance CO monitors.

This is a sub-study within a larger ongoing prospective study of hemodynamic changes in hospitalized patients as characterized by non-invasive CO monitoring. The Aesculon CO monitor (Cardiotronic Inc., La Jolla CA) calculates surrogate measures of CO by electrical velocimetry (EV), a subtype of bio-impedance monitoring. The device has been validated in sedated children with congenital heart disease but has not been assessed in non-sedated infants.

Patients were eligible for the study if they were previously healthy and required hospitalization for acute illness. After obtaining informed consent, we obtained daily five-minute recordings for each patient with the CO monitor from admission to discharge. In addition to the CO, stroke volume (SV) and heart rate (HR) measures from the monitor, we compiled routine data from the patient charts including vital signs, diagnostic tests and clinical interventions. We analyzed hemodynamic changes within the subset of patients who had a primary diagnosis of bronchiolitis.

SUBJECT CHARACTERISTICS

We recruited 16 subjects during one bronchiolitis season (1/14 – 2/26/2010) from the Medical Intensive Care Unit (N=5), the Intermediate Care Program (N=6) and Medical Inpatient Units (N=5). Our subject characteristics are consistent with those of other infants studied in the literature with acute, moderate-to-severe bronchiolitis. The majority of these infants had respiratory syncytial virus (RSV).

Demographics		
N = 16 (11 Male, 5 Female)		
	Mean	Range
Age (months)	4.4	0.5 - 18.2
Weight (kg)	6.5	3.0 - 11.0
History of Present Illness (days)	4	1 - 6
Length of Stay (days)	3.9	1.6 - 8.9

15 of 16 patients were RSV positive by rapid test and/or DFA. 15 patients received a chest x-ray that was consistent with bronchiolitis; the 16th patient did not receive a chest x-ray. One patient developed a suprainfection (pneumonia) secondary to bronchiolitis.

Medical Interventions		
	N	% of Total
Oxygen Supplementation	14	88%
Non-invasive positive pressure O2 support	6	38%
Intubation	0	0%
Albuterol Nebulization	14	88%
3% Hypertonic Saline Nebulization	11	69%
Atrovent Nebulization	1	6%
Racemic Epinephrine Nebulization	8	50%
Steroids	3	19%
IV Fluids	12	75%
Antibiotics	13	81%

DATA ANALYSIS

Routine clinical measures of heart rate, respiratory rate, oxygen saturation and mean arterial pressure were compared (repeated measures one-way ANOVA) in the following four periods: a) the first 6 hours after patient presentation, b) 3 hours pre- and post- our initial CO recording, c) 3 hours pre- and post- our final CO recording, and d) the last six hours prior to discharge.

For the initial and final recordings obtained with the CO monitor, we compared CO, SV and HR (paired t-test) and calculated the percent changes.

RESULTS

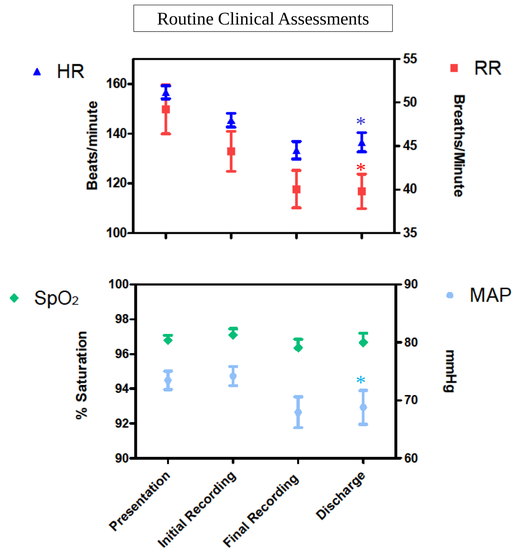


Figure 1. Heart rate (HR), respiratory rate (RR), oxygen saturation (SpO2) and mean arterial pressure (MAP) from patient presentation to discharge. The average time between patient presentation and the first recording was 18 hours (range 4 to 34). The average time from the final recording to discharge was 9 hours (range 0 to 28).

There were significant decreases in HR($p<0.0001$), RR($p<0.0001$), and MAP ($p=0.02$) during the hospital course (repeated measures ANOVA with post-hoc linear trend analysis).

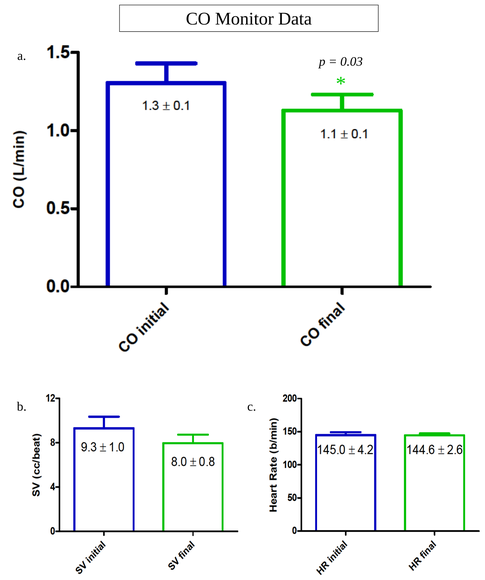


Figure 2. We observed a significant drop in cardiac output (CO) between the initial and final recordings (15.4% ; $p=0.03$; Figure 2a). Stroke volume decreased 14.0% though the change did not reach significance ($p=0.06$; Figure 2b). Unlike the routine clinical measures (Figure 1) there was no difference in heart rate at the initial and final recordings (Figure 2c). *All recordings were performed when patients were awake (Mean State Behavioral Scale were the same between initial (0.0) and final recordings (0.1)).*

CONCLUSION

- We detected a significant decrease in cardiac output during the hospital course of 16 infants with acute bronchiolitis, as measured by a non-invasive CO monitor.
- The change in CO was largely attributed to a decrease in stroke volume, though this latter measure did not reach statistical significance ($p=0.06$).
- Our observations in this study build confidence that the non-invasive CO monitor is sufficiently sensitive to detect hemodynamic changes in this age group.
- Non-invasive CO monitors may provide a practical alternative to invasive CO measurements for directing treatment of pediatric diseases.

REFERENCES

Norozi K, Beck C, Osthaus WA, Wille I, Wessel A, Bertram H. Electrical velocimetry for measuring cardiac output in children with congenital heart disease. Br J Anaesth. 2008 Jan;100(1):88-94.

Plint AC, Johnson DW, Patel H, Wiebe N, Correll R, Brant R, Mitton C, Gouin S, Bhatt M, Joubert G, Black KJ, Turner T, Whitehouse S, Klassen TP. Epinephrine and dexamethasone in children with bronchiolitis. N Engl J Med. 2009 May 14;360(20):2079-89.

Curley MA, Harris SK, Fraser KA, Johnson RA, Arnold JH. State Behavioral Scale: a sedation assessment instrument for infants and young children supported on mechanical ventilation. Pediatr Crit Care Med. 2006 Mar;7(2):107-14.

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