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Brief Reports

PLETH VARIABILITY INDEX TO ASSESS COURSE OF ILLNESS IN CHILDREN WITH ASTHMA

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☐ **Abstract—Background: Status asthmaticus (SA) is a common reason for admission to the pediatric emergency department (ED). Assessing asthma severity efficiently in the ED can be challenging for clinicians. Adjunctive tools for the clinician have demonstrated inconsistent results. Studies have shown that pulsus paradoxus (PP) correlates with asthma severity. Pleth Variability Index (PVI) is a surrogate measure of PP. Objective: We investigated whether PVI at triage correlates with disposition from the ED. Methods: We recruited children aged 2–18 years old who presented to the pediatric ED of a tertiary care children's hospital with SA. PVI, Respiratory Severity Score, and vital signs were documented at triage and 2 hours into each patient's ED stay. PVI was measured using the Masimo Radical-7® monitor (Masimo Corp., Irvine, CA). Results: Thirty-eight patients were recruited. Twenty-seven patients were discharged home, 10 patients were admitted to the general pediatrics floor and 1 patient was admitted to the intensive care unit. PVI values at triage did not correlate with disposition from the ED (p = 0.63). Additionally, when trending the change in PVI after 2 hours of therapy in the ED, no statistically significant patterns were demonstrated. Conclusions: Our study did not demonstrate a correlation between PVI and clinical course for asthmatics. PVI may be more clinically relevant in sicker children. Furthermore, it is possible that continuous monitoring of PVI may demonstrate more unique trends in relation to asthma severity versus single values of PVI. Additional studies are necessary to help clarify the relationship between PVI and the clinical course of children with SA.** © 2018 Elsevier Inc. All rights reserved.

☐ **Keywords—asthma; pediatrics; pediatric emergency medicine; pediatric emergency department; PVI; pulsus paradoxus; triage; Pleth Variability Index; status asthmaticus; asthma exacerbation**

INTRODUCTION

Asthma is the most common chronic condition of children in the United States and is responsible for 1.8 million visits to an emergency department (ED) annually (1). The disease burden of asthma on health care resources can be substantial during high-risk time periods and respiratory viral epidemics. An accurate, reliable method of stratifying relative acuity that reduces triage time and personnel resources can be helpful and effective.

Several studies have reported that severity of asthma exacerbations correlates with degree of pulsus paradoxus (PP) (2,3). PP is a decrease by >10 mm Hg in systolic blood pressure during inspiration and can be exacerbated in cases of pericardial effusion or obstructive pulmonary disease, among others. In obstructive pulmonary disease,

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such as in status asthmaticus (SA), increased intrathoracic pressure due to hyperinflated lungs causes decreased left heart filling and a corresponding decrease in systolic blood pressure during inspiration. Increased PP correlates significantly with Respiratory Severity Score (RSS) and wheeze in obstructive disease, and PP > 15 mm Hg has been shown to correlate with a very severe asthma attack (2,4,5). Previous studies have also compared PP to forced expiratory volume (FEV), showing that decreased FEV correlates with worsened PP (6,7). However, FEV may be challenging to obtain with an uncooperative patient. Measuring PP, therefore, may be an alternative way of gauging severity of asthma exacerbations.

PP is traditionally measured via sphygmomanometry. However, in uncooperative children, it is challenging to coordinate blood pressure readings with the respiratory cycle, making this a difficult means of measuring PP in the pediatric population. Plethysmography, on the other hand, is more easily obtained in children and can be used as an alternative method for measuring PP. Variability in the amplitude of the pulse oximetry wave form has been shown to correlate with changes in pulse pressure that occur during the respiratory cycle (8). This metric has been termed *Pleth Variability Index* (PVI). Recent studies have shown that PVI is an accurate, noninvasive way of measuring PP via infrared signal (9). These studies have shown that a greater PVI is associated with a higher degree of PP. In general, a patient in normal respiratory status would have a PVI of 10–20, and someone with severe PP would have a PVI of 60–70.

Previously, our group showed significant differences in PVI in patients with different dispositions from our ED (10). In this study, PVI was calculated manually by the research team using printed pulse oximetry tracings. Patients discharged directly from the ED had a lower calculated PVI than those admitted directly to the hospital floor or pediatric intensive care unit (PICU). As manual calculations of PVI are not routinely feasible in a busy ED, we sought to examine whether similar findings would occur with an automated PVI monitor and whether this monitor would detect changes in PVI after treatment. Masimo Corporation (Irvine, CA) produces a commercial PVI monitor capable of measuring PVI automatically. Through an equipment loan from Masimo, we were able to study PVI in our patient population.

OBJECTIVE

We investigated whether automated measurements of PVI could accurately distinguish between patients with mild vs. severe asthma exacerbations and whether PVI at triage in asthmatic patients would correlate with their disposition from the ED. Our hypothesis was that patients with higher automated PVI values would have an increased likelihood of being admitted to the hospital.

MATERIALS AND METHODS

We prospectively recruited patients through the triage center of a pediatric ED at a tertiary care children's hospital. Patients 2–18 years of age were identified with signs and symptoms of SA or reactive airway disease exacerbation and were then approached for inclusion in the study. Patients with respiratory distress secondary to diseases other than SA (such as bronchiolitis) were excluded. Patients were enrolled in the study from 9 AM to 5 PM on weekdays by a research assistant as part of a convenience sample method of recruitment. The Northwell Health Institutional Review Board approved the study protocol.

Study Protocol

After identification for inclusion in the study, verbal consent was obtained from parents or primary caregiver. Written consent was obtained after initial evaluation by clinical staff. Baseline vital signs, RSS, and PVI were all recorded at triage at the same time. RSS is currently used at our institution to stratify asthma severity; we chose to use RSS as a gold standard to compare to PVI because it was easier to obtain and less user-dependent than other measurements of severity, such as FEV. The parameters used to calculate the RSS at our institution, which is part of our asthma pathway, are listed in Supplementary Figure 1.

Patients received bronchodilator treatments (either albuterol or a combination of albuterol and atrovent) and systemic corticosteroids (if they had an initial RSS in the moderate to severe range or if they required two or more albuterol treatments) as part of routine care. RSS and PVI were repeated and recorded 2 hours after initial assessment in triage. Due to limited equipment availability, PVI was not assessed after transfer from the ED to the inpatient floors. PVI was measured using the Masimo Radical-7® monitor, which has been approved by the U.S. Food and Drug Administration for the monitoring of cardiorespiratory parameters. PVI is calculated by the device automatically and is continuously displayed on the screen. All clinicians in the ED were blinded to the output of the monitors and PVI was not taken into consideration for any clinical decisions, including whether to admit the patient to the hospital or to discharge them directly from the ED.

Basic demographic information for these patients, such as age and sex, was also recorded. Patients were followed after initial presentation in the ED, either through phone calls if discharged home or via electronic medical records if admitted.

We excluded all patients under the age of 2 years, as the Masimo Radical-7® monitor has only been validated