Published in final edited form as:

Am J Emerg Med. 2019 March ; 37(3): 506–509. doi:10.1016/j.ajem.2019.01.026.

Respiratory Adjusted Shock Index for Identifying Occult Shock and Level of Care in Sepsis Patients

Lynn Jiang, M.D.,

New York Presbyterian-Columbia and Cornell Residency Program

Nicholas D. Caputo, M.D.,

Department of Emergency Medicine, Columbia University Medical Center

Bernard P. Chang, M.D., Ph.D

Department of Emergency Medicine, Columbia University Medical Center

Abstract

Objective: Early identification of shock allows for timely resuscitation. Previous studies have noted the utility of bedside calculations such as the shock index and quick sepsis-related organ failure assessment (qSOFA) to detect occult shock. Respiratory rate may also be an important marker of occult sepsis. The goal of our study was to evaluate whether using a modified shock index with respiratory rate would improve identification of emergency department sepsis patients admitted to an ICU or stepdown unit.

Methods: A prospective, observational cohort study of the respiratory adjusted shock index (RASI), defined as $HR/SBP \times RR/10$, was conducted. RASI was calculated from triage vital signs and compared to serum lactate. Primary outcome was admission to higher level of care defined as ICU or stepdown unit. A multivariable logistic regression model including RASI, shock index, lactate, age and sex was performed with disposition as the outcome variable. Receiver operator characteristic curves were created to detect occult shock and level of care for RASI, shock index, and qSOFA.

Results: 408 patients were enrolled. Regression analysis revealed that lactate (OR 1.6, $z = 5.05$, $p < .0001$) and RASI (OR 2.60, $z = 3.55$, $p < .001$) were predictive of need for higher level of care. Receiver operator curves found an area under the curve (AUC) for predicting occult shock was 0.73 compared to shock index (0.58) and qSOFA (0.60). RASI had a significant AUC in predicting level of care at 0.7 compared to shock index (0.54) and qSOFA (0.62).

Conclusions: RASI may have utility as a rapid bedside tool for predicting critical illness in sepsis patients.

Keywords

sepsis; screening; shock index

⁴**Corresponding Author:** Lynn Jiang, **Present/Permanent Address,** Lynn Jiang, MD, Weill Cornell Medical Center, Department of Emergency Medicine, 525 E. 68th Street, NY, NY 10065, Phone: 773-987-6050, lgj7001@nyp.org.

⁶**Meetings:** Preliminary analysis and results of this work was presented at the Society for Academic Emergency Medicine on May 16, 2018 in Indianapolis, Indiana.

1.1 Introduction

Sepsis is the 11th leading cause of death and among the costliest disease conditions across U.S. hospitals (1). Emergency physicians play a crucial role in early identification and management of sepsis. Timely resuscitation in the emergency department (ED) has been associated with significant improvement in near and long-term patient outcomes, such as mortality and hospital length of stay (2,3). Given the importance of time-sensitive interventions and treatments, past work has sought to create early identification schemes in the ED. While vital signs are a key component in identifying shock, they often do not change until later in a patient's course of illness (4). One commonly used index, the shock index (SI) [heart rate (HR) / systolic blood pressure (SBP)] assesses shock severity with a normal range defined as 0.5 – 0.7 (5). It presents a sensitive marker for occult hypoperfusion states compared to vital signs alone (6). The SI has already been applied to trauma patients to determine severity of illness and has been extrapolated to sepsis and post-intubation patients. The limitations of SI pertain to cardiovascular compensation, especially in younger patients. This means that as SI increases, the patients are already starting to declare their hypo-perfused state, often obviating the need for the screen itself.

Prior studies have found that tachypnea is a predictor of cardiac arrest on hospital wards, often presenting before changes in heart rate or systolic blood pressure (7). While tachypnea has been thought to represent a sensitive marker of critical disease and has been used in some scales, such as the quick Sequential Organ Failure assessment (qSOFA) score, few bedside screening measures of sepsis have broadly attempted to include respiratory rate in the past (8). A recently developed assessment of disease severity called the Respiratory Adjusted Shock Index (RASI), integrates the use of respiratory rate, along other markers of acute physiologic stress assessed in the SI and has been found to successfully identify occult sepsis in a cohort of trauma patients (9). We sought to build on this work by examining if using such a bedside tool as the RASI would help identify clinical course in a sample of ED patients evaluated for potential sepsis. Specifically, the goal of our study was to evaluate if RASI score calculated in suspected ED sepsis patients, predicted subsequent hospital disposition to a stepdown or intensive care unit (ICU) level

1.2 Methods

1.2.1 Study Design

A prospective observational cohort study was performed. The study was reviewed and approved by the institutional review board and waiver of informed consent and authorization were granted.

1.2.2 Study Setting and Population

Between July 2017 to January 2018, patients presenting at a single academic emergency department in New York City deemed to have a suspicion for sepsis by the treating provider and who had an initial lactate drawn within the first hour of care were included. Any patient who may have had an elevated lactate for reasons other than sepsis (e.g. bleeding, cardiogenic shock) were excluded.

1.2.3 Measurements/Outcomes

The RASI score was calculated by $HR/SBP \times (RR/10)$. RASI was calculated from triage vital signs and compared to serum lactate drawn within one hour of ED presentation. Primary outcome was final ED disposition. Final disposition was operationalized into two categories – those at a general level of care who were either discharged or admitted to the floor and those with more critical illness as defined by requiring a higher level of care (i.e. admission to stepdown or ICU). Final discharge diagnosis of sepsis was confirmed by chart review. No intervention or change in management was performed on study participants.

1.2.4 Data Analysis

Descriptive statistics including demographics, lactate, and white blood count levels were recorded. The association between RASI score and hospital disposition was analyzed by logistic regression with RASI as a predictor and hospital disposition as outcome. Correlation of RASI and lactate was also recorded. Receiver operator characteristics and area under the curve were created for test characteristics and comparative states for RASI, shock index, and qSOFA.

1.3 Results

408 participants were included in the study. Average age was 61 years old (median 62, STDev 18.7 years; min 20; max 99). 208 participants were female (51%), 200 were male (49%). Fifty-three patients were admitted to a higher level of care, defined as stepdown and ICU, including three patients who expired in the emergency room. Average age of this cohort was 65 years old and 51% were female. Of those with a lower level of care, average lactate was 2 (median 1.7; STDev 1.1). Those with more critical illness had an average lactate of 3.9 (median 2.69; STDev 3.4).

Using a logistic regression model with higher level of care disposition as the outcome variable, lactate level significantly predicted subsequent higher level of care disposition lactate (OR 1.6, $z = 5.05$ $p < .0001$) adjusting for age, sex, and serum white blood cell count. In this model, RASI also significantly predicted disposition after being adjusted for age, gender, white blood cell level, and lactate level (OR 2.60, 95% CI: 1.53, 4.4) (Table 1). Pearson's correlation between RASI and lactate was low ($r.24$) however, suggesting these variables were not significantly associated. Receiver operator curves found AUC for predicting occult shock was 0.73 while for shock index and qSOFA it was 0.58 and 0.6 respectively. RASI also had a significant AUC in predicting level of care at 0.7 compared to shock index (0.54) and qSOFA (0.62) (Figure 1).

1.4 Discussion

Our study found that RASI scores significantly predicted ED disposition in a sample of patients with suspected sepsis. While existing tools such as the shock index have been found to aid the identification of sepsis in the ED (10), such scoring systems may be less sensitive identifying patients with early/occult shock as it relies largely on cardiovascular measures that may not change until later on in a patient's course of illness (11).

In our study, we integrated respiratory rate into a novel tool, RASI. And found greater predictive ability of RASI for identifying ED sepsis patients who ultimately were dispositioned to a higher level of care compared to lactate alone, as well as compared to other common bedside screening instruments such as the SI and qSOFA. RASI was not found, however, to be significantly correlated with lactate, suggesting that while both assessments significantly predict hospital disposition in ED patients with sepsis, they may be capturing different aspects of the variance in patient distribution. This may be because vital signs assessed at the bedside and serum lactate drawn, while having some overlap, may be operationalizing distinct physiological mechanisms (12).

The findings of our study build on the existing literature using rapid bedside screening assessments for potential sepsis severity (5,6). By including a commonly assessed vital sign, respiratory rate, clinicians may gain additional information with regards to potential clinical prognosis and course for suspected sepsis patients in the ED. Given the existing collection of respiratory rate and the ease of calculation at the bedside, applications for the RASI in sepsis patients include its potential use in early triage systems to detect early potential sepsis, as well integration with physician extenders and nurses. When used in conjunction with clinical judgement and other more testing in the ED, such as serum lactate and blood gas, RASI helps to complement these tools by offering a quick and easily applied assessment that can be calculated immediately on patients' ED arrival.

1.4.2 Limitations

This study was a single site study conducted at an urban medical center which may raise questions of generalizability in different clinical environments and local disease prevalence. Additionally, in creating only two categories for level of care (e.g. ICU vs Step Down), the spectrum of clinical disposition may have been too simplified. Future work may examine other assessments of care utilization, such as amount of critical care billed or the presence or absence of acute medical events or need for more invasive monitoring to better operationalize level of care. Additionally, a broad clinical difference between patients that are discharged and admitted to the hospital exists. By combining these two into a singular "lower level of care" category, the difference in their clinical status is not appreciated. Further analysis that divides level of care into further categories could provide a more detailed picture of RASI's correlation with overall level of care. Finally, RASI being calculated from triage vital signs brings to question the accuracy of respiratory rate measured in triage. For some institutions, respiratory rate is only cursorily measured leading to default 'normal' respiratory rates rather than an accurate measurement. Future work may focus on other more objective assessments of respiratory rate to help ensure reliability and accuracy.

1.4.3 Conclusions

Our study presented preliminary data on a bedside application of vital signs to aid in the screening for possible clinical severity. There are already existing panels of blood work and other measures to predict sepsis progression but RASI offers a rapid, easy bedside assessment that can be calculated within seconds. It could provide an important measure of

impending critical illness and quickly identify patients that may require more aggressive intervention and a higher level of care going forward.

Future working looking at the potential utility of the RASI index, alongside other measures of clinical severity, may provide additional information in the search for rapid bedside assessments of clinical severity that, when coupled with clinical history, physical and assessment, may aid in the timely identification of severe illness.

Acknowledgments

5) **Grant:** BC is supported in part by an R01 grant from NIH/NHLBI 141811.

References

1. Torio CM, Andrews RM. National inpatient hospital costs: the most expensive conditions by payer, 2011 Statistical brief no. 160. Health Care Cost and Utilization Project (HCUP). Rockville, MD: Agency for Healthcare Research and Quality, 8 2013.
2. Rivers E, Nguyen B, Havstad S, et al. Early goal-directed therapy in the treatment of severe sepsis and septic shock. *N Engl J Med*. 2001; 345: 1368–1377. [PubMed: 11794169]
3. Pittet D, Tarara D, Wenzel RP. Nosocomial blood stream infection in critically ill patients: excess length of stay, extra costs, and attributable mortality. *JAMA*. 1994; 271 (20): 1598–1601. [PubMed: 8182812]
4. Rady MY, Rivers EP, Nowak RM: Resuscitation of the critically ill in the ED: responses of blood pressure, heart rate, shock index, central venous oxygen saturation, and lactate. *Am J Emerg Med*. 1996; 14: 218–225. [PubMed: 8924150]
5. Singh A, Ali S, Agarwal A, et al. Correlation of shock index and modified shock index with the outcome of adult trauma patients: a prospective study of 9860 patients. *N AM J Med Science*. 2014 9, 6(9): 450–452.
6. Berger T, Green J, Horeczko T, et al. Shock index and early recognition of sepsis in the emergency department: pilot study. *West J Emerg Med*. 2013; 14(2):168–174. [PubMed: 23599863]
7. Fiesemann JF, Hendryx MS, Helms CM, et al. Respiratory rate predicts cardiopulmonary arrest for internal medicine patients. *J Gen Intern Med*. 1993; 8: 354–360. [PubMed: 8410395]
8. Bone RC, Balk RA, Cerra FB, Dellinger RP et al. Definitions for sepsis and organ failure and guidelines of the use of innovative therapies in sepsis. *Chest*. 1992; 101 (6): 1644–55. [PubMed: 1303622]
9. Caputo N, Reilly J, Kanter M, West J. *J Trauma Acute Care Surg*. A retrospective analysis of the respiratory adjusted shock index to determine the presence of occult shock in trauma patients. 2018 4; 84(4): 674–678.
10. McLymont N, Glover GW. Scoring systems for the characterization of sepsis and associated outcomes. *Annals of Translational Medicine*. 2016; 4(24): 527. [PubMed: 28149888]
11. Caputo N, Fraser R, Paliga A, Kanter M, Hosford K, Madlinger R. Triage vital signs do not correlate with serum lactate or base deficit, and are less predictive of operative intervention in penetrating trauma patients: a prospective cohort study. *Emerg Med J*. 2013 7; 30(7): 546–50. [PubMed: 22802455]
12. Arnold RC, Sherwin R, Shapiro NI, O'Connor JL, Glaspey L, Singh S, Medado P, Trzeciak S, Jones AE; Emergency Medicine Shock Research Network (EM Shock Net) Investigators. Multicenter observational study of the development of progressive organ dysfunction and therapeutic interventions in normotensive sepsis patients in the emergency department. *Acad Emerg Med*. 2013 5; 20(5):433–40. [PubMed: 23672356]

Figure 1:
AUC for RASI to determine level of care and early/occult shock

Table 1:

Logistic regression for RASI and level of care disposition

Dispo	Odds Ratio	Std. Error	Z	P	95% CI
<i>RASI</i>	2.599	0.698	3.55	0.00	1.53 – 4.40
<i>AGE</i>	1.009	0.009	1.03	0.304	0.99 – 1.03
<i>SEX</i>	0.950	0.319	−0.15	0.881	0.49 – 1.84
<i>WBC</i>	1.009	0.019	0.47	0.642	0.97-1.05
<i>LACT</i>	1.527	0.146	4.44	0.00	1.26-1.84
LR = 57.77					