Shock Index in COVID Era

Souvik Dey[1] Rohan Magoon[1] Jasvinder Kaur Kohli[1] Ramesh Chand Kashav[1] ItiShri[1] Ashish Walian[1]

[1] Department of Cardiac Anaesthesia, Atal Bihari Vajpayee Institute of Medical Sciences (ABVIMS) and Dr. Ram Manohar Lohia Hospital, New Delhi, India

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Address for correspondence Ramesh Chand Kashav, Department of Cardiac Anaesthesia, Atal Bihari Vajpayee Institute of Medical Sciences (ABVIMS) and Dr. Ram Manohar Lohia Hospital, Baba Kharak Singh Marg, New Delhi 110001, India (e-mail: drkashav@yahoo.co.in).

Abstract

The health care burden and risks to health care workers imposed by novel coronavirus disease 2019 (COVID-19) mandated the need for a simple, noninvasive, objective, and parsimonious risk stratification system predicting the level of care, need for definitive airway, and titration of the ongoing patient care. Shock index (SI = heart rate/systolic blood pressure) has been evaluated in emergency triage, sepsis, and trauma settings including different age group of patients. The ever accumulating girth of evidences demonstrated a superior predictive value of SI over other hemodynamic parameters. Inclusion of respiratory and/or neurological parameters and adjustment of the cutoffs appropriate to patient age increase the predictability in the trauma and sepsis scenario. Being reproducible, dynamic, and simple, SI can be a valuable patient risk stratification tool in this ongoing era of COVID-19 pandemic.

Keywords
- ► coronavirus disease 2019
- ► risk stratification
- ► shock index
- ► health care burden
- ► level of patient care

Introduction

Shock, a clinical state of impaired oxygen delivery or utilization, is a major cause of mortality, morbidity, and increased resource utilization in the critically ill patient cohort.[1] Time-sensitive intervention and treatment as emphasized by the early researches mandate the need of an early identification strategy.[2,3] In this context, an exhaustive list of clinical, hemodynamic, and laboratory parameters (►**Table 1**) have been evaluated in various surgical and nonsurgical patient populations. However, a mere correction of the these parameters doesn't necessarily improve outcome in shock patients.[4] Moreover, lack of specificity, invasive nature of the laboratory parameters, and need of additional monitoring equipments and expertise (such as $ScvO_2$ [central venous oxygen saturation], cardiac output, echocardiography, etc.) construct the ground to formulate other novel risk stratification parameters.

In conjunction to the aforementioned fact, a derived hemodynamic parameter, shock index (SI = heart rate [HR]/systolic blood pressure [SBP]) emerged as a simple, noninvasive, bedside, and objective parameter to predict the outcome and risk stratification in shock patients.

Types of SI

Originally SI was formulated to include both vascular and myocardial component (as reflected by SBP and HR, respectively) and a value more than the normal range (0.5–0.9) predicted poor tissue perfusion as evidenced by a positive correlation with serum lactate and mixed venous oxygen saturation.[5] Subsequently, several modifications have been made to address the aforementioned issue as enlisted in ►**Table 2**. Additionally, respiratory rate and SpO_2

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Table 1 Commonly employed methods for evaluation of shock

Clinical parameters	Hemodynamic parameters	Laboratory parameters
• Mental status • Temperature of the extremities • Urine output • Capillary refill time (in seconds)	• HR • Blood pressure (invasive/noninvasive) • PA catheter–based monitoring • Echocardiography-based monitoring	• ABG analysis • Serum lactate • Hematocrit • Mixed/central venous oxygen saturation

Abbreviations: ABG, arterial blood gas; HR, heart rate; PA catheter, pulmonary artery catheter.

Table 2 Different types of shock indices

Types of indices	Formula to calculate indices
SI	HR/SAP
MSI	HR/MAP
DSI	HR/DAP
rSI	SAP/HR
Age SI	Age × (HR/SAP)
SIPA	HR/SAP
RASI	(HR/SAP) × RR/10
SS	(HR/SAP)/SpO_2
rSIG	GCS × (SAP/HR)
SIPF	HR/SAP > 0.7 (1 point) + PaO_2/FiO_2 < 250 (1 point) = total 0–2 points

Abbreviations: AgeSI, age-adjusted shock index; DAP, diastolic arterial pressure; DSI, diastolic shock index; GCS, Glasgow Coma Scale; HR, heart rate; MAP, mean arterial pressure; MSI, modified shock index; RASI, respiratory adjusted shock index; rSI, reversed shock index; rSIG, reversed shock index multiplied with GCS; SAP, systolic arterial pressure; SI, shock index; SIPA, shock index pediatric age-adjusted; SIPF, shock index and hypoxemia; SS, shock index to SpO_2 ratio.

[peripheral blood oxygen saturation] have been introduced along with SI to incorporate the respiratory component (►**Table 2**).

Where Can it Help (in COVID-19)?

Despite the continuous endeavor and ongoing researches, little is known about the novel coronavirus disease 2019 (COVID-19) and subsequent management of the patients requiring intensive care unit (ICU) admission. According to few studies, about 5 to 10% of the patients infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) require ICU admission.[6] Shock (up to 67% of patients admitted in the ICU) has been implicated as the primary cause of death in 7% of COVID-19 cases and as a contributing factor in an additional 33%.[7] All the four types of shock (hypovolemic, cardiogenic, distributive, and obstructive) have been observed in COVID-19 patients owing to the peculiar pathophysiology of the disease—hypovolemia occurring due to the associated fever, diarrhea, and fluid restrictive treatment protocol; systemic inflammation with circulating cytokine storm giving the etiology of septic/distributive shock; a direct injury to the myocardium due to myocarditis and pulmonary hypertension (caused by positive pressure ventilation, chronic hypoxia, pulmonary fibrosis) leading to right ventricular dilatation, all can attribute to the myocardial dysfunction leading to cardiogenic shock; and, finally, sudden pulmonary thromboembolism (owing to the inherent hypercoagulable disease pathology) and tension pneumothorax form the etiology of obstructive shock.[8] Therefore, a close monitoring and early detection of the shock pathology are the cornerstone for a better outcome. On the other hand, a breach in the safety precautions adapted by the health care workers (HCW) in the process of patient care imposes a unique challenge in the ongoing COVID-19 pandemic. To address the this issue, the World Health Organization (https://www.who.int/publications-detail/clinical-management-of-severe-acuterespiratory-infection-when-novel-coronavirus-(ncov)-infectionis-suspected) and the National Institutes of Health (https://covid19treatmentguidelines.nih.gov/critical-care/hemodynamics/) released recommendations for the hemodynamic management of COVID-19 patients, ensuring minimum number of exposures for the HCWs without compromising patient safety. However, indication for endotracheal intubation in COVID-19 patients is controversial, albeit it carries the greatest risk of exposure (by aerosol generation). Previous researches recommend a lower threshold for endotracheal intubation (and mechanical ventilation) despite low arterial oxygen saturation.[8] Compensation by the cardiovascular system may have a pivotal role as described by Tobin and colleagues.[9] SI and its modifications might play a crucial role by indicating the compensatory cardiovascular reserve. On the other hand, being a noninvasive, continuous, and objective parameter, SI can be a valuable tool in the triage area (to determine the level of care) as well as in the inpatient management in titrating the treatment protocol without exhausting resources of the already overburdened health care system.

Encouraging Literatures

Diverse Patient Populations

Till date, various scoring system and indices have been evaluated in COVID-19 patients for prognostication and risk stratification, with variable success. In this context, quick sequential organ failure assessment score (qSOFA), combining respiratory rate, neurological status, and hemodynamics; CURB 65; NEWS (National Early Warning Score); and 4C mortality scores have been validated with improved predictive efficacy.[10] The available literature demonstrated the equivalent efficacy of SI with qSOFA in trauma triage scenario.[11] Another study depicted the positive correlation between serum lactate and diastolic SI and

Table 3 Shock indices evaluated in different patient cohort

Patient cohort	Variants of SI studied	Other parameters compared	Conclusion
Trauma	SI, MSI, AgeSI	ABC score, DBP, SBP, HR, RTS, REMS	SI correlates with increased need for MTP, performs equally with ABC score MSI is a better predictor than SI and other hemodynamic parameters
Triage	SI, MSI, AgeSI	SBP	SI is a better predictor of inpatient mortality but not admission to ICU
Sepsis	SI	CVP, SIRS	High NPV with normal SI for lactate < 4.0 mmol/L
Obstetric	SI	HR, SBP	SI consistently higher in ruptured ectopic pregnancy
Pediatric	SIPA	SI, SBP, DBP, age-adjusted hypotension	SIPA has higher sensitivity and specificity
Geriatric	SI	Age SI, MSI, HR, SBP	Higher specificity

Abbreviations: AgeSI, age-adjusted shock index; CVP, central venous pressure; DBP, diastolic blood pressure; HR, heart rate; MSI, modified shock index; SI, shock index; SIPA, shock index pediatric age-adjusted.

better prognostic efficacy in septic shock patient cohort recruited from ANDROMEDA-SHOCK trial.[12] Similarly, respiratory adjusted shock index (RASI) and shock index to SpO_2 ratio (SS) have been validated in acute respiratory distress syndrome (ARDS) and community-acquired pneumonia patients to predict the need for mechanical ventilation and hospitalization.[13,14] Jiang and colleagues have successfully applied RASI in sepsis for identifying occult shock and subsequent triage of the patients for the level of care required.[13] Adjusting the cutoff appropriate for age, Ray and colleagues[15] highlighted a better predictive efficacy of on admission SI pediatric age-adjusted (SIPA) over the conventional hemodynamic parameters (SBP, HR) and positive correlation with arterial lactate level. Utility of SI in different patient subgroups is enlisted in ►**Table 3**.

Ambiguity in Cutoff

An increased SI value universally indicates hypoperfusion. However, there is no universal consensus regarding the cutoff value for SI in adult patients. Previous researches demonstrated multiple cutoff values as documented in ►**Table 4**.[16–21]

Table 4 Different cutoffs for shock indices

Patient cohort	Cutoff for SI	Study types and outcome
Triage	0.5–0.7 >0.7 >1 >1.2	Retrospective cohort of 58,336 patients with a highest likelihood ratio to admission and mortality with SI > 1.2[16]
Trauma	>0.7 >0.9 >1 1.2 >1.3	Retrospective cohort; better predictor of preceding bleeding and initiation of MTP[17,18]
Obstetrics	>0.7 >0.85	Both prospective (280 patients) and retrospective (56 patients) studies, better ability to predict ruptured ectopic pregnancy[19,20]
Sepsis	>0.7 >1	Retrospective cohort of 2,524 patients, SI as a predictor of vasopressor use, in patient mortality[21]

Abbreviations: MTP, massive transfusion protocol; SI, shock index.

Limitations of SI

First, SI value doesn't change over a wide range of cardiovascular compensatory phase (increase in heart rate to compensate hypotension), particularly in the younger age group. Second, the mode of blood pressure recording (invasive vs. noninvasive) is not universal in the existing literature. Accordingly, the variations in systolic, diastolic, and mean blood pressure between noninvasive and invasive method would create ambiguity in calculating the SI value, specifically in the shock state.

Conclusion

SI, a noninvasive, simple, dynamic, objective, and parsimonious index, can appropriately predict the outcome in COVID-19 patients and upgrade the patient care in a timely manner.[22] As it is aptly said, *to be forewarned is to be forearmed and half the victory.*

Conflict of Interest
None declared.

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