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Shock Index as a Predictor of Massive Transfusion and Emergency Surgery on the Modern Battlefield

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ABSTRACT

Background: Shock Index (SI) has been used to predict the need for massive transfusion (MT) and emergency surgical procedures (ESP) in civilian trauma. We hypothesize that SI can reliably identify combat trauma patients that will require MT and ESP when applied to the resource-constrained, combat environment.

Methods: A retrospective review was performed within the Department of Defense Trauma Registry (2008-2016). SI was calculated using heart rate and systolic blood pressure on arrival to the initial facility with surgical capabilities. A threshold value of 0.8 was used to stratify patients into two groups (Group I, SI $<$ 0.8; and Group II, SI $\geq$ 0.8). The need for MT, ESP, and mortality was compared. Regression analyses were conducted to determine the independent association of SI with MT and ESP.

Results: A total of 4008 patients were included. The mean age of the patients was 25.5 y, and the majority were predominately male (98%). Mechanisms of injury were blunt and blast injury (62%), penetrating injury (36.7%), and burn injury (0.5%). Overall, 77% of patients (n = 3070) were stratified to Group I, and 23% of patients (n = 938) were stratified to Group II, by SI. Group II patients had a significantly greater need for MT (8.4% *versus* 0.4%) and ESP (30.7% *versus* 6.5%), both $P < 0.001$. Regression analysis controlling for age, gender, Injury Severity Score, and Glasgow Coma Score confirmed that SI $\geq$ 0.8 was an independent risk factor for both MT and need for ESPs ($P < 0.001$).

Conclusions: SI is a significant predictor of the need for MT and ESPs in the military trauma population, representing a simple and potentially potent tool for triage and prediction of resource consumption in the resource-limited, austere setting.

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Introduction

The allocation of limited medical resources on the battlefield is of the most difficult challenges faced by military health care personnel and planners. In an effort to reduce the time to surgical care to an absolute minimum, there is a trend in today's military toward smaller and more mobile surgical teams being deployed into increasingly austere and hostile environments. Examples of such teams include the Army's Golden Hour Offset Surgical Treatment Teams, the Expeditionary Resuscitative Surgical Teams, and the Air Force's Special Operations Surgical Team. These units generally

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consist of a single surgeon with as few as three to four support personnel. Such teams are often where the most critically injured service members undergo initial resuscitation and damage control surgery. Despite this weighty responsibility, blood products and surgical consumables within these units are severely limited, and rapid resupply frequently unavailable. Mass casualty incidents or massive transfusion (MT) needs can rapidly overwhelm both surgical capabilities and blood product resources in such settings. Unique solutions to the limited supply of blood and blood products have thus been developed. The most notable of these uses the concept of the “walking blood bank,” in which military personnel will donate blood on demand to meet the needs of the injured patients. Although this concept increases the supply of blood, the time needed to assemble and use this resource results in an inherent delay. This creates a potentially dangerous reality for critically injured service members. Thus, a validated tool capable of predicting blood product and surgical resource utilization would prove invaluable in the deployed setting.

Current teaching recommends the triage of combat casualties be based on an evaluation of a trauma patient’s vital signs, physical examination findings, laboratory values, and radiographic findings. However, such an evaluation may not be ubiquitous or standardized among providers across deployed settings. Moreover, the personnel often assigned to triage roles may have limited medical or surgical backgrounds. Unfortunately, traditional vital signs have been found to be a relatively insensitive marker of both hypoperfusion and shock.[1] Shock Index (SI), defined as heart rate divided by systolic blood pressure, has been demonstrated to be a sensitive predictor of outcomes, thereby improving triage and decreasing mortality in the emergency civilian sector.[2,3] Purported advantages of SI over other triage scoring systems include its simplicity, noninvasiveness, and rapidly repeatability. In the trauma and critical care settings, SI has been found to reliably predict hypoperfusion, sepsis, and postintubation hypotension.[4] Multiple studies have further validated its utility to predict the need for MT in the civilian trauma.[5,6] SI has also been proven to be an accurate predictor of morbidity and mortality in the geriatric trauma population, as assessing hemodynamic instability can prove difficult because of their altered hemodynamic response to injury.[7] Age-adjusted SI in the pediatric population has further proven superior to other techniques in identifying those children at risk for emergency operation, endotracheal intubation, and blood transfusion among the pediatric blunt trauma population.[8]

While validated in a multitude of patient populations, information on the utility of the SI in combat trauma, in which penetrating and blast injuries predominate, is limited. The purpose of this study was to evaluate the utility of the SI in the prediction of need for MT and emergency surgical procedures (ESPs) in the military trauma population. We hypothesize that SI can be used to identify those casualties that would require MT and ESP to improve resource allocation to the most severely injured patients.

Methods

We performed a retrospective review of all adult combat casualties within the Department of Defense Trauma Registry (DoDTR) between 2008 and 2016. The DoDTR is a comprehensive database of combat trauma from recent conflicts overseas and includes records from approximately 80,000 patients. The registry is maintained by the United States Army Institute of Surgical Research under the auspices of the Joint Trauma System and the DoD Department of Excellence for Trauma. The DoDTR has been used to draw key lessons regarding deployed medicine and develop practice guidelines for the care of injured servicemen and women.[9]

SI was calculated for all patients using vital signs recorded on arrival to the initial echelon of care with surgical capabilities (Role 2-3 Combat Support Hospital). Those patients without initial arrival vital signs recorded or whose first set of complete vital signs was recorded at a tertiary care center (Role IV and above) were excluded from the analysis. A threshold value of 0.8 was used to stratify patients into two groups (Group I with SI < 0.8 and Group II with SI ≥ 0.8).

The primary outcomes of interest were the need for MT and ESP. MT was defined as the transfusion of $\geq$10 U blood products in the first 24 h of care. ESP included exploratory thoracotomy, exploratory laparotomy, and fasciotomy performed at the initial echelon of care. Secondary outcomes included large volume transfusion (LVT) and mortality. LVT was defined as the transfusion of between 4 and 9 U of blood product in the first 24 h of care. Patient demographics, mechanism of injury, injury pattern, injury severity, need for intubation, Glasgow Coma Score (GCS), and total transfusion requirement within 24 h were also compared between groups. Patients with Injury Severity Score (ISS) > 15 were considered severely injured, whereas Abbreviated Injury Score $\geq$3 by body region was considered severe. Of note, GCS was divided into three categories ($\leq$8, 9-12, and $\geq$13) for the purpose of analysis.

Descriptive statistics for the cohort as a whole and the groups independently were calculated, and values were reported as percentages or means with standard deviation. Univariate analysis was then performed using Pearson’s chi-squared test for categorical variables and independent Student’s *t*-test for continuous variables as appropriate. Binary logistic regression analysis was then performed to determine the relative impact of SI on the primary outcomes of interest. Co-factors of the model included patient age, gender, ISS, and GCS. On both univariate and multivariate analyses, a *P* value of $\leq$0.05 was considered significant. The overall predictive performance of our chosen threshold value of 0.8 was evaluated using the Youden Index (YI), calculated by the addition of the sensitivity of a test to its specificity minus 1, which is particularly useful for comparing predictive ability of various thresholds for the same diagnostic test. Finally, various other threshold values ranging from 0.5 to 1.1 in increments of 0.1 were similarly evaluated to assess for potential superior cutoffs. All statistical analysis was performed using IBM SPSS version 24 (Armonk, NY) and Microsoft Excel (Redmond, WA). The designation of our study as “exempt” along with a waiver for informed consent was obtained through our institutional review board before data abstraction and analysis.

Results

We identified a total of 4008 patients from the database who met the inclusion criteria during the 8 y studied. The mean age

Table 1 – Patient demographics, injury patterns and severity, and mechanisms of injury by SI group.

Variable	Overall	Group I (SI < 0.8)	Group II (SI ≥ 0.8)	*P* value
N	4008 (100)	3070 (76.6)	938 (23.4)	NA
Age (y), mean (SD)	25.5 (5.8)	25.5 (5.9)	25.3 (5.6)	0.396
Gender, *n* (%)				
Female	83 (2.1)	66 (2.1)	17 (1.8)	0.601
Male	3925 (97.9)	3004 (97.9)	921 (98.2)	
Injury pattern, *n* (%)				
Blunt	2515 (62.7)	2125 (69.3)	390 (41.6)	<0.001
Penetrating	1470 (36.7)	929 (30.3)	541 (57.7)	<0.001
Burns	22 (0.5)	15 (0.5)	7 (0.7)	<0.001
Mechanism of injury, *n* (%)				
Blast	3288 (82.0)	2472 (80.5)	816 (87.0)	<0.001
GSW	170 (4.2)	118 (3.8)	52 (5.5)	0.026
MVC	176 (4.4)	69 (2.2)	107 (11.4)	<0.001
Fall	177 (4.4)	89 (2.9)	89 (9.4)	<0.001
Other	191 (4.8)	116 (3.8)	75 (8.0)	<0.001
GCS category, *n* (%)				
GCS ≤ 8	494 (12.3)	254 (8.3)	240 (25.6)	<0.001
GCS 9-12	100 (2.5)	47 (1.5)	53 (5.7)	<0.001
GCS ≥ 13	3414 (85.2)	2769 (90.2)	645 (68.8)	<0.001
ISS, mean (SD)	10.8 (11.0)	8.5 (8.7)	18.4 (14.2)	<0.001
Severely injured (ISS > 15)	954 (23.8)	463 (15.1)	491 (52.3)	<0.001
Severely injured body region (AIS ≥ 3), *n* (%)				
Head	540 (13.5)	353 (11.5)	187 (19.9)	<0.001
Face	21 (0.5)	17 (0.6)	4 (0.4)	0.799
Neck	383 (9.6)	198 (6.4)	185 (19.7)	<0.001
Chest	220 (5.5)	90 (2.9)	130 (13.9)	<0.001
Abdomen	748 (18.7)	331 (10.8)	417 (44.5)	<0.001
Spine	42 (1.0)	13 (0.4)	29 (3.1)	<0.001

AIS = Abbreviated Injury Score; GSW = gunshot wound; MVC = motor vehicle accident; NA = not applicable.

was 25.5 ± 5.8 y, and the patients were predominately male (97.9%, $n = 3925$). On arrival to the initial echelon of care, the mean GCS was 14 ± 3, and the mean ISS was 10.8 ± 11.0, with 23.8% of patients classified as severely injured. The most common mechanism of injury was blast injury (82%, $n = 3288$). The most common injury pattern was blunt injury (62%, $n = 2515$), followed by penetrating injury (36.7%, $n = 1470$) and burn injury (0.5%, $n = 22$). For the cohort as a whole, the rates of MT and ESP were 2.2% ($n = 90$) and 12.2% ($n = 488$), respectively. Meanwhile, the incidence of LVT was 4.1% ($n =$

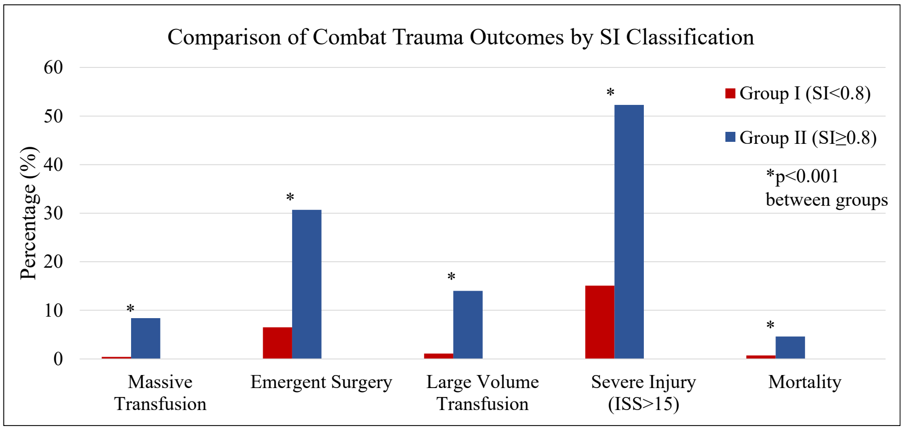

Fig – Comparison of combat trauma outcomes by SI classification. (Color version of figure is available online.)

Table 2 – Comparison of transfusion requirements, surgical procedures, and mortality by SI group.

Variable	Overall	Group I (SI < 0.8)	Group II (SI ≥ 0.8)	P value
MT, n (%)	90 (2.2)	11 (0.4)	79 (8.4)	<0.001
LVT, n (%)	164 (4.1)	33 (1.1)	131 (14.0)	<0.001
Blood products (U)*, mean (SD)				
Whole blood	0.1 (1.0)	0.01 (0.2)	0.38 (2.0)	<0.001
PRBCs	0.75 (2.6)	0.18 (1.1)	2.6 (4.5)	<0.001
Combined whole blood and PRBCs	0.69 (2.8)	0.15 (1.1)	2.5 (5.1)	<0.001
FFP	059 (2.3)	0.12 (0.9)	2.1 (4.1)	<0.001
Platelets	0.11 (0.52)	0.02 (0.2)	0.38 (0.9)	<0.001
Cryoprecipitate	0.24 (2.0)	0.04 (0.79)	0.86 (3.7)	<0.001
ESP, n (%)	488 (12.2)	200 (6.5)	288 (30.7)	<0.001
Exploratory laparotomy	198 (4.9)	71 (2.3)	127 (13.5)	<0.001
Thoracotomy	20 (0.5)	4 (0.1)	16 (1.7)	<0.001
Fasciotomy	335 (8.4)	142 (4.6)	193 (20.6)	<0.001
Intubation, n (%)	405 (10.1)	150 (4.9)	255 (27.2)	<0.001
Mortality, n (%)	63 (1.6)	20 (0.7)	43 (4.6)	<0.001

FFP = fresh frozen plasma; PRBCs = packed red blood cells; SD = standard deviation.
*Transfused in first 24 h after injury.

164), and the mortality rate was 1.6% ($n = 63$). The most common severely injured body region was the abdomen (18.7%, $n = 748$), followed by the head (13.5%, $n = 540$), and then neck (9.6%, $n = 383$). Further descriptive statistics are summarized in Table 1.

Using the chosen threshold value of 0.8, 76.6% ($n = 3070$) of patients were stratified to Group I, and 23.4% ($n = 938$) were stratified to Group II.

There was no difference in the mean ages or gender between the two groups. Regarding injury patterns, patients with SI ≥ 0.8 (Group II) were significantly more likely to have suffered a penetrating injury (57.7% *versus* 30.3%) as opposed to a blunt injury (41.6% *versus* 69.2%), both $P < 0.001$. Those patients in Group II had a significantly higher incidence of severe head, neck, chest, abdominal, and spinal injury (Table 1). Similarly, patients in Group II had significantly higher initial ISS (18.3 *versus* 8.5) and were consequently more likely to be classified as severely injured (52.3% *versus* 15.1%), both $P < 0.001$. Meanwhile, patients in Group II were significantly more likely to have a GCS ≤ 8 (25.6% *versus* 8.3%; $P < 0.001$).

Shifting focus to our primary outcomes, compared with patients in Group I, those in Group II had significantly higher need for MT (8.4% *versus* 0.4%) and ESP (30.7% *versus* 6.5%), $P < 0.001$ (Figure). Patients in Group II likewise demonstrated a significantly higher incidence of LVT (14.0% *versus* 1.1%) and mortality (4.6% *versus* 0.7%), both $P < 0.001$. Furthermore, the average total blood products required in the first 24 h was significantly higher in Group II (2.5 *versus* 0.2; $P < 0.001$; Table 2).

Binary logistic regression analysis controlling for age, gender, ISS, and GCS confirmed that SI ≥ 0.8 was an independent risk factor for both MT (odds ratio [OR] = 11.6, 95% confidence interval [CI] = 6.0-22.6; $P < 0.001$) and ESP (OR = 3.4, 95% CI 2.7-4.2; $P < 0.001$). Notably, the only other significant, independent predictor of the primary outcomes on regression analysis was ISS (Tables 3 and 4).

The sensitivity of the chosen threshold value of SI ≥ 0.8 in predicting the need for MT was 87%, the specificity was 78%, and the negative predictive value (NPV) was 99.6%, with a YI of 0.66. The sensitivity and specificity of this threshold for predicting the need for ESP were less robust at 59% and 81.5%, respectively, but the NPV remained high at 93.5% with a YI of 0.41.

A thorough evaluation of other potential threshold values revealed that the area under the curve (AUC) for the use of SI in the prediction of MT and ESP peaked at or very near the chosen threshold of 0.8 (Table 5). Of note, a threshold of SI ≥ 0.9 of note was slightly superior in the prediction of MT (YI = 0.68).

Discussion

This work represents the largest study to date of the utility of SI in the military trauma population. Although the literature contains a multitude of proposed military triage scoring systems such as the Field Trial Score and Revised Trauma Score designed to predict resource needs and outcomes, to our knowledge, there are only two previous studies, which have examined the application of SI to combat trauma.

Vassallo *et al.* in a prospective observational study of 345 patients presenting to a single British combat support hospital in Afghanistan found that an SI > 0.75 on presentation was a significant predictor of the need for "life-saving intervention" following trauma, with a reported sensitivity and specificity of 70.0% and 74.7%, respectively.[10] Although the results of this work were promising, the study left unexplored the potential role of SI in the prediction of needs for MT or blood product utilization in general. Furthermore, the single-center nature of the study limited the generalizability of their findings. Morrison *et al.* in a retrospective study of 103 patients presenting to a single FST in Afghanistan found that an SI > 0.9 was strongly

Table 3 – Multivariate logistic regression analysis of clinical factors associated with need for MT in combat trauma.

Factors	Variables in the equation							
	B	SE	Wald	df	P value	OR	95% CI for OR	
							Lower	Upper
Age, y	−0.005	0.022	0.045	1	0.833	0.995	0.953	1.039
Male gender	0.020	1.045	0.000	1	0.985	1.020	0.132	7.915
ISS	0.071	0.008	70.965	1	0.000	1.073	1.056	1.091
SI ≥ 0.8	2.455	0.338	52.813	1	0.000	11.642	6.005	22.569
GCS	0.034	0.028	1.417	1	0.234	1.034	0.978	1.093
Constant	−6.895	1.308	27.803	1	0.000	0.001		

B = beta values; df = degrees of freedom; SE = standard error.

predictive of the need for operative intervention with a positive predictive value (PPV) of 81% (AUC = 0.85). The narrow focus of the inclusion criteria, only patients with "ballistic battlefield torso trauma" were considered, and the single-center character of the study again limits the ability to generalize their findings.[11] This is all in contrast to our cohort, which included patients from multiple facilities (46 in total) and across multiple theaters of combat and therefore allows for broader application of our findings.

We found that SI >0.8 on arrival to the initial level of care was a significant predictor of the need for both MT and ESPs in the military trauma population. These findings coincide well with the current body of literature examining the use of SI in civilian trauma. Vandromme *et al.* in a retrospective review of 8111 civilian blunt trauma patients presenting to a Level 1 trauma center concluded that SI > 0.9 was associated with a significantly increased risk of MT.[12] In a more recent retrospective study conducted by El-Menyar *et al.*, among 8710 civilian trauma patients admitted a Level 1 trauma center, an arrival SI ≥ 0.8 was a significant predictor of MT protocol, need for laparotomy, and in-hospital mortality.[13] Although useful for the prediction of resource utilization in civilian trauma care, the resource-constrained nature of battlefield medicine adds increased gravity to the predictive ability of SI in military trauma. In many combat support hospitals, a single MT has the potential to deplete the facility's entire blood product inventory, and as such, the prompt identification of patients in need of MT is essential for a unit to remain mission capable. In the same vein, accurately predicting patients in need of emergency surgery is of greater importance in the deployed setting because of the limited number of surgical providers as well as the frequently extended time the casualty may spend in the evacuation chain before reaching a higher echelon of care.

Moving on to our secondary outcomes, we again found that SI ≥ 0.8 was significantly associated with both LVT and mortality among traumatically injured service members. The nearly seven-fold higher mortality rate associated with elevated SI echoes data from civilian literature. In one of the largest studies of SI in trauma to date, including more than 21,000 trauma patients from Germany, Mutschler *et al.* found that SI on arrival to the emergency department was a strong predictor of transfusion requirements and mortality.[14] Unsurprisingly, the increased incidence of death seen in patients with an elevated SI mirrors the significantly higher rates of severe injury, as defined by ISS.

Our comparison of the predictive value of various cutoffs for SI according to YI revealed that the chosen threshold of 0.8 was superior to all others tested for ESP and only marginally inferior to a cutoff of 0.9 for MT. Although multiple studies have endeavored to determine the optimal cutoff for SI, nearly all conclude that a value of between 0.8 and 1.0 demonstrates

Table 4 – Multivariate logistic regression analysis of clinical factors associated with need for ESPs in combat trauma.

Factors	Variables in the equation							
	B	SE	Wald	df	P value	OR	95% CI for OR	
							Lower	Upper
Age, y	−0.013	0.010	1.715	1	0.190	0.987	0.968	1.007
Male gender	0.021	0.433	0.002	1	0.961	1.021	0.437	2.384
ISS	0.073	0.005	194.091	1	0.000	1.076	1.065	1.087
SI ≥ 0.8	1.215	0.117	107.673	1	0.000	3.369	2.678	4.238
GCS	−0.007	0.015	0.215	1	0.643	0.993	0.965	1.022
Constant	−3.113	0.561	30.762	1	0.000	0.044		

B = beta values; df = degrees of freedom; SE = standard error.

Table 5 – Comparison of various threshold values for SI in the prediction of MT and ESPs in combat trauma.

Threshold value	Massive transfusion					ESP				
	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	YI	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	YI
SI ≥ 0.5	97.8	13.5	2.5	99.6	0.11	94.7	14.3	13.3	95.1	0.09
SI ≥ 0.6	96.7	36.0	3.4	99.8	0.33	86.5	38.3	16.3	95.3	0.25
SI ≥ 0.7	93.3	61.7	5.3	99.8	0.55	71.9	65.0	22.1	94.3	0.37
SI ≥ 0.8	87.8	78.1	8.4	99.6	0.66	59.0	81.5	30.7	93.5	0.41
SI ≥ 0.9	80.0	87.7	13.0	99.5	0.68	42.6	90.2	37.6	91.9	0.33
SI ≥ 1.0	80.0	87.7	13.0	99.5	0.68	42.6	90.2	37.6	91.9	0.33
SI ≥ 1.1	72.2	93.4	20.1	99.3	0.66	30.1	95.0	45.4	90.7	0.25

NPV = negative predictive value; PPV = positive predictive value; YI = Youden Index.

superior predictive ability.[2,15-17] As the use of different thresholds would undermine the simplicity of SI and in light of the high sensitivity and specificity exhibited by the chosen threshold, we would advocate for the uniform use of SI ≥ 0.8 for the prediction of MT and ESP in military trauma patients.

It is worth noting that a low PPV is exhibited by each SI threshold evaluated in relation to our primary outcomes (Table 5). However, this should be viewed as a function of the overall low prevalence of MT and ESP among military wounded and is comparable to those quoted in the civilian trauma literature.[13]

Meanwhile, the high NPV demonstrated by the threshold value of SI ≥ 0.8 alludes to a previously undescribed advantage of SI in battlefield triage, screening out those patients not in need of blood products or surgical care. This has broad implications not only for medical resource utilization but also allocation of transportation assets. As the military trauma paradigm shifts to prolonged field care capabilities in preparation for more conventional conflicts in which aeromedical evacuation may prove unavailable, the ability to identify patients who do not require rapid transport up echelons of care is as important as the reverse.[18]

Considerable efforts have been made in the past decade to derive greater predictive value from an assortment of variants or alternatives to SI, including delta SI, modified-SI, age-adjusted SI, and reverse-SI. The calculation and interpretation of each of these values either depends on additional information, such as age or GCS, or requires measurement of vital signs at multiple time points. Furthermore, the key benefit of certain variants such as age-adjusted SI lies in the improved predictive ability in children and the elderly, which does not correspond to the military trauma population.[19-21] Altogether although promising, these variants tend to detract from the simple, uniform, and rapid application of SI to the trauma patient, which we believe to be its principal advantages.

Other researchers, notably Mutschler *et al.*, have advocated for multiple categories of SI as opposed to a simple dichotomy.[14] Again, although likely useful, the added complexity of such a multitiered system of SI must be weighed against the advantage gained in terms of predictive ability in the fast-paced, often chaotic real world of combat triage. Further prospective studies are clearly warranted to weigh the use of SI against the various alternatives in the combat wounded.

There are several limitations to this study. Its retrospective nature subjects it to the well-known inherent biases of such studies. The exclusion of patients without a heart rate or systolic blood pressure recorded (617 patients, 13.3% of total) before analysis limits the power of the study, and certain patients in extremis, those without a palpable pulse, were not considered. The predominantly young male nature of our cohort as well as the prevalence of blast injuries prevents easy translation of these results back to a civilian trauma population in which a wider distribution of ages and gender than the military is observed and in which blast injuries are rare. In a similar way, the patients included in this study were presumably of good health and physical fitness at the time of injury, in accordance with military deployment standards, something that cannot be assumed of the civilian trauma patient. Regardless, the utility of SI in the civilian population has already been clearly demonstrated.[12-15] Our goal was to evaluate its applicability in the combat environment.

In conclusion, we found that SI is an accurate and reliable predictor of the need for MT and emergency surgery in battlefield trauma. As such, it represents a potentially potent tool for the triage of combat wounded. We further identified a threshold value of SI ≥0.8 to be superior in the prediction of these resource-intensive interventions. Despite inherent differences between civilian military trauma, our findings support the wide body of literature affirming the utility of SI in the prediction of trauma outcomes. Although prospective, multicenter studies should be conducted to further explore the precise role for SI in the evaluation of traumatically injured service members, strong consideration should be given to incorporating SI into current military triage guidelines.

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Authors' contributions: C.M. and K.M. conducted the literature search. M.E. and M.M. contributed to study design. C.M., J.B., and M.E. participated in data acquisition. D.L., K.M., and C.M. contributed to data analysis and interpretation. C.M., D.L., and K.M. drafted the article. M.M., M.E., and J.B. critically revised the final article. C.M., D.L., K.M., J.B., M.M., and M.E. reviewed and approved the final article.

Disclosures

The views expressed are those of the authors and do not reflect the official policy or position of the US Army, the Department of Defense, or the US Government. In addition, they do not reflect the official policy of position of any affiliated institution of the author group. The authors have no financial or other conflicts of interest related to this work to disclose. There are no sources of funding related to this work to disclose.

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