RESEARCH

NCPD 2.0 ANCC Contact Hours

Comparison of Shock Index With the Assessment of Blood Consumption Score for Association With Massive Transfusion During Hemorrhage Control for Trauma

Darcy L. Day, BSN, RN, CCRN, TCRN, CEN ■ Karen Ng, RN ■ Jonathan B. Huang, MD ■ Richard Severino, MS ■ Michael S. Hayashi, MD

ABSTRACT

Background: Hemorrhage is a leading cause of early mortality following trauma. A massive transfusion protocol (MTP) to guide resuscitation while bleeding is definitively controlled may improve outcomes. Prompts to initiate massive transfusion (MT) include shock index (SI) and the Assessment of Blood Consumption (ABC) score.

Objective: To compare SI with the ABC score for association with transfusion requirement, need for emergency hemorrhage interventions, and early mortality.

Methods: A retrospective cohort analysis of trauma MTP activations at our Level I trauma center was conducted from January 1, 2012, to December 31, 2016. The study data were obtained from the Trauma Registry and the blood bank. An SI cutoff of 1.0 was chosen for comparison with the positive ABC score.

Results: The study cohort included 146 patients. Shock index ≥ 1 had significant association with MT requirement ($p = .002$) whereas a positive ABC score did not ($p = .65$). More patients with SI ≥ 1 required bleeding control interventions (67% surgery, 47% interventional radiology) than patients having a positive ABC score (49% surgery, 29% interventional radiology). For geriatric patients who received MT, 65% had SI ≥ 1 but only 30% had a positive ABC score. Three-hour mortality following emergency department arrival was similar (60% SI ≥ 1, 62% positive ABC score).

Conclusion: Shock index ≥ 1 outperformed a positive ABC score for association with MT requirement. Shock index is a simple tool registered nurses can independently utilize to anticipate MT.

Key Words

ABC score, Hemorrhage, Massive transfusion, Massive transfusion protocol, Shock index

Hemorrhage resulting in hypovolemic shock is a leading cause of death following trauma, accounting for 38.6% of deaths during the first 24 hr after injury in a multicenter study involving 11 regional trauma centers (Tisherman et al., 2015). A separate multicenter study reported uncontrolled hemorrhage to be the most frequent cause of mortality (44.7%) in the field or emergency department (ED) (Callcut et al., 2019). In addition to hemorrhage control, the use of a massive transfusion protocol (MTP) is essential to the early management of these patients. Massive transfusion protocols may improve life-threatening bleeding outcomes by promoting early goal-directed balanced transfusion practices to restore circulating blood volume and correct trauma-associated coagulopathy (Cannon et al., 2017; Vogt et al., 2012). To achieve trauma center verification, hospitals are required to develop and maintain an MTP (Rotondo et al., 2014). Our trauma center continuously evaluates the efficiency of the MTP through the Trauma Performance Improvement and Patient Safety (PIPS) program.

Timely activation of the MTP is a quality benchmark that is monitored by the PIPS program. Although several tools have been described to facilitate timely MTP initiation, the American College of Surgeons Trauma Quality Improvement Program (TQIP) Guideline for Massive Transfusion (MT) in Trauma (American College of Surgeons, 2014) recommends the Assessment of Blood Consumption (ABC) score (Nunez et al., 2009), which is currently utilized at our institution. The ABC score consists of four variables: heart rate (HR), systolic blood pressure (SBP), penetrating mechanism, and Focused Assessment with Sonography for Trauma (FAST) examination.

Author Affiliations: The Queen's Medical Center, Honolulu, Hawaii (Mss Day and Ng, Mr Severino, and Dr Hayashi); and University of Hawaii School of Medicine, Honolulu (Dr Huang).

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.journaloftraumanursing.com).

Correspondence: Darcy L. Day, BSN, RN, CCRN, TCRN, CEN, Crisis/Rapid Response Program, The Queen's Medical Center, 1301 Punchbowl, Honolulu, HI 96813 (daday@queens.org).

DOI: 10.1097/JTN.0000000000000613

The ABC score has been validated in a multicenter study (Cotton et al., 2010).

Shock index (SI) consists of the physiological components of the ABC score and is defined as the quotient of HR/SBP. Previous research shows that SI correlates with the identification of hemorrhagic shock and need for MT (Jehan et al., 2019; Olaussen et al., 2015; Vandromme et al., 2011).

OBJECTIVES

The purpose of this study was to compare the performance of SI with the ABC score for patients with trauma who had MTP activation. Both SI and the ABC score were compared for strongest association with transfusion requirement, need for definitive hemorrhage control interventions, and mortality at 3, 6, and 24 hr following ED arrival for traumatic injury.

METHODS

Study Design, Population, and Setting

This retrospective cohort analysis of all MTP activations for patients with trauma from January 1, 2012, to December 31, 2016, was conducted at The Queen's Medical Center (QMC) in Honolulu, HI. Verified by the American College of Surgeons, QMC is the only Level I trauma center serving the state of Hawaii and the Central Pacific region, treating more than 2,900 injured patients annually. Data for this study were obtained from the electronic medical chart, blood bank, and Trauma Registry. The Trauma Registry is maintained by full-time staff, and the collected data are submitted to the National Trauma Databank and TQIP. The QMC Research and Institutional Review Committee approved the study protocol and waived informed consent.

Definitions

For this study, MT is defined as the transfusion of 10 units of red blood cells (RBCs) during MTP activation in the "interval of hemorrhage control," as described by Sharpe et al. (2012). The interval of hemorrhage control is specified as the time from ED presentation to inpatient admission, when ongoing bleeding is managed in the resuscitation bay, the operating room (OR), or in interventional radiology (IR) (Sharpe et al., 2012). The ABC score is defined as positive if two of four variables are present: HR 120 or more beats per minute, SBP 90 mmHg or less, penetrating mechanism, or positive FAST examination (Nunez et al., 2009). The normal SI is 0.7 (Haider et al., 2016). Based on previous research (Day et al., 2016; Jehan et al., 2019), SI ≥ 1 was selected for comparison with the ABC score for association with MT requirement.

Inclusion/Exclusion Criteria

Patients with trauma who required MTP activation were identified from QMC blood bank records and considered for study inclusion. Patients who received an MTP were added to the research database if they presented from the field with the trauma activation occurring prior to ED arrival and received at least 1 unit of RBCs during the first hour after ED presentation. Patients who were younger than 18 years, pregnant, pulseless on ED arrival, or had no vital signs recorded on ED arrival were excluded from the study. Patients with an ABC score of 1 or less and without FAST examination results were excluded because of insufficient data to determine whether the ABC score would have triggered the MTP activation. Patients who died during the first 50 min following ED arrival were excluded to account for survivor bias (eligible patients who did not live long enough to receive MT).

Data Variables and Measurements

The Trauma Registry and the electronic medical record were audited for demographics (age, gender, ethnicity), injury data (mechanism, Injury Severity Score; Abbreviated Injury Score for head, thorax, abdomen, and extremity; first FAST result; primary survey pelvic x-ray result), vital signs (first ED HR, SBP, and temperature), laboratory data (hemoglobin [Hb], platelet count, international normalized ratio, base excess), disposition (OR, IR, ED arrival time; arrival time to inpatient unit), and outcome (mortality at 3, 6, and 24 hr following ED arrival). The QMC blood bank supplied the transfusion data (number and type of blood products transfused throughout the MTP activation during the interval of hemorrhage control).

Shock index was calculated from the first HR and SBP measured on arrival to the ED. The variables to calculate the ABC score were the first HR, SBP, and FAST examination results obtained in the ED. Included subjects were initially divided into two cohorts for analysis based on whether the definition for MT was met. Shock index ≥ 1 was compared with the positive ABC score for strongest association with receiving MT. For patients receiving MT, SI ≥ 1 and the positive ABC score were evaluated for blunt versus penetrating mechanism injuries and for the geriatric subset, defined as age 65 years or more. For the geriatric subset, the ABC score was also tallied using an SBP cutoff of 110 mmHg in addition to the defined SBP parameter of 90 mmHg for comparison. The primary outcome measure was the association of SI versus the ABC score for MT requirement. Secondary outcome measures included association of SI and the ABC score with the need for bleeding control interventions and mortality. Statistical analysis using the chi-square and McNemar tests was performed with Statistical Analysis System, SAS v9.4 (SAS Institute, Cary, NC). Statistical significance was determined as $p < .05$.

RESULTS

During the 5-year study period the MTP was activated for 194 patients with trauma initially eligible for study inclusion. The flowchart showing patient selection is displayed in Figure 1. Forty-eight patients with exclusion criteria were removed, leaving 146 patients for analysis. The most frequent reasons for removal were as follows: referral from a previous hospital; pulseless on ED arrival; unobtainable SBP; or vital signs present on ED arrival, but the patient expired during the first 50 min of ED presentation.

Baseline characteristics of the 71 patients who received MT versus the 75 patients who did not receive MT are shown in Table 1. Male patients accounted for 79% of the cohort. Asian patients made up the largest ethnic group. Mechanism of injury was 75% for blunt and 25% for penetrating, with struck pedestrian (23%), falls (23%), motorcycle/moped crash (16%), and stab wound (16%) occurring most frequently. Mean Injury Severity Score for the entire study cohort was 27, consistent with severe injury. Abbreviated Injury Score 3 or more, also consistent with a severe injury, was most frequent for injury to the thorax (63% for the total cohort). Pelvic fracture diagnosed by pelvic radiographs during the primary survey was present in 33% of the total study cohort, with 60% of these needing MT.

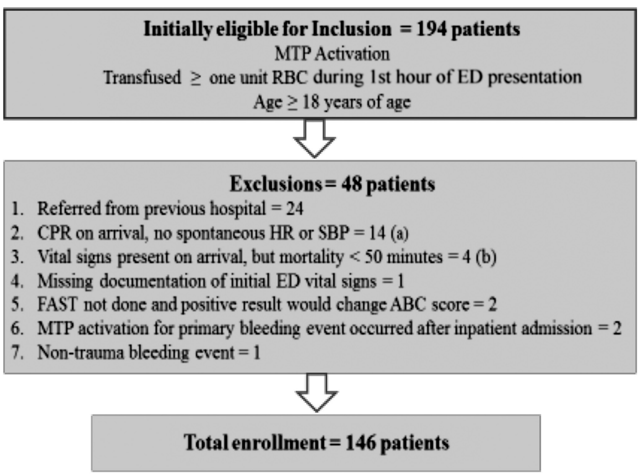

Figure 1. Flowchart of patient selection. (a) Unable to calculate shock index or ABC score for patient when HR and SBP = 0. (b) Presumed to not have lived long enough to receive massive transfusion, attempting to control for survivor bias. ABC = Assessment of Blood Consumption; CPR = cardiopulmonary resuscitation; ED = emergency department; FAST = Focused Assessment with Sonography for Trauma; HR = heart rate; MTP = massive transfusion protocol; RBC = red blood cell; SBP = systolic blood pressure.

Data for the geriatric subset ($n = 34$; 23% of total) are presented in Table 2. Massive transfusion was required for 71% of the cohort. Mechanism of injury was blunt for all geriatric subjects, and one half of these patients sustained a pelvic fracture found on primary survey pelvic radiographs. Of the 16 geriatric patients who died by 24 hr, half ($n = 8$) died during the first 3 hr and three fourths ($n = 12$) were dead by the first 6 hr. All geriatric patients who died by 3 hr received MT, and MT was administered to 11 of the 12 geriatric patients who died by 6 hr. For geriatric patients who received MT, 65% had SI ≥ 1 but only 30% had a positive ABC score. When the higher SBP parameter of 110 mmHg to calculate the ABC score was added to the analysis, there was no change in the number of positive ABC scores.

The association of SI for MT was compared with the MTP activation triggers, including the ABC score, that are currently in place at our trauma center (see Supplemental Digital Content Table 1, available at: http://links.lww.com/JTN/A41). Shock index ≥ 1 was the strongest variable overall, correlating with the largest number of patients receiving MT (77%). The MTP trigger with the best correlation for receiving MT was base excess −6 mmol or less (70%), followed by Hb of less than 11 g/dl (61%). Shock index ≥ 1 and the positive ABC score for MT patients, divided by the mechanism of injury, are contrasted in Table 3. The ABC score was split into the individual components for further evaluation. Massive transfusion was administered to 59 patients with blunt mechanism injury and 12 patients with penetrating mechanism injury. For patients with blunt mechanism injury, 75% had SI ≥ 1 but the ABC score was positive for only 32%. The individual component of the ABC score with the strongest association with MT for patients with blunt mechanism injury was SBP 90 mmHg or less at 54%. Both SI (92%) and the ABC score (100%) had strong correlation with patients with penetrating mechanism injury who received MT.

The relationship of SI and the ABC score to the outcome variables of transfusion requirement, need for hemorrhage control intervention, and mortality is presented in Table 4. Shock index ≥ 1 had significant association for MT requirement ($p = .002$), whereas a positive ABC score did not ($p = .65$). Shock index ≥ 1 also had a stronger correlation versus a positive ABC score for overall transfusion requirement and need for bleeding control intervention, whereas the two variables were similar for association with mortality. Patients who received MT having SI ≥ 1 got twice as many plasma units compared to patients with a positive ABC score, 62% and 31%, respectively. For RBC and platelet transfusions, the group with SI ≥ 1 got nearly double the amount of blood products compared with patients with a positive ABC score (RBC 63% vs. 32% and platelet 57% vs. 32%, respectively). More

TABLE 1 Baseline Patient Characteristics: Massive Transfusion Compared With No Massive Transfusion

Variable, *n* (%)	Total Patients (*N* = 146)	Received MT (*n* = 71)	No MT (*n* = 75)
Age, mean (SD)	49 (21)	54 (20)	45 (20)
Gender			
Male	115 (79)	54	61
Female	31 (21)	17	14
Ethnicity			
Asian	55 (38)	28	27
Black	3 (2)	2	1
Hispanic	7 (5)	3	4
HI/Pacific Islander	30 (21)	10	20
White	43 (29)	23	20
Unknown	8 (5)	5	3
Mechanism			
Blunt, total	110 (75)	59 (54)	51 (46)
Pedestrian	33 (23)	25	8
Fall	33 (23)	15	18
MCC/moped	23 (16)	12	11
MVC	13 (9)	4	9
Crush	3 (2)	3	0
Bicycle	2 (1)	0	2
Water	2 (1)	0	2
Blunt assault	1 (1)	0	1
Penetrating, total	36 (25)	12 (33)	24 (67)
SW	24 (16)	9	15
GSW	9 (6)	2	7
Animal	3 (2)	1	2
Injury Severity Score, mean (SD)	27 (15)[a]	33 (15)	21 (11)[a]
AIS ≥3[b]			
Head	56 (38)	35 (63)	21 (37)
Chest	92 (63)	53 (58)	39 (42)
Abdomen	54 (37)	31 (57)	23 (43)
Extremity	55 (38)	33 (60)	22 (40)
Pelvic fracture present[c]	48 (33)	29 (60)	19 (40)

Note. AIS = Abbreviated Injury Score; GSW = gunshot wound; HI = Hawaii; MCC = motorcycle collision; MT = massive transfusion; MVC = motor vehicle collision; SW = stab wound.

[a]Missing one data point.

[b]Head, Chest and Abdomen missing one data point each and Extremity missing two data points.

[c]Diagnosed by primary survey pelvic radiographs.

TABLE 2 Subset of Geriatric Patients Who Received Massive Transfusion

Variable, *n* (%)	Total Cohort	Received MT	Did Not Receive MT
Age ≥65 years	34	23	11
Mechanism, blunt	34	23 (100)	11
Shock index ≥1	18	15 (65)	3
ABC score positive if			
SBP ≤90 mmHg	7	7 (30)	0
SBP <110 mmHg	7	7 (30)	0
Pelvic fracture present[a]	16	12 (52)	4
Mortality			
3 hr	8	8 (35)	0
6 hr	12	11 (48)	1
24 hr	16	14 (61)	2

Note. ABC = Assessment of Blood Consumption; MT = massive transfusion; SBP = systolic blood pressure.

[a]Diagnosed by primary survey pelvic radiographs.

patients with SI ≥ 1 required bleeding control interventions, surgery (67%) or IR (47%), than patients with a positive ABC score (49% surgery, 29% IR). Mortality at 24 hr following ED presentation for patients requiring MT for the SI ≥ 1 group was 22% (n = 20) compared with 20% (n = 13) for the positive ABC score group. For the SI ≥ 1 group, 60% of the patients were dead at 3 hr and 85% died by 6 hr. For the positive ABC score group, 62% of the deaths during the first 24 hr occurred by 3 hr, with 77% expiring by 6 hr. Traumatic brain injury was listed as the cause of death for six patients during the first 24 hr following ED arrival. Half of these patients received MT, and all expired during the first 6 hr following ED arrival. For this traumatic brain injury subgroup, all patients had SI ≥ 1 but negative ABC scores.

TABLE 3 Comparison of Shock Index With Assessment of Blood Consumption Score for Massive Transfusion, Stratified by Blunt and Penetrating Mechanisms

Received MT (*N* = 71), *n* (%)	Blunt (*n* = 59)	Penetrating (*n* = 12)
Shock index ≥1	44 (75)	11 (92)
ABC positive	19 (32)	12 (100)
HR ≥120 beats per minute	23 (39)	10 (83)
SBP ≤90 mmHg	32 (54)	9 (75)
FAST positive	19 (32)	4 (30)
Penetrating mechanism	NA	12 (100)

Note. ABC = Assessment of Blood Consumption; FAST = Focused Assessment with Sonography for Trauma; HR = heart rate; MT = massive transfusion; SBP = systolic blood pressure.

DISCUSSION

Along with interventions to control hemorrhage, early initiation of MT may improve the outcome for patients with bleeding trauma. Meyer et al. (2017) demonstrated a 5% increase in odds of mortality for every minute that passes from the time of MTP activation to first blood product arrival to the patient. These authors suggest that an opportunity for improvement is to increase provider awareness of the need for MTP activation. Timely recognition of the need for MT is crucial for MTP activation, and provider awareness may be facilitated by prediction criteria. A study by Motameni et al. (2018) found a potential 35-min reduction in time to MTP activation if the ABC score had been applied versus physician judgment-only.

For the current investigation, SI ≥ 1 was compared with a positive ABC score for association with MT for patients who received MTP activation. We found transfusion requirement and need for hemorrhage control interventions to have a greater correlation overall with SI than with the ABC score. Of patients receiving MT, the majority sustained blunt mechanism (83%). Shock index ≥ 1 was positive for 77% of patients needing MT, but only 44% had a positive ABC score. The inferior performance of the ABC score for blunt trauma may be explained by previous research showing SI to have better predictive value for MT than for either HR or SBP alone, the physiological elements in the ABC score (El-Menyar et al., 2018; Joseph et al., 2018). Traditional vital signs may poorly reflect compromised perfusion and shock (Marenco et al., 2020). Shock index can identify the patient with "normal" vital signs who may be in unrecognized occult shock (Hanna et al., 2020; Vandromme et al., 2011).

Besides HR and SBP, the FAST examination is another component of the ABC score. For this study, the results of the initial FAST examination were used to compute the ABC score. If the FAST result was read as "equivocal," we counted it as positive. Six patients with blunt trauma had the initial FAST examination interpreted as equivocal, and three of these required MT. The total number of positive FAST examinations for blunt mechanism injury, including the equivocal results, was low (n = 19; 32%). Two multicenter investigations report a high number of false-negatives (up to 49%) for the FAST examination, including for hypotensive patients (Do et al., 2019; Rowell et al., 2019). The authors conclude that patients with negative FAST results still need a high level of monitoring for

TABLE 4 Comparison of Shock Index and Assessment of Blood Consumption Score for Massive Transfusion, Transfusion Requirement, Bleeding Control Intervention, and Mortality

Variable, *n* (%)	Total Cohort (*N* = 146)	Shock Index ≥ 1, 93 (64%)	ABC Score Positive, 66 (45%)
Received MT	71	55 (77)*	31 (44)**
Number blood products during the hemorrhage control period			
RBC, units	1,838	1,158 (63)	594 (32)
Plasma, units	1,666	1,040 (62)	519 (31)
Platelets, bags[a]	230	132 (57)	73 (32)
Bleeding control intervention			
Surgery	81	54 (67)	40 (49)
Interventional radiology	35	26 (47)	10 (29)
Mortality following ED arrival			
3 hr	20	12 (13)	8 (12)
6 hr	26	17 (18)	10 (15)
24 hr	33	20 (22)	13 (20)

Note. ABC = Assessment of Blood Consumption; ED = emergency department; MT = massive transfusion; RBC = red blood cell.

[a]One apheresis platelet bag = 6–8 units.

*p = .002. **p = .65.

bleeding. In consideration of these previous findings, the small number of positive FAST scores in the present study may have contributed to the poorer performance of the ABC score.

Schroll et al. (2018) demonstrated that SI ≥ 1 predicted MT with significantly greater sensitivity than the ABC score (p = .035). For their subset of patients with penetrating injury (25%), however, SI was not predictive of MTP activation (p = .66). Schroll et al. note, “Patients with positive ABC scores (≥2) had significantly higher rates of penetrating trauma than those with an ABC score of less than 2 (59% vs. 20%, respectively).” Since the ABC score tallies 1 point for penetrating injury mechanism, a positive score is easier to achieve for penetrating injuries than for blunt injuries. Only 12 patients who received MT in our study had penetrating injuries, but all had positive ABC scores. Eleven of the 12 (92%) also had SI ≥ 1.

The Revised Assessment of Blood Consumption Transfusion (RABT) score (Joseph et al., 2018) is based on the ABC score—but substitutes SI ≥ 1 for the HR and SBP criteria and includes positive pelvic fracture as an additional variable, improving the utility of the score for blunt trauma (see Supplemental Digital Content Table 2, available at: http://links.lww.com/JTN/A42). Pelvic fractures, which can be identified by portable radiographs during the primary survey, are typically caused by blunt trauma and can generate life-threatening injuries (Hanna et al., 2020; Stahel et al., 2017). If at least two variables are present, the RABT score is considered positive (Joseph et al., 2018). When the RABT and ABC scores were evaluated together, 84.3% of patients with a RABT score of 2 or more got MT versus 41.2% for a positive ABC score (p < .001) (Joseph et al., 2018). The RABT score has been validated in a multicenter study (Hanna et al., 2020). Our data support the revision of the ABC score to substitute SI for the individual values of HR and SBP, as originally proposed by Joseph et al. (2018) and validated by Hanna et al. (2020). The addition of the pelvic fracture to the ABC score strengthens the score for the blunt trauma group, which was 75% of our total study population. One third of our study population sustained a pelvic fracture identified by primary survey pelvic radiographs, with 60% of these requiring MT. Half of the geriatric patients who received MT also had a pelvic fracture diagnosed with primary survey pelvic radiographs.

The definition of MT typically used in research studies, including the Schroll et al. (2018) and RABT studies (Hanna et al., 2020; Joseph et al., 2018), is 10 RBC units transfused over a 24-hr period. This traditional definition of MT has been criticized for not being clinically relevant to the time period when most patients die from bleeding. For our study, we chose to describe MT during MTP activation using the Sharpe et al. (2012) definition: 10 RBC units or more during the “time to hemorrhage control from hospital arrival … considerably less than 6 hr.” The interval of hemorrhage control may reflect a more realistic phase of acute bleeding when MT is required. The landmark PROMMTT (Prospective, Observational, Multicenter, Major Trauma Transfusion) and PROPPR (Transfusion of Plasma, Platelets, and Red Blood Cells in a 1:1:1 vs. 1:1:2 Ratio) studies investigating optimal blood product transfusion ratios showed that death from hemorrhage occurs quickly after injury, with a median time to death of 2.3–2.6 hr (Holcomb et al., 2013, 2015). Our data correlate with this finding, as approximately two thirds of the patients who expired during the first 24 hr died within the first 3 hr of ED presentation. Eighty-five percent of these patients received MT (17 of 20).

Both SI and the ABC score were compared for the geriatric patient subset. Geriatric patients may be more severely injured than initially identified, potentially delaying crucial interventions. DeMuro et al. (2013) note that for older adults accustomed to living with hypertension, normal blood pressure measurements may represent a "relative hypotension," which may be underappreciated. For patients 65 years and older, SBP of less than 110 mmHg is the criterion for the highest level trauma team activation at our trauma center, in contrast to SBP of less than 90 mmHg for younger adults. This change in SBP cutoff is supported by Brown et al. (2015), who demonstrated improvement in the undertriage of geriatric patients with trauma when SBP of 110 mmHg was substituted for SBP of 90 mmHg in the National Trauma Triage Protocol. We questioned whether substituting an SBP cutoff of 110 mmHg in place of the SBP 90 mmHg parameter to calculate the ABC score would increase the utility of the ABC score for the geriatric population. Despite this more inclusive SBP parameter for geriatric patients, SI still outperformed the ABC score for correlation with MT by 2 to 1. Massive transfusion was required for 71% of this subset. Of the geriatric patients who died during the first 24 hr following ED presentation, half died during the first 3 hr, with all of these patients receiving MT. Ohmori et al. (2017) suggest MT in older patients with trauma should be considered on the basis of SI rather than traditional vital signs, along with injury anatomy, anticoagulant/antiplatelet use, and elevated lactate level. As the elderly population continues to grow, with blunt mechanism being the predominate cause of geriatric injury, our data support SI as a trigger for MT in this population.

Limitations

Limitations must be mentioned in regard to this study. The research design is retrospective. There were no personnel dedicated to real-time blood transfusion data collection, which improves the accuracy of transfusion time documentation. As this is a small single-institution study, the results may not apply to other populations. No data were collected on pain, anxiety, medications, or underlying conditions that could have altered HR or SBP. We did not evaluate SI or the ABC score for patients with trauma who did not receive RBCs to assess for overestimation. Both SI and the ABC score were calculated from the first vital signs measured in the ED and from the results of the first FAST examination. This can be a limitation because vital signs and FAST results may change over time. Later, SI and ABC scores could have predicted an association with MT, but these data were not captured. The study also does not account for ongoing bleeding resuscitation still required following intensive care unit admission.

CONCLUSION

The European guideline on *Management of Major Bleeding and Coagulopathy Following Trauma* suggests that "SI be used to assess the degree of hypovolemic shock" (Spahn et al., 2019). This research demonstrates that for patients with trauma requiring MTP activation and who receive 10 RBC units or more during the initial period when bleeding control is managed, SI overall outperforms the ABC score. Shock index ≥ 1 had a stronger association with MT than the positive ABC score did, for patients injured by blunt mechanism and for geriatric patients. Our data suggest the ABC score may have stronger utility for patients with penetrating mechanism injury, but the small sample size limits this interpretation.

Supported by previous investigations (Haider et al., 2016; Jehan et al., 2019; Ohmori et al., 2017; Pandit et al., 2014), we chose SI ≥ 1 as the cutoff value for our study because no mathematical calculation is required, which increases clinical utility. If the HR is equal to or greater than SBP, SI will always be 1 or more. We believe simplicity is an important requirement for a prediction tool to be useful during a busy trauma resuscitation. Timely MT initiation can positively impact patient outcomes (Holcomb et al., 2013; Meyer et al., 2017). Shock index is a basic tool clinicians can independently employ to anticipate and prepare for MT, even before the patient arrives from the field. Our data support recent research demonstrating a stronger association of SI with MT for patients with blunt trauma injury compared to the ABC score (Schroll et al., 2018) and for including SI as a component of a revised ABC score (Joseph et al., 2018; Hanna et al., 2020). Predictive tools for MT initiation continue to evolve.

The findings of this research do not necessarily represent the viewpoint of QMC.

KEY POINTS

- Shock index outperformed the ABC score for correlation with MT for blunt injury and geriatrics.
- The majority of deaths from hemorrhage occurred within the first 3–6 hr; timely intervention is key to survival.
- Shock index empowers nurses to anticipate need for MT, improving early outcomes.

REFERENCES

American College of Surgeons. (2014). *Massive transfusion in trauma guidelines. American College of Surgeons Trauma Quality Insurance Program* (1st ed.). Retrieved November 16, 2020, from https://www.facs.org/-/media/files/qualityprograms/trauma/tqip/transfusion guidelines.ashx

Brown, J. B., Gestring, M. L., Forsythe, R. M., Stassen, N. A., Billar, T. R., Peitzman, A. B., & Sperry, J. L. (2015). Systolic blood pressure criteria in the National Trauma Protocol for geriatric trauma: 110 is the new 90. *The Journal of Trauma and Acute Care Surgery*, *78*(2), 352–359. https://doi.org/10.1097/TA.0000000000000013523

Callcut, R. A., Kornblith, L. Z., Conroy, A. S., Robles, A. J., Meizoso, J. P., Namias, N., Meyer, D. E., Haymaker, A., Truitt, M. S., Agrawal, V., Haan, J. M., Lightwine, K. L., Porter, J. M., San Roman, J. L., Biffl, W. L., Hayashi, M. S., Sise, M. J., Badiee, J., Recinos, G., … Western Trauma Association Multicenter Study Group. (2019). The why and how our trauma patients die: A prospective multicenter Western Trauma Association study. *The Journal of Trauma and Acute Care Surgery*, *86*(5), 864–870. https://doi.org/10.1097/TA.0000000000002205

Cannon, J. W., Khan, M. A., Raja, A. S., Cohen, M. J., Como, J. J., Cotton, B. A., Dubose, J. J., Fox, E. E., Inaba, K., Rodriguez, C. J., Holcomb, J. B., & Duchesne, J. C. (2017). Damage control resuscitation in patients with severe traumatic hemorrhage: A practice management guideline from the Eastern Association for the Surgery of Trauma. *The Journal of Trauma and Acute Care Surgery*, *82*(3), 605–617. https://doi.org/10.1097/TA.0000000000001333

Cotton, B. A., Dossett, L. A., Haut, E. R., Shafi, S., Nunez, T. C., Au, B. K., Zaydfudim, V., Johnston, M., Arbogast, P., & Young, P. P. (2010). Multicenter validation of a simplified score to predict massive transfusion in trauma. *Journal of Trauma*, *69*(Suppl. 1), S33–S39. https://doi.org/10.1097/TA.0b013e3181e42411

Day, D. L., Anzelon, K. M., & Conde, F. A. (2016). Association of prehospital shock index and trauma bay uncrossmatched red blood cell transfusion with multiple transfusion. *Journal of Trauma Nursing*, *23*(2), 89–95. https://doi.org/10.1097/JTN.0000000000000192

DeMuro, J. P., Simmons, S., Jax, J., & Gianelli, S. M. (2013). Application of the shock index to the prediction of need for hemostasis intervention. *American Journal of Emergency Medicine*, *31*(8), 1260–1263. https://doi.org/10.1016/j.ajem.2013.05.027

Do, W. S., Chang, R., Fox, E. E., Wade, C. E., Holcomb, J. B., & Martin, M. J., & NCTH Study Group. (2019). Too fast, or not fast enough? The FAST exam in patients with non-compressible torso hemorrhage. *American Journal of Surgery*, *217*(5), 882–886. https://doi.org/10.1016/jamjsurg.2019.02.012

El-Menyar, A., Goyal, P., Tilley, E., & Lafiti, R. (2018, July). The clinical utility of shock index to predict the need for blood transfusion and outcomes in trauma. *Journal of Surgical Research*, *227*, 52–59. https://doi.org/10.1016/j.jss.2018.02.013

Haider, A. A., Azim, A., Rhee, P., Kulvatunyou, N., Ibraheem, K., Tang, A., O'Keeffe, T., Iftikhar, H., Vercruysse, G., & Joseph, B. (2016). Substituting systolic blood pressure with shock index in the National Trauma Triage Protocol. *The Journal of Trauma and Acute Care Surgery, 81*(6), 1136–1141. https://doi.org/10.1097/TA.0000000000001205

Hanna, K., Harris, C., Trust, M. D., Bernard, A., Brown, C., Hamidi, M., & Joseph, B. (2020). Multicenter validation of the Revised Assessment of Bleeding and Transfusion (RABT) score for predicting massive transfusion. *World Journal of Surgery*, *44*(6), 1807–1816. https://doi.org/10.1007/s00268-020-05394-5

Holcomb, J. B., del Junco, D. J., & Fox, E. E., Wade, C. E., Cohen, M. J., Schreiber, M. A., Alarcon, L. H., Bai, Y., Brasel, K. J., Bulger, E. M., Cotton, B. A., Matijevic, N., Muskat, P., Myers, J. G., Phelan, H. A., White, C. E., Zhang, J., Rahbar, M. H., & PROMMTT Study Group. (2013). The Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) study: Comparative effectiveness of a time-varying treatment with competing risks. *JAMA Surgery*, *148*(2), 127–136. https://doi.org/10.1001/2013.jamasurg.387

Holcomb, J. B., Tilley, B. C., Baraniuk, S., Fox, E. E., Wade, C. E., Podbielski, J. M., del Junco, D. J., Brasel, K. J., Bulger, E. M., Callcut, R. A., Cohen, M. J., Cotton, B. A., Fabian, T. C., Inaba, K., Kerby, J. D., Muskat, P., O'Keeffe, T., Rizoli, S., Robinson, B. R., … PROPPR Study Group. (2015). Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs. a 1:1:2 ratio and mortality in patients with severe trauma. The PROPPR randomized clinical trial. *JAMA*, *313*(5), 471–482. https://doi.org/10.1001/jama.2015.12

Jehan, F., Con, J., McIntyre, M., Khan, M., Azim, A., Prabhakaran, K., & Latifi, R. (2019). Pre-hospital shock index correlates with transfusion, resource utilization, and mortality: The role of patient first vitals. *American Journal of Surgery*, *218*(6), 1169–1174. https://doi.org/10.1016/j.amjsurg.2019.08.028

Joseph, B., Khan, M., Truitt, M., Jehan, F., Kulvatunyou, N., Azim, A., Jain, A., Zeeshan, M., Tang, A., & O'Keefe, T. (2018). Massive transfusion: The Revised Assessment of Bleeding and Transfusion (RABT) score. *World Journal of Surgery*, *42*(11), 3560–3567. https://doi.org/10.1007/s00268-018-4674-y

Marenco, C. W., Lammers, D. T., Morte, K. R., Bingham, J. R., Martin, M. J., & Eckert, M. J. (2020, December). Shock index as a predictor of massive transfusion and emergent surgery on the modern battlefield. *Journal of Surgical Research*, *256*, 112–118. https://doi.org/10.1016/j.jss.2020.06.024

Meyer, D. E., Vincent, L. E., Fox, E. E., O'Keeffe, T., Inaba, K., Bulger, E. M., Holcomb, J. B., & Cotton, B. A. (2017). Every minute counts: Time to delivery of initial massive transfusion cooler and its impact on mortality. *The Journal of Trauma and Acute Care Surgery*, *83*(1), 19–24. https://doi.org/10.1097/TA.0000000000001531

Motameni, A. T., Hodge, R. A., Mckinley, W. I., Georgel, J. M., Strollo, B. P., Benns, M. V., Miller, K. R., & Harbrecht, B. G. (2018). The use of the ABC score in activation of massive transfusion: The yin and the yang. *The Journal of Trauma and Acute Care Surgery*, *85*(2), 298–302. https://doi.org/10.1097/TA.0000000000001949

Nunez, T. C., Voskresensky, I. V., Dossett, L. A., Shinall, R., Dutton, W. D., & Cotton, B. A. (2009). Early prediction of massive transfusion in trauma: Simple as ABC (Assessment of Blood Consumption)? *Journal of Trauma*, *66*(2), 346–352. https://doi.org/10.1097/TA.0b013e3181961c35

Ohmori, T., Kitamura, T., Ishihara, J., Onishi, H., Nojima, T., Yamamoto, K., Tamura, R., Muranishi, K., Matsumoto, T., & Tokioka, T. (2017). Early predictors for massive transfusion in older adult severe trauma patients. *Injury*, *48*(5), 1006–1012. https://doi.org/10.1016/j.injury.2016.12.028

Olaussen, A., Peterson, E. L., Mitra, B., O'Reilly, G., Jennings, P. A., & Fitzgerald, M. (2015). Massive transfusion prediction with inclusion of the pre-hospital shock index. *Injury*, *46*(5), 822–826. https://doi.org/10.1016/j.injury.2014.12.009

Pandit, V., Rhee, P., Hashmi, A., Kulvatunyou, N., Tang, A., Khalil, M., O'Keeffe, T., Green, D., Friese, R. S., & Joseph, B. (2014). Shock index predicts mortality in geriatric trauma patients: An analysis of the National Trauma Data Bank. *The Journal of Trauma and Acute Care Surgery*, *76*(4), 1111–1115. https://doi.org/10.1097/TA.0000000000000160

Rotondo, M. F., Cribari, C., & Smith, R. S. (2014). *Resources for optimal care of the injured patient* (6th ed.). American College of Surgeons.

Rowell, S. E., Barbosa, R. R., Holcomb, J. B., Fox, E. E., Barton, C. A., & Schreiber, M. A. (2019). The focused assessment with sonography in trauma (FAST) in hypotensive injured patients frequently fails to identify the need for laparotomy: A multi-institutional pragmatic study. *Trauma Surgery and Acute Care Open*, *4*, e000207, 11-16. https://doi.org/10.1136/tsaco-2018-000207

Schroll, R., Swift, D., Tatum, D., Couch, S., Heaney, J. B., Llado-Farrulla, M., Zucker, S., Gill, F., Brown, G., Buffin, N., & Duchesne, J. (2018). Accuracy of shock index versus ABC score to predict need for massive transfusion in trauma patients. *Injury*, *49*(1), 15–19. https://doi.org/10.1016./j.injury.2017.09.015

Sharpe, J. P., Weinberg, J. A., Magnotti, L. J., Croce, M. A., & Fabian, T. C. (2012). Toward a better definition of massive transfusion: Focus on the interval of hemorrhage control. *The Journal of Trauma and Acute Care Surgery*, *73*(6), 1553–1557. https://doi.org/10.1097/TA.0b013e3182660119

Spahn, D. R., Bouillon, B., Cerny, V., Duranteau, J., Filipescu, D., Hunt, B. J., Komadina, R., Maegele, M., Nardi, G., Riddez, L., Samama, C. M., Vincent, J. L., & Rossaint, R. (2019). The European guideline on management of major bleeding and coagulopathy following trauma: Fifth edition. *Critical Care*, *23*(1), 98. https://doi.org/10.1186/s13054-019-2347-3

Stahel, P. F., Burlew, C. C., & Moore, E. E. (2017). Current trends in the management of hemodynamically unstable pelvic ring injuries. *Current Opinion in Critical Care*, *23*(6), 511–519. https://doi.org/10.1097/MCC.0000000000000454

Tisherman, S. A., Schmicker, R. H., Brasel, K. J., Bulger, E. M., Kerby, J. D., Minei, J. P., Powell, J. L., Reiff, D. A., Rizoli, S. B., & Schreiber, M. A. (2015). Detailed description of all deaths in both the shock and traumatic brain injury hypertonic saline trials of the Resuscitation Outcomes Consortium. *Annals of Surgery*, *261*(3), 586–590. https://doi.org/0000000000000837

Vandromme, M. J., Griffin, R. L., Kerby, J. D., McGwin, G., Rue, L. W., 3rd, & Weinberg, J. A. (2011). Identifying risk for massive transfusion in the relatively normotensive patient: Utility of the prehospital shock index. *Journal of Trauma*, *70*(2), 384–390. https://doi.org/10.1097/TA0b013e382095a0a

Vogt, K. N., Van Koughnett, J. A., Dubois, L., Gray, D. K., & Parry, N. G. (2012). The use of transfusion pathways for blood component transfusion in the civilian population: A systematic review and meta-analysis. *Transfusion Medicine*, *22*(3), 156–166. https://doi.org/10.1111/j.1365-3148.2012.01150.x

Lippincott® NursingCenter®

NCPD Nursing Continuing Professional Development

TEST INSTRUCTIONS

- Read the article. The test for this nursing continuing professional development (NCPD) activity is to be taken online at **www.NursingCenter.com/CE/JTN**. Tests can no longer be mailed or faxed.
- You'll need to create an account (it's free!) and log in to access My Planner before taking online tests. Your planner will keep track of all your Lippincott Professional Development online NCPD activities for you.
- There's only one correct answer for each question. A passing score for this test is 7 correct answers. If you pass, you can print your certificate of earned contact hours and access the answer key. If you fail, you have the option of taking the test again at no additional cost.
- For questions, contact Lippincott Professional Development: 1-800-787-8985.
- Registration deadline is December 6, 2024.

PROVIDER ACCREDITATION

Lippincott Professional Development will award 2.0 contact hours for this nursing continuing professional development activity.

Lippincott Professional Development is accredited as a provider of nursing continuing professional development by the American Nurses Credentialing Center's Commission on Accreditation.

This activity is also provider approved by the California Board of Registered Nursing, Provider Number CEP 11749 for 2.0 contact hours. Lippincott Professional Development is also an approved provider of continuing nursing education by the District of Columbia, Georgia, and Florida, CE Broker #50-1223. Your certificate is valid in all states.

Payment: The registration fee for this test is FREE for STN members and $21.95 for nonmembers.

STN members can take JTN CE for free using the discount code available in the members-only section of the STN website. Use the discount code when payment is requested during the check-out process.

DOI: 10.1097/JTN.0000000000000621