Clinical Practice Guideline: Massive Transfusion Scoring Systems

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Clinical Question

Which massive transfusion scoring systems are most useful and effective in predicting the need for massive transfusion in adult non-military emergency department trauma patients?

Background and Significance

Injury is a global healthcare problem. In 2016, injuries were reported as the leading cause of death among people ages 1–44 (Centers for Disease Control and Prevention [CDC], 2016). In 2014, an estimated 26.9 million people were treated for injury in emergency departments within the United States (CDC, 2016). Globally, hemorrhage is a common cause of injury-related death among trauma patients (Elmer, Wilcox & Raja, 2013). In the management of the trauma patient, urgent surgical intervention and/or rapid volume resuscitation with blood products for the management of hypovolemic, hemorrhagic shock can be the most vital intervention (Kuhne, Zettl, Fischbacher, Lefering, & Ruchholtz, 2008; Mizobata, 2017; Reed et.al., 2016; Ruchholtz et al., 2006). Massive transfusion (MT) of blood products may be required. Although there are various definitions for MT, the administration of greater than or equal to 10 units of packed red blood cells in 24 hours is a widely recognized definition for MT in adult trauma patients (McLaughlin et al., 2008) and therefore will be utilized for the purpose of this Clinical Practice Guideline (CPG).

To meet the needs of the trauma patient suffering from acute blood loss, trauma and non-trauma designated centers should have a massive transfusion protocol (MTP) in place (Cannon et al., 2017; Nunez, Young, Halcomb, & Cotton, 2010). MTPs facilitate the rapid delivery of the massive amounts of blood products necessary for hemodynamically unstable trauma patients (Nunez et al., 2010). Prompt activation of the MTP is crucial. One challenge is the rapid identification of the patient in need of MT, which ideally should occur during the initial trauma assessment. Blood products are a finite and expensive resource; therefore, ED providers have an obligation to accurately assess and be judicious in decisions to administer blood products (Kuhne et al., 2008). However, there are no universal guidelines for MT (Davis, Johannigman, & Pritts, 2012). Independent variables or triggers that may predict the need for MT such as blood pressure, international normalized ratio (INR) value, hemoglobin and hematocrit, temperature and base deficit, have been studied. Further, guidelines for the management of bleeding and coagulopathy for patients who experience major trauma suggest that scoring systems for hemorrhagic shock may also be useful for guiding treatment (Spahn et al., 2013).

Some MT scoring systems and predictors were derived using civilian databases and others were derived from military/combat databases (Brockamp et al., 2012). This CPG addresses the ED care of adults injured in non-military incidents; therefore, only MT scoring systems and predictors studied in the non-military setting are reviewed in this CPG. Although the McLaughlin score was initially developed for military use, it was compared to civilian scoring systems using civilian databases in some studies and is therefore included in this review (Krumrei, Park, Cotton, & Zielinski, 2012; Nunez et al., 2010).

Methods

This CPG was created based on a thorough review and critical analysis of the literature following the ENA Clinical Practice Guidelines Development Manual (ENA, 2018). Articles relevant to the topic were identified with a comprehensive literature search. The following databases were searched: MEDLINE, CINAHL, ProQuest and BIOMED. Searches were conducted using the following search terms: massive transfusion, trauma, emergency department, civilian, non-military, scoring systems, mass transfusion scoring systems, Trauma Associated Severe Hemorrhage Score (TASH), Assessment of Blood Consumption (ABC), transfusion, transfusion protocols, Prince of Wales Hospital (PWH) transfusion scoring system, Rainer scoring system, massive blood loss prediction, transfusion prediction system, hemorrhage prediction models, trauma shock management, massive blood loss management, transfusion triggers, McLaughlin model, Emergency Transfusion Score (ETS) model, massive transfusion protocol, massive transfusion and prediction, massive transfusion and triage, and massive transfusion and screening. The initial development of this guideline in 2004 was limited to English language articles on human subjects from 2004-May 2014. An update on this topic in 2017 included articles published from June 2014-December 2017. In addition, the reference lists in the selected articles were reviewed for pertinent research findings. Research articles from ED settings, non-ED settings, position statements and guidelines from other sources were also reviewed. Clinical findings and levels of recommendations regarding patient management were made by the CPG Committee according to ENA's classification of levels of recommendation for practice (Table 1). The articles reviewed to formulate the recommendations in this CPG are described in Appendix 1.

Table 1. Levels of Recommendation for Practice

Level A Recommendations: High
• Reflects a high degree of clinical certainty • Based on availability of high quality level I, II, and/or III evidence rated using the Melnyk and Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2015) • Based on consistent and good quality evidence; has relevance and applicability to emergency nursing practice • Is beneficial
Level B Recommendations: Moderate
• Reflects moderate clinical certainty • Based on availability of Level III and/or Level IV and V evidence rated using the Melnyk and Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2015) • There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice • Is likely to be beneficial
Level C Recommendations: Weak
• Has limited or unknown effectiveness • Level V, VI, and/or VII evidence rated using the Melnyk and Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2015) - Based on consensus, usual practice, evidence, case series for studies of treatment or screening, anecdotal evidence, and/or opinion
Not Recommended for Practice
• No objective evidence or only anecdotal evidence available, or the supportive evidence is from poorly controlled or uncontrolled studies • Other indications for not recommending evidence for practice may include: ∘ Conflicting evidence ∘ Harmfulness has been demonstrated ∘ Cost or burden necessary for intervention exceeds anticipated benefit ∘ Does not have relevance or applicability to emergency nursing practice • There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. For example: ∘ Heterogeneity of results ∘ Uncertainty about effect magnitude and consequences ∘ Strength of prior beliefs ∘ Publication bias

Summary of Literature Review

The literature search that was completed for the original version of this CPG found six scoring systems developed and used to predict the need for MT in the civilian population. The updated literature search indicates there has been an expansion of methods used to predict MT that includes multiple physiologic variables, in addition to the use of scoring systems. This is likely because scoring systems may require a calculation that is complex or rely on lab values that are not readily available (Pommerening et al., 2015) as well as the advancing ability of point-of-care testing to analyze specimens (Hildyard & Curry, 2015). This review updates information on scoring systems used to predict the need for MT identified in the original CPG and introduces new material regarding the use of physiologic variables.

TRAUMA ASSOCIATED SEVERE HEMORRHAGE SCORE

The Trauma Associated Severe Hemorrhage (TASH) score incorporates seven variables into a risk score for the probability of MT (Yűcel et al., 2006). The variables include systolic blood pressure (SBP), hemoglobin, intra-abdominal fluid (i.e., focused assessment with sonography in trauma [FAST]), complex long bone and/or pelvic fractures, heart rate, base excess, and gender (Yücel et al., 2006). Points are assigned to each variable with possible scores ranging from 0–28. Higher TASH scores correlate with an increase in the probability of MT. During the initial development and validation study, Yücel et al. (2006) determined that a TASH-Score of 16 predicts an individual probability for MT of 50% and scores greater than 27 are associated with a 100% risk for MT. This study showed excellent reliability in predicting the need for MT as demonstrated by area under the receiver operator curve (AUC/AUROC) of 0.892 and 0.887 in the developmental data set and the validation data set, respectively. The same group of investigators performed an additional study to revalidate the TASH score (Maegele et al., 2011). After modifying the logistic function, the probability for MT, using a TASH score of 16, was reduced from 50% in the original validation study to 35% (Maegele et al., 2011). The AUC, sensitivity, and specificity for the revalidation study were 0.905, 31% and 98%, respectively (Maegele et al., 2011).

The high overall accuracy of the TASH score was further validated in numerous studies. These studies revealed the AUC score generally ranged from 0.842–0.889 (Brockamp et al., 2012; Chico-Fernandez et al., 2011; Nunez et al., 2009; Moore et al., 2017; Ogura et al., 2014), but was as low as 0.51 in one study (Krumrei et al., 2012). Krumrei et al. (2012) reported the following findings for the TASH score: sensitivity of 2.6%, specificity of 99.7%, positive predictive value (PPV) of 0.5%, and negative predictive value (NPV) of 0.90%, while Ogura et al. (2014) found a sensitivity of 81.6% and a specificity of 78.2%.

Several studies compared the TASH score to other MT scoring systems, taking cut offs into consideration (Brockamp et al., 2012; Chico-Fernandez et al., 2011; Krumrei et al., 2012; Nunez et al., 2009; Ogura et al., 2014). The results from these comparison studies are discussed later in the individual review of each MT scoring system. One study used the TASH score to assist with determining the benefits and complications associated with the use of a high FFP:RBC ratio (Borgman et al., 2011). They found a strong association between survival and the use of a high FFP:RBC transfusion strategy when utilizing the TASH score to rapidly identify trauma patients at risk for MT (Borgman et al., 2011).

Two studies examined the relationship between patient variables and the TASH scoring tool. De Jong et al. (2016) completed a retrospective study exploring the role relationship between obesity and the scoring tool. This study reports that TASH scoring was an effective tool in both non-obese and obese patients. Ohmori et al. (2017), investigated the effectiveness of the TASH score in patients > 65 years old with severe traumatic injuries. While the AUC (0.881) for patients <65 years was consistent with other studies, the AUC (0.793) for older patients was found to be less reliable

One benefit of the TASH score is the variables of the scoring system are available within a maximum of 15 minutes from time of arrival to the emergency department (Yűcel et al., 2006). While all facilities should be able to assess these variables, a timeframe of 15 minutes from time of arrival may not be feasible in facilities with limited resources. Possible limitations for the use of TASH include the laboratory blood tests, difficulty with memorizing the scoring system, and the mathematical calculations (Kumrei et al., 2012; Vandromme et al., 2011b).

ASSESSMENT OF BLOOD CONSUMPTION

The Assessment of Blood Consumption (ABC) score was developed by Nunez et al. (2009) in an effort to create an MT scoring tool that would not require laboratory data, tabulation of injury severity scores, or any significant mathematical computations. The ABC score consists of four components that are easily determined at the bedside and include: penetrating mechanism, ED SBP less than 90 mmHg, ED heart rate (HR) greater than 120, and a positive FAST (Nunez et al., 2009). Each variable is given 1 point if positive and 0 if negative. A score of 2 or more is considered a positive predictor of the need for MT within 24 hours of admission.

In Nunez et al. (2009), the authors used multiple logistic modeling to examine the odds ratios (OR) of each variable to independently predict MT. SBP less than 90 (OR 13.0, $p < 0.001$, CI 95% CI [6.93,24.52]), positive FAST (OR 8.2, $p < 0.001$, 95% CI [4.34,5.30]), and HR greater than 120 (OR 3.9, $p < 0.001$, 95% CI [2.00,6.85]) were significantly associated with MT. While less significant, a penetrating mechanism of injury demonstrated an OR of 1.9 ($p < 0.02$, 95% CI [1.15,3.44]). The ability of the score to predict MT was estimated by using AUROC. The AUROC was 0.852, which was comparable to the TASH (0.842) and McLaughlin (0.767) scores calculated on the same population. The ABC score was found to be 75% sensitive and 86% specific. In a study by Cotton et al. (2010), the ABC score was validated across three demographically diverse trauma centers. MT rate was similar between the centers (14 to 15%). AUROC, sensitivity, and specificity were all relatively similar to the rest of the scores. The PPV was low at 55%, but the negative predictive value (NPV) was extremely high at 97%. A study by Krumrei et al. (2012) was conducted in a rural Level I trauma center, and the ABC score was validated and compared against the TASH and McLaughlin scores. The ABC score was the only one of the three found to be predictive of MT.

Ohmori et al. (2017) investigated the effectiveness of the ABC score for older patients with severe traumatic injuries. While the AUC (0.792) for patients under 65 years was consistent with other studies, the AUC (0.665) for patients 65 years and older was found to be less accurate. Ohmori et al. (2017) suggest that MT be considered in patient 65 years and older based on anatomical factors, pre-injury anticoagulant or antiplatelet agent use, lactate level, and shock index (SI) even if vital signs are normal. Three international studies found some limitations and varied results when comparing the ABC score to other scoring tools (Brockamp et al., 2012; Chico-Fernandez et al., 2011; Nunez et al., 2009; Wijaya, Cheng, & Chong, 2016). One study found that the TASH score was significantly better than both the ABC and ETS scores; however, the authors recognized the TASH score poses a challenge with its large number of variables in comparison to the ABC score (Chico-Fernandez et al., 2011). In a study from Germany, the authors compared the TASH, Vandromme, PWH and ABC scoring systems (Brockamp et al., 2012). The ABC score had the lowest AUROC (0.763) of the group, but sensitivity (76.1%) and specificity (70.3%) were comparable to the rest of the scores. Overall, the authors concluded that the TASH and PWH scores were superior to the others (Brockamp et al., 2012). One difference in the Brockamp et al. (2012) study sample was that 95% of the mechanism of injury was blunt trauma. This was significantly higher than the original population studied by Nunez et al. (2009), in which blunt mechanisms accounted for only 82.8%. Finally, a study conducted in Japan compared the effectiveness of the TBSS tool to the ABC and TASH scores when used with older adult patients (Ogura et al., 2014). The AUROC, sensitivity and specificity of the ABC score were lower when compared to the TASH and Traumatic Bleeding Severity Score (TBSS). The simplicity of the ABC score was noted as a positive for facilities with limited resources

The ABC score has been extensively validated using retrospective studies both in the United States and internationally. The international studies identified possible limitations in that patients with blunt mechanisms of injury were studied predominantly. While some studies identified improved predictive values with other scoring tools, all have pointed out the ABC score's main strength being its simplicity. The ABC score requires no laboratory testing, and parameters are readily determined during initial assessment. Like other MT scoring tools, studies to date have been retrospective, which is a limitation. Future studies are recommended to validate the prospective use of this scoring tool.

EMERGENCY TRANSFUSION SCORE

The Emergency Transfusion Score (ETS) was developed to address the need for a valid and accurate tool using quickly assessed parameters to predict the need for packed red blood cells (pRBCs) in ED patients requiring trauma team activation (Ruchholtz et al., 2006). Derived from the American College of Surgeons (ACS) Committee on Trauma Activation admission criteria, the scored and weighed parameters of the ETS are the following: age, admission from scene, type of injury (blunt or penetrating), trauma mechanism (car/truck, motor cyclist, pedestrian, fall from a height of less than or more than 3 meters, fall from stairs, fall from a horse, gunshots, burns), systolic blood pressure on admission, abdominal ultrasound, and pelvic ring stability (Ruchholtz et al., 2006). Using these parameters, the emergent need for a transfusion can be evaluated (Kuhne et al., 2008).

Ruchholtz et al. (2006) developed an assessment tool designed to quantify the likelihood of the need for pRBCs via three distinct groups: low-risk (less than 3 points), intermediate-risk (3 points), and high-risk (greater than 3 points). In initial tool evaluation, 1.6% classified as in the low-risk category of patients andrequired a transfusion, compared to 8.5% in the intermediate-risk and 34.6% in the high-risk groups (Ruchholtz et al., 2006). In further research, the tool was validated with a sensitivity of 97.5% and a specificity of 68% for predicting the need for immediate transfusion with pRBCs in the civilian blunt force trauma population (Kuhne et al., 2008). An ETS score of greater than 2 was associated with a 100% sensitivity, specificity of 44.2% and PPV of 0.115, a score of greater than 3 was associated with a sensitivity of 97.5%, specificity of 68%, and a PPV of 0.222, and with a score of greater than 4 the sensitivity dropped to 84.2%, with a specificity of 92.5%, and a PPV of 0.314 (Kuhne et al., 2008). Based on the data from Ruchholtz et al. (2006) and Kuhne et al. (2008), an ETS score of 3 indicates a need for pRBCs with the addition of clinical discretion to include hemodynamic status.

When compared with the TASH and ABC scoring systems, the ETS was found to be inferior to the TASH for predicting the need for MT. While exhibiting 89% sensitivity, an ETS of greater than 3 was only associated with 36% specificity; with an increased ETS of greater than 6 there was 66% sensitivity with 94% specificity (Chico-Fernandez et al., 2011). An ETS of greater than 3 had a PPV of 26%, while the TASH score, with a cut-off of greater than 16 was associated with a PPV of 78% and 85%; an ETS of greater than 6 increases the PPV to 66%, but this value is above the validated clinical parameters for use studied by Ruchholtz et al. (2006) and Kuhne et al. (2008) (Chico-Fernandez et al., 2011). There were no significant statistical differences noted between the predictive value of ETS and the ABC scores (Chico-Fernandez et al., 2011).

The ETS is not predictive of the need for a MT, nor has it been validated in patients with penetrating trauma. However, a low ETS score is predictive for lack of need for MT. In development, the low-risk group, ETS less than 3, 98.5% were not transfused (Ruchholtz et al., 2006). In comparison to TASH and ABC, the ETS had amongst the highest negative predictive value (NPV); an ETS greater than 6 was equal only to a TASH greater than 16 with 86% NPV, while an ETS greater than 4 and greater than 3 had NPVs of 91% and 92%, respectively, of MT (Chico-Fernandez et al., 2011).

The ETS has appropriate clinical applications, particularly in smaller hospitals, which may not have blood products readily available. The tool has limited scope for predicting the need for immediate blood transfusion. It is not a good predictor of the degree of resuscitation required (Kuhne et al., 2008; Ruchholtz et al., 2006). As a tool for predicting and screening patients for MT, the ETS is comparable to the ABC but inferior to the TASH (Chico-Fernandez et al., 2011). The ETS uses fast and easily obtained data, which can be readily incorporated into an existing trauma survey to identify patients likely to need immediate blood transfusion (Kuhne et al., 2008; Ruchholtz et al., 2006). While the ETS is an easy-to-use, reliable tool in the non-military blunt trauma population, it cannot be used to predict the degree of volume of resuscitation (Kuhne et al., 2008; Ruchholtz et al., 2006).

The ETS may bridge a practice gap because it is based on readily available, ACS required parameters (Kuhne et al., 2008; Ruchholtz et al., 2006). The simplicity of its use and absence of the need for laboratory values are strengths, and its high NPV may be beneficial as an early assessment strategy for excluding patients from consideration for MT. Its use in clinical practice should be limited to predicting the need for emergent transfusion because it is not specific or sensitive enough for predicting the need for MT (Chico-Fernandez et al., 2011).

MCLAUGHLIN MASS TRANSFUSION SCORE

The McLaughlin MT Scoring System is non-weighted and uses both clinical and laboratory components. The four-component tool includes HR greater than 105, SBP less than 110 mmHg, pH less than 7.25, and hematocrit less than 32% (Krumrei et al., 2012). Within this four-component scoring system, each positive indicator represents a 20% chance of the need for MT to a maximum of 80% (Krumrei et al., 2012; Nunez et al., 2009). The McLaughlin MT Scoring System, initially developed for military use, was applied to a cohort in a retrospective study in comparison to the TASH and ABC scoring systems. Each of these systems varied in complexity. The specificity of the ABC, TASH, and McLaughlin MT Scoring System for predicting MT was 85%, 99.7%, and 98% respectfully; while the sensitivity was 89%, 2.6% and 15.8% (Krumrei et al., 2012). Nunez et al. (2009) explored the application of the TASH, ABC, and McLaughlin MT Scoring System in a retrospective study as related to false positives and false negatives. This was a single population of predefined trauma patients with the ABC and TASH demonstrating better predictability of need for mass transfusion than the McLaughlin MT Scoring System.

The strength of the McLaughlin MT Scoring System is its simplicity. This system's components are readily obtainable at the stretcher side, with the exception of the hematocrit and pH, the availability of which may vary, based on resources. The ease of calculation and basic components provides a tool that may be useful in facilities with fewer resources. Its weaknesses are the requirement for laboratory data and failure to apply the score in a prospective study to validate the criteria.

PRINCE OF WALES HOSPITAL/RAINER SCORE

An additional MT scoring methodology is based on a retrospective analysis from the Prince of Wales Hospital (PWH) in Hong Kong (Rainer et al., 2011). The PWH/Rainer Scoring System is a weighted system, consisting of seven components: HR greater than or equal to 120, SBP less than or equal to 90 mm Hg, Glasgow coma scale less than or equal to eight, displaced pelvic fracture, computed tomography (CT) scan or FAST positive for fluid, base deficit greater than 5-mmol/L, and hemoglobin less than or equal to 7 g/dL (Rainer et al., 2011). These components were selected because they are readily available in the emergency department. The primary outcome measure was MT within 24 hours after injury. Rainer et al. (2011) determined that with a cutoff score of greater than or equal to six the PWH/Rainer scoring system had a sensitivity of 31.5%, specificity of 99.7%, and a PPV of 82.9%. In the retrospective validation of six scoring systems, four of which were civilian datasets, by Brockamp et al. (2012), the TASH and PWH/Rainer were found to have similar sensitivities (84.4% and 80.6%) and specificities (78.4% and 77.7%), respectively.

Ohmori et al. (2017), investigated the effectiveness of the PWH score for older patients with severe trauma. While the AUC (0.858) for patients younger than 65 years old was consistent with other studies, the AUC (0.764) for the patients 65 years and older was less accurate. Ohmori et al. (2017) suggest that MT be considered in patients 65 years or older based on anatomical factors, pre-injury anticoagulant or antiplatelet agent use, lactate level, and SI, even if traditional vital signs are normal.

Strengths of the PWH/Rainer include the ability to obtain the score within the emergency department and a weighted scoring system. The acquisition of the scoring system components is also a limiting factor because it requires information from laboratory and radiographic studies. While this score has been validated, this was a retrospective study (Brockamp et al., 2012). A significant weakness is the lack of real-time application of the scoring system. This tool may be useful in facilities where laboratory and radiographic resources are readily available.

VANDROMME SCORE

Vandromme et al. (2011b) sought to develop a predictive model for MT for use in civilian trauma patients. The Vandromme score is a non-weighted scoring system adapted from MT scoring systems in the military arena (Vandromme et al., 2011b). The scoring components can be obtained in the emergency department either by clinical assessment or point-of-care testing. Vandromme et al. (2011b) reported they were unable to develop a predictive model to identify civilian trauma patients at risk for need of MT. However, they did conclude that the most effective predictive model included three or more positive clinical measures with a sensitivity of 53%, specificity of 98%, PPV of 33%, and NPV of 99% (Vandromme et al., 2011b). When all clinical measures were positive, the PPV was 98% (Vandromme et al., 2011b). Brockamp et al. (2012) found results similar to those from studies that used other non-weighted scoring systems; however, the sensitivity of 78.9% and specificity of 76.2% of the Vandromme score is lower than that of the weighted systems (Brockamp et al., 2012).

A strength of the Vandromme scoring system is that with point-of-care testing the components are readily obtainable. Weaknesses include that it is a non-weighted system, requires laboratory or specialized equipment, and lacks prospective studies to validate the score.

TRAUMA BLEEDING SEVERITY SCORE

The Trauma Bleeding Severity Score (TBSS) was derived retrospectively from a single institution in Japan using adult patients with blunt trauma, excluding isolated head trauma. It is a predictive model for assessing a patient's need for MTP activation. The scoring system was created to better assess and screen for the needs of older adult patients in a Japanese trauma center (Ogura et al., 2014). The TBSS is derived from five components: age, SBP, number of positive regions on FAST scan, pelvic fracture, and serum lactate. Scores range from 0 to 57 (Ogura et al., 2014).

During the validation phase, the TBSS was concurrently compared with the TASH and ABC tools. The TBSS as a screening tool, with a cutoff of 15 points, provides a sensitivity of 97.4% and a specificity of 96.2% for predicting MT (Ogura et al., 2014). In the same patient population, the TASH, with a cutoff score of eight, had a sensitivity of 81.6% and a specificity of 78.2%; while the ABC with a score of one had sensitivity and specificity of 79% and 78.2%, respectively.

The superiority of the TBSS in the older adult population in Japan, where 22% of the population are over 65, are results that require further validation in broader clinical settings. The advantages of the TBSS include increased sensitivity to physiologic changes in the older adult and it accounts for the location and severity of bleeding detected on a bedside FAST. The TBSS does require laboratory values, which may delay protocol initiation. In an attempt to streamline usage, the TBSS is available as an application for handheld devices. The increased sensitivity and specificity of a TBSS score of greater than 15, compared to the TASH and ABC scores, demonstrates potential for a more sensitive assessment tool, particularly in the older adult population (Ogura et al., 2014).

Ogura, Lefor, Masuda, and Kushimoto (2016) used the previously referenced database to compare the recently developed modified TBSS (MTBSS) to the TASH as a predictor of MT early in the resuscitation process. The TBBS is calculated after the initial fluid resuscitation while the MTBSS uses the presenting systolic BP for the calculations. Three-hundred patients were enrolled of which 84 patients received MT. The AUC of the TBSS was higher than that of the TASH score (0.956 / 0.912) and the Modified TBSS (0.956/ 0.915). Ogura et al. (2016) concluded that the predictive value of the MTBSS is equivalent to the TASH but MTBSS enables earlier resuscitation than the original TBSS.

Ogura et al. (2015) examined the "gray zone" of MT indicators. In a retrospective studying using the previously referenced database, 264 patients were identified with 85 requiring MT. The cutoffs were TBSS 17 and higher or TBSS of 10 or less, with a gray zone of TBSS 11–16. Ogura et al. (2015) identified 46 patients in the gray zone and 12 required MT. While this gray area does not have clear indications for MT, activation of MT protocols should be considered, especially for patients with coagulopathy (PT-INR ≥ 1.2) or extravasation on CT scan (Ogura et al., 2015).

SHOCK INDEX

Shock index (SI), defined as the heart rate divided by the systolic BP (SBP), serves as a simple predictive model for early identification of critical bleeding (CB) in multiple settings (DeMuro et al., 2013; Pottecher et al., 2016; Olaussen, Blackburn, Mitra, & Fitzgerald, 2014; Vandrome et al., 2011a). In a systematic review on the use of SI in predicting critical bleeding by Olaussen et al. (2014), five studies met their inclusion criteria. This review identified a SI cutoff of 0.9 or greater with higher SI serving as a predictor of CB, while a cutoff of 1.0 or greater had a higher specificity and was easier to calculate in both the pre- and in-hospital settings.

In addition to the recognized SI calculations based on HR and SBP, a modified shock index (MSI) was developed. MSI was calculated by HR divided by mean arterial pressure (MAP) and Age SI (ASI). The SI and MSI were compared in a retrospective study of trauma registry data of 2509 patients who received blood within the first 24 hours (Rau et al., 2016). Of these identified patients, 99 patient received MT. Rau et al. (2016) identified cut off points of S I≥ 0.95 (area under curve (AUC 0.76) and MSI ≥ 1.15 (AUC 0.756). The researchers concluded that the MSI and the ASI did not provide improved predictability, with the ASI impacted by comorbid factors including hypertension, diabetes, and coronary artery disease.

DeMuor et al. (2013) found that while there were minimal differences in the sensitivity between age groups (< 65 years 57.5% and > 65 years 41.2%) with an SI ≥ 0.9, the specificity was 95.7% in the greater than 65-year-old population and 91.6% for those < 65, indicating fewer false positives. When the SI cutoff was decreased to 0.8, the sensitivity fell to 76.1% with a specificity of 87.4% for both populations, thus leading the researchers to conclude that decreasing the SI cut off to ≥ 0.8 was a simple system to implement as a CB indicator (DeMuro, Simmons, Jax, & Gianelli, 2013).

PHYSIOLOGIC VARIABLES USED TO PREDICT MT

The utility of physiologic variables to predict the need for MT has been studied in the last several years. Twenty-three studies investigated the use of vital signs, serum studies, and trauma-related variables, in combination or alone, to predict which patients may need MT. The findings of these studies vary in terms of which variables may be useful in predicting the need for MT.

Vital Signs

Fifteen studies reported findings regarding the use of vital signs to predict the need for MT. A systolic blood pressure of 90 mm Hg or lower predicted the need for MT in eight studies (Blackmore et al., 2006; Burkhardt et al., 2014; Callcut, Johannigman, Kadon, Hanseman, & Robinson, 2011; Charbit et al., 2013; Dente et al., 2010; Parimi et al., 2016; Reed et al., 2016; Umemura, Nakamura, Nishida, Hoshino & Ishikura, 2016). Six other studies found that blood pressure may also predict MT need and all but one (Tonglet, Minon, Seidel, Poplavsky, & Vergnion, 2014) did not use the 90 mm Hg cutoff point (Fligor et al., 2016; Mina, Winkler & Dente, 2013; Rau et al., 2016; Shackelford et al., 2015; Vandromme, Griffin, Weinberg, Rue & Kerby, 2010). Ten studies examined heart rate as a predictor for MT and eight found that heart rate successfully predicted the need for MT (Blackmore et al., 2006; Dente et al., 2010, Mackenzie et al., 2014; Mina et al., 2013; Parimi et al., 2016; Shackelford et al., 2015; Umemura et al., 2015; Yumotoi et al., 2014) and two found that heart rate did not predict MT need (Fligor et al., 2016; Rau et al., 2016). Among these studies, different cutoff levels for heart rate were used when predicting the need for MT. Temperature was also considered as a predictor for MT by Callcut et al. (2011),who found that it significantly ($p = 0.004$) and independently predicted the need for MT in patients who had experienced trauma and required immediate operative intervention. Based on this evidence, blood pressure and heart rate are useful predictors for MT. However, the point at which these variables become useful in their capacity to predict MT remains unclear.

Serum Studies

Of the 23 studies that investigated physiologic variables, twenty reported findings on the use of serum studies to predict the need for MT in trauma patients; each study reported findings in the context of different combinations of these variables. Of those studies examining hemoglobin (Hgb) and/or hematocrit (Hct) (n=7) as predictors, the majority (n=5) found that Hgb and/or Hct significantly predicted the need for MT (Blackmore et al., 2006; Burkhardt et al., 2014; Callcut et al., 2011; Shackelford et al. 2015; Umemura et al., 2015); two studies found the opposite (Rau et al., 2016; Yumoto et al., 2014). Five studies explored the predictive ability of the INR. Three found that the INR predicted the need for MT (Callcut et al., 2011; Hagemo et al., 2015; Hsu, Hitos, & Fletcher, 2013), but the cutoff level for the INR was not uniform among these studies. Conversely, the other 2 studies did not find that the INR was predictive of MT (Shackelford et al., 2015; Umemura et al., 2015). Measures of clot firmness (ROTEM assays) and fibrinogen levels were also studied (Hagemo et al., 2015; Schöchl et al., 2011; Umemura et al., 2015). All studies found that fibrinogen level was an adequate predictor of the need for MT. One study found that fibrinogen level was a significantly better predictor of MT need than two serum assays of clot firmness (Hagemo et al., 2015); yet another study found that fibrinogen level was equal to serum assays of clot firmness in its ability to predict need for MT (Schochl et al., 2011). Base excess, base deficit and serum lactate levels were also evaluated. Umemura et al. (2015) and Yumoto et al. (2014) found that base excess levels were predictive of MT (OR 0.767, $p < 0.0001$, 95% CI [0.681,0.847]; OR 0.72, p=0.002, 95% CI [0.58,0.89], respectively) and Charbit et al. (2013) found that a base excess of 6 or greater was associated with MT (OR 6.7, $p < 0.001$, 95% CI [3.9,11.6]). Further, base deficit levels were found to be predictive of MT (Dente et al., 2010; Hsu et al., 2013; Mina et al., 2013; Rau et al., 2016), but the levels at which it was predictive of MT varied among studies. Ohmori et al. (2017) and Shackelford et al. (2015) reported that lactate levels were predictive of MT (OR 1.2, $p = 0.013$, 95% CI [1.04,1.39]; AUC 0.80, $p = 0.04$), respectively. According to the evidence, the ability of serum studies to predict the need for MT in trauma patients varies, and the utility of these tests for this purpose is unclear. As science advances and point of care testing makes timely results more attainable, it is likely that these parameters will be studied more in depth, but until that time, there is not enough evidence to recommend using specific serum studies independently, or in combination with one another, to predict MT.

Trauma-related Variables

It is possible that radiographic detection of hemorrhage and type of bone fracture may help anticipate which trauma patients will need MT. The presence and/or size of hematoperitoneum was detected by laparotomy (Hsu et al., 2013), CT scan (Charbit et al., 2013), or FAST exam (Ohmori et al., 2017; Umemura et al., 2015; Yomoto et al., 2014). Hematoperitoneum on laparotomy was predictive of MT (OR 2.5, $p = 0.013$, 95% CI [1.1,4.0]) as was a greater size hematoperitoneum found on CT

(OR 6.4, $p < 0.001$, 95% CI [0.6,2.7]). A positive FAST exam was a predictor of MT in 2 studies (OR 5.58, $p < 0.001$, 95% CI [2.10,14.99]; OR $p < 0.001$, 95% CI [2.24,23.61]) (Ohmori et al., 2017; Yomoto et al., 2014). However, in the final model of a third study, it was not found to be predictive of MT (Umemura et al., 2015). Additionally, the type and location of fractures was also found to predict MT. Blackmore et al. (2006) found that a displaced obturator ring fracture was predictive of hemorrhage and need for MT; conversely, Burkhardt et al. (2014) found that the type of pelvic facture does not make possible an accurate estimation of blood loss and would therefore not be useful in predicting MT. Similarly, Umemura et al. (2015) found that pelvic fractures, in addition to femur fractures, were not helpful in predicting MT. However, Ohmori et al. (2017) reported that unstable pelvic fractures (OR 21.56, $p < 0.001$, 95% CI [6.05,90.78]) and open long bone fractures of the legs (OR 12.21, $p < 0.001$, 95% CI [4.04,39.09]) were predictive of MT. The conflicting evidence regarding the capacity of hemorrhage detection or the location of fracture to aid in foreseeing the need for MT in trauma patients makes it difficult to come to conclusions about the value of these variables; hence, until more evidence is available, no recommendations can be made.

All of the studies reviewed for this CPG were performed retrospectively with the use of existing datasets. Further prospective research is warranted to strengthen the validity and applicability of these MT scoring systems for predicting the need for MT in adult non-military ED trauma patients.

Description of Decision Options/Interventions and the Levels of Recommendations

	Description of Decision Options/Interventions and the Level of Recommendation	
Usage	The use of a massive transfusion scoring system during the initial assessment of adult less than 65 years old with blunt trauma in a non-military ED setting is recommended (Borgman et al., 2011; Brockamp et al., 2012; Chico-Fernandez et al., 2011; Cotton et al., 2010; Krumrei et al., 2012; Kuhne et al., 2008; Maegele et al., 2011; Nunez et al., 2010; Ogura et al., 2014; Rainer et al., 2011; Rucholtz et al., 2006; Blackmore et al., 2011; Yűcel et al., 2006).	B
Massive Transfusion Scoring Systems	Assessment of Blood Consumption (ABC) is useful and effective for predicting the need for massive transfusion (Brockamp et al., 2012; Chico-Fernandez et al., 2011; Cotton et al., 2010)	B
	Trauma Associated Severe Hemorrhage Score (TASH) is useful and effective for predicting the need for massive transfusion. (Borgman et al., 2011; Brockamp et al., 2012; Chico-Fernandez et al., 2011; Krumrei et al., 2012; Maegele et al., 2011; Nunez et al., 2010; Ogura et al., 2014; Yűcel et al., 2006).	B
	Shock Index (SI) may be effective for predicting the need for massive transfusion (DeMuro et al., 2013; Pottecher et al., 2016; Olaussen et al., 2014; Vandromme et al., 2011a).	C
	McLaughlin Score may be effective for predicting the need for massive transfusion (Krumrei et al., 2012; Nunez et al., 2010).	C
	Prince of Wales Hospital/Rainer (PWH/Rainer) may be effective for predicting the need for massive transfusion (Brockamp et al., 2012; Rainer et al., 2011).	C
	Traumatic Bleeding Severity Score (TBSS) may be effective for predicting the need for massive transfusion (Ogura et al., 2014).	C
	Vandromme Score may be effective for predicting the need for massive transfusion (Brockamp et al., 2012; Vandromme et al., 2011a; Vandromme et al.,2011b).	C
	Emergency Room Transfusion Score (ETS) has limited ability to predict the need for massive transfusion (Chico-Fernandez et al., 2011; Kuhne et al., 2008).	N/R

Level A (High)	Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.
Level B (Moderate)	There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.
Level C (Weak)	There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.
N/R	Not recommended based upon current evidence.
I/E	Insufficient evidence upon which to make a recommendation.
N/E	No evidence upon which to make a recommendation.

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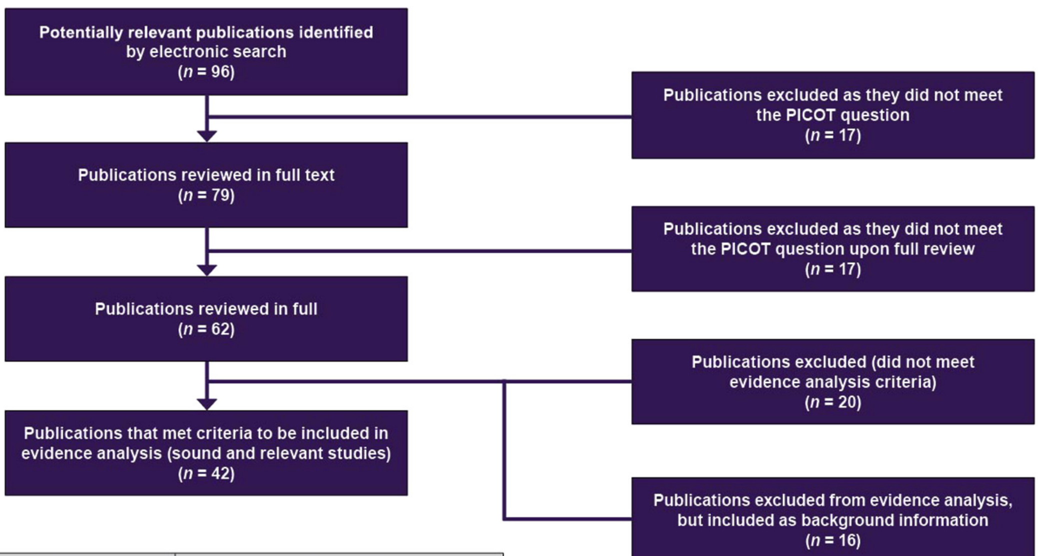
Appendix 1. Evidence Table

Forthcoming in the November 2019 issue.

Appendix 2. Other Resources Table

Reference	Description	Conclusions
Burman, S. & Cotton, B. A. (2012). Trauma patients at risk for massive transfusion: The role of scoring systems and the impact of early identification on patient outcomes. *Expert Review of Hematology, 5*(2), 211–218. https://doi.org/10.1586/ehm.11.85	Summarize current literature regarding massive transfusion protocols. How can we correctly predict those patients who will benefit from an MT? How might MT protocol improve survival in severely injured patients? How fast does the coagulopathy associated with SB occur and how lethal is it? Does early identification of these patients improve survival?	Discussed variables predicting MT and coagulopathy. Clinical parameters – ISS: volume of blood. hypotension, tachycardia, decreased LOC (GCS), penetrating torso injury = ncreased risk MT and coagulopathy. Lab data – Base deficit: transfusion requirements. Increased risk of MT INR > 1.5, hgb <11.0 g/l, hematocrit < 32%, pH < 7.25. Thromboelastography predicts MT. Uncrossmatched blood trigger for activation of MT protocol. Scoring systems reviewed. TASH, McLaughlin, Emergency Transfusion Score, Prince of Wales, ABC. Treatment strategies discussed
Callcut, R. A., Cripps, M. W., Nelson, M. F., Conroy, A. S., Robinson, B. B., & Cohen, M. J. (2016). The Massive Transfusion Score as a decision aid for resuscitation: Learning when to turn the massive transfusion protocol on and off. *The Journal of Trauma and Acute Care Surgery, 80*(3), 450–456. https://doi.org/10.1097/TA.0000000000000914	Utilization of Mass Transfusion Score (MTS) at 6 hours to determine who should continue resuscitation from hours 7–24 (hour 6 as endpoint), to use score to predict 24-hour and 28-day mortality.	Revised NTS better indicator than original MTS and ABC for predicting MT at 6 hours and 24 hours. MTS is a predictor of on-going transfusion and failure to normalize at 6 hours is an indicator of poor prognosis.
Callcut, R. A., Cotton, B. A., Muskat, P., Fox, E. E., Wade, C. E., Holcomb, J.B., … Robinson, B.R. (2012). Defining when to initiate massive transfusion: A validation study of individual massive transfusion triggers *Journal of Trauma and Acute Care Surgery, 74*(1), 59–68. https://doi.org/10.1097%2FTA.0b013e3182788b34	To determine the utility of individual triggers compared with a Massive Transfusion Score (MTS) for expeditious identification of who is likely to benefit from damage control resuscitation.	All triggers except penetrating trauma and heart rate were valid individual predictors of MT, with INR as the most predictive (adjusted OR 2.5, 95% CI, 1.7–3.7). Patients with an MTS of less than 2 were unlikely to receive MT (NPV 89%). If any 2 triggers were present, MTS ≥ 2, sensitivity for predicting MT was 85%. MT was present in 33% with MTS of 2 or greater compared with 11% of those with MTS less than 2 (OR 3.9, 95% CI, 2.6–5.8; $p < 0.0005$).
Cantle, P., & Cotton, B. (2017). Prediction of massive transfusion in trauma, *Critical Care Clinics, 33*(1), 71–84, https://doi.org/10.1016/j.ccc.2016.08.002	To discuss the evolution of MT and various parameters utilized to predict MT in the trauma patient.	Additional research is needed to determine which patients require MT initiation thru early identification and accurate management.
Cotton, B., Faz, G., Hatch, Q., Radwan, Z., Podbielski, J., Wade, C., et al. (2011). Rapid thrombelastography delivers real-time results that predict transfusion within 1 hour of admission. *Journal of Trauma, Injury, Infection and Critical Care, 71*(2), 407–417. https://doi.org/10.1097/TA.0b013e31821e1bf0	Evaluate the timeliness of rapid thrombelastography (r-TEG) (activated clotting time ACT) results as the correlate with conventional coagulation testing (CCT) and the ability of rTEG to predict early transfusion.	Early r-TEG values available within 5 minutes, late within 15 minutes with CCT within 48 minutes. $n = 84$ (31%) received transfusion within first 24 hours with $n = 29$ (10.6%) receiving 10 or more units within first 24 hours, $n = 17$ (6.3%) received 10 or more units in first 6 hours. ACT > 128 predicted MT within first 6 hours CI 95% and ACT < 105 predicted patient who do not receive any transfusion in first 24 hrs.
Guerado, E., Medina, A., Mata, M. I., Galvan, J. M., & Bertrand, M. L. (2016). Protocols for massive blood transfusion: When and why, and potential complications. *European Journal of Trauma and Emergency Surgery, 42*(3), 283–295. https://doi.org/10.1007/s00068-015-0612-y	A review of protocols to address massive bleeding and its possible complications, including coagulation abnormalities, complications related to blood storage, immunosuppression and infection, lung injury associated with transfusion, and hypothermia is carried out.	Effective management of the trauma patient with serve bleeding includes early recognition, diagnosis of the source of bleeding in combination with resuscitative interventions including surgery. To provide the effective interventions, it must be based on multiple parameters, which were reviewed in this reference.
Maegele, M. (2009). Frequency, risk stratification and therapeutic management of acute post-traumatic coagulopathy. *Vox Sanguninis, 97*(1), 39–49. https://doi.org/10.1111/j.1423-0410.2009.01179.x	Present clinical impact of acute post traumatic coagulopathy upon admission to the ED. To present a simple scoring system for early and reliable estimation for the need of MT. To present key issues that should be considered during the acute care of a bleeding trauma pt.	Increased incidence of acute post-traumatic coagulopathy is present upon ER admission, and this is associated with significant mortality. The TASH score is recognized as an easy-to-calculate and valid scoring system to predict the individual's probability for MT and ongoing life-threatening hemorrhage at a very early stage after severe multiple injuries. Early aggressive management of acute post-traumatic coagulopathy, including a more balanced administration of blood products suggested to improve outcomes.
Maegele, M., Brockamp, T., Nienaber, U., Probst, C., Schoechl, H., Görlinger, K., & Spinella P. (2012). Predictive models and algorithms for the need of transfusion including massive transfusion in severely injured patients. *Transfusion Medicine and Hemotherapy, 39*(2), 85–97. https://doi.org/10.1159%2F000337243	Review of algorithms and scoring systems for transfusion civilian and military. Seven scoring systems ABC, Baker, Larson, PWH, Schreiber, TASH, Vandromme	Models developed suggest combinations of parameters to evaluate the need for MT. These models have a common limitation of development and analysis based on retrospective data.
Mitra B., Mori, A., Cameron, P.A., Fitzgerald, M., Street, A. & Bailey, M. (2007). Massive blood transfusion and trauma resuscitation, *Injury, 38*(9), 1023–1029 https://doi.org/10.1016/j.injury.2007.03.021	To explore the massive transfusion practice in an Australian adult major trauma centre.	Median Injury Severity Score was 34.0 (IQR 26—48) with a mortality 27%. The median number of packed red blood cell transfused was 8.0 (IQR 6—14) in the 1st 4 h. Initial clinical features and injuries independently associated with a larger volume of blood transfused were initial hypotension, fractures of the pelvis, kidney injuries, initial acidemia, and thrombocytopenia. The Injury Severity Score, initial coagulopathy measured by APTT, and the presence of head injuries were found to be independent predictors of mortality
Mitra, B., Rainer, T.H., & Cameron, P.A. (2012). Predicting massive blood transfusion using clinical scores post-trauma. *Vox Sanguinis,* 102, 324–330 https://doi.org/10.1111/j.1423-0410.2011.01564.x	To apply the PWH score to trauma patients presenting to a major trauma center in Australia and assess its validity. To compare the PWH score with the ABC and TASH scores in predicting MT post-trauma.	PWH Score: 37% sensitivity, 97% specificity, 88% correctly classified, 71% PPV, 89% NPV; TASH Score: 25% sensitivity, 100% specificity, 88% correctly classified, 96% PPV, 88% NPV; ABC Score: 46% sensitivity, 94% specificity, 87% correctly classified, 60% PPV, 90% NPV; AUROC: TASH > PWH ($\chi^2 = 19.8$, $p < 0.001$), PWH > ABC ($\chi^2 = 9.3$, $p > 0.001$); PWH score was validated in sample, PWH score was better than ABC score, but worse than TASH score, in predicting MT based upon AUROC.
Mizobata, Y. (2017). Damage control resuscitation: A practical approach for severely hemorrhagic patients and its effect on trauma surgery. *Journal of Intensive Care, 5*(4), 1–9. https://doi.org./10.1186/s40560-016-0197-5	To explore the role of damage control resuscitation including the administration of blood products and the rations of fresh frozen plasma, packed red blood cells, and platelets and trauma-induced coagulopathy.	With an increase understanding of the physiology of coagulopathy in trauma patients, the findings suggest that coagulopathy should be addressed during major trauma resuscitation. DCR strategy is a measure available to address trauma-induced coagulopathy, and it can change the treatment strategy of trauma patients. The effect of the reversal of coagulopathy in massively hemorrhagic patients may change the operative strategy.
Ordoñez, C., Badiel, M., Pino, L., Salamea, J., Loaiza, J., Parra, M., & Puyana, J. C. (2012). Damage control resuscitation: Early decision strategies in abdominal gunshot wounds using an easy ''ABCD'' mnemonic. *Journal of Trauma and Acute Care Surgery, 73*(5), 1074–1078. https://doi.org/10.1097/TA.0b013e31826fc780	To identify the clinical indicators to standardize damage control resuscitation initiation policy in a specific set of patients.	Total of 162 (49%) underwent DCR, and 169 (51%) did not. Comparison of TASH (AUROC, 0.8333), McLaughlin (AUROC, 0.8148), ABC (AUROC, 0.7372) scores and our ABCD mnemonic (AUROC, 0.8745) were all good predictors of DCR, and the difference between them was statistically significant ($p < 0.001$).
Pommerening, M., Goodman, M., Holcomb, J., Wade, C., Fox, E., del Junco, D., ... MPH on behalf of the PROMMTT Study Group. (2015). Clinical gestalt and the prediction of massive transfusion after trauma. *Injury, 46*(5), 807–813. https://doi.org/10.1016/j.injury.2014.12.026	To investigate the role of the clinical gestalt among experienced trauma surgeons as a reliable measure for determining the need for mass transfusion.	Of 1245 patients, 966 met inclusion criteria, with 221 (243%) receiving MT. 415 (43%) were predicted to have MT and 551 (57%) were predicted to not have MT. Patients predicted to have MT were younger, more often sustained penetrating trauma, had higher ISS scores, higher heart rates, and lower systolic blood pressures (all $p < 0.05$). Gestalt sensitivity was 65.6% and specificity was 63.8%. PPV and NPV were 34.9% and 86.2% respectively.
Spahn, D. R., Bouillon, B, Cerny, V., Coats, T., Duranteau, J., Fernández-Mondéjar, E., … Rossaint, R. (2013). Management of bleeding and coagulopathy following major trauma: An updated European guideline. *Critical Care, 17*(2), R76. https://doi.org/10.1186/cc12685	To define clinically relevant "bundles" for diagnosis and therapy, in order to facilitate the adaptation of the guiding principles.	"Diagnosis and monitoring of bleeding Initial assessment recommendation. We recommend that the physician clinically assess the extent of traumatic hemorrhage using a combination of patient physiology, anatomical injury pattern, mechanism of injury and the patient's response to initial resuscitation. (Grade 1C)". Rationale includes TASH score validation and revalidation. Also addresses shock index as predictor of hemorrhagic shock: usefulness not optimal.
Tonglet, M. (2016). Early prediction of ongoing hemorrhage in severe trauma: Presentation of the existing scoring systems. *Archives of Trauma Research, 5*(4), e33377. https://doi.org/10.5812/atr.33377	Brief description of all of the existing scoring systems.	Predicting the need for MT is challenging and there are multiple scoring systems or algorithms developed to serve as a resource. These systems are utilized in many clinical areas although the evidence related to accuracy is low.
Vandromme, M. J., Griffin, R. L., McGwin, G., Weinberg, J.A., Rue, L.W., & Kerby, J. D. (2011). Prospective identification of patients at risk for massive transfusion: An imprecise endeavor. *The American Surgeon, 77*(2), 155–161.	To develop a model that predicts MT in civilian trauma pts.	Best fit predictive model included three or more clinical measures (Sens: 53%; Spec 98%; PPV 9%; Spec 100%; PPV 86%; NPV 98%). All combinations or clinical measures alone = lower predictive probability. A predictive model to successfully identify civilian trauma patients at risk for MT was not able to be developed.

Appendix 3. Study Selection Flow Chart and Inclusion/Exclusion Criteria



Inclusion Criteria	Exclusion Criteria
Studies published in English	Studies not published in English
Studies involving human subjects	Non-human studies
January 1990 - December 2017	Studies not in the timeframe listed
Studies addressing the PICOT question	Studies not addressing the PICOT questions

The following databases were searched: PubMed, Google Scholar, CINAHL, Cochrane – British Medical Journal, Agency for Healthcare Research and Quality (AHRQ; www.ahrq.gov), and the National Guideline Clearinghouse (www.guidelines.gov).

Search terms included: massive transfusion, trauma, emergency department, civilian, non-military, scoring systems, mass transfusion scoring systems, Trauma Associated Severe Hemorrhage Score (TASH), Assessment of Blood Consumption (ABC), transfusion, transfusion protocols, Prince of Wales (PWH) transfusion scoring system, Rainer scoring system, massive blood loss prediction, transfusion prediction system, hemorrhage prediction models, trauma shock management, massive blood loss management, transfusion triggers, McLaughlin model, Emergency Transfusion Score (ETS)model, massive transfusion protocol, massive transfusion AND prediction, massive transfusion AND triage, and massive transfusion AND screening.

Appendix 4. Massive Transfusion Scoring Systems by Clinical Measures/Variables

	Massive Transfusion Scoring System							
Clinical Measures/Variables	ABC	TASH	SI	McLaughlin	PWH/Rainer	TBSS	Vandromme	ETS
Systolic BP	X	X	X	X	X	X	X	X
Heart Rate	X	X	X	X	X		X	
Gender		X						
Hemoglobin		X			X		X	
FAST	X				X	X		X
Fast or CT		X			X			
Pelvic Fractures		X			X	X		
Femur Fracture		X						X
pH				X				
Hematocrit				X				
Blood Lactate						X	X	
INR							X	
GCS					X			
Base Excess		X						
Penetrating Trauma	X							
Age (years)						X		X
Admission from Scene								X
Injury Mechanism – Fall								X
Injury Mechanism – Traffic Accident								X

Krumrei et al., 2012; Nunez et al. 2009, Ogura et al., 2014; 2016; Rainer et al., 2011; Ruchholtz et al., 2006; Vandromme, 2011a, b; Yücel et al., 2006

Level A (High)	Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.
Level B (Moderate)	There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.
Level C (Weak)	There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.
N/R	Not recommended based upon current evidence.
I/E	Insufficient evidence upon which to make a recommendation.
N/E	No evidence upon which to make a recommendation.

Synopsis

CLINICAL QUESTION

Which massive transfusion scoring systems are most useful and effective in predicting the need for massive transfusion in adult non-military emergency department trauma patients?

PROBLEM

In the management of the trauma patient, urgent surgical intervention and/or rapid volume resuscitation with blood products for the management of hypovolemic, hemorrhagic shock can be the most vital intervention (Kuhne et al., 2008; Mizobata, 2017; Reed et al., 2016; Ruchholtz, et al., 2006). Massive transfusion (MT) of blood products may be required; however, one challenge is the prompt identification of the patient in need of MT, which should occur during the initial trauma assessment. Although there are indications for the transfusion of blood products, there are no universal guidelines for MT (Davis, Johannigman, & Pritts, 2012). Several MT scoring systems that utilize differing sets of specific variables (physiological parameters and/or triggers) have been developed to predict the need for MT during the initial assessment of the trauma patient. Determining which scoring systems are most useful and effective for predicting the need for MT is important for providing high-quality, evidence-based care for non-combat emergency department trauma patients.

	Description of Decision Options/Interventions and the Level of Recommendation	
Usage	The use of a massive transfusion scoring system during the initial assessment of adult less than 65 years old with blunt trauma in a non-military ED setting is recommended (Borgman et al., 2011; Brockamp et al., 2012; Chico-Fernandez et al., 2011; Cotton et al., 2010; Krumrei et al., 2012; Kuhne et al., 2008; Maegele et al., 2011; Nunez et al., 2010; Ogura et al., 2014; Rainer et al., 2011; Rucholtz et al., 2006; Blackmore et al., 2011; Yűcel et al., 2006).	B
Massive Transfusion Scoring Systems	Assessment of Blood Consumption (ABC) is useful and effective for predicting the need for massive transfusion (Brockamp et al., 2012; Chico-Fernandez et al., 2011; Cotton et al., 2010)	B
	Trauma Associated Severe Hemorrhage Score (TASH) is useful and effective for predicting the need for massive transfusion. (Borgman et al., 2011; Brockamp et al., 2012; Chico-Fernandez et al., 2011; Krumrei et al., 2012; Maegele et al., 2011; Nunez et al., 2010; Ogura et al., 2014; Yűcel et al., 2006).	B
	Shock Index (SI) may be effective for predicting the need for massive transfusion (DeMuro et al., 2013; Pottecher et al., 2016; Olaussen et al., 2014; Vandromme et al., 2011a).	C
	McLaughlin Score may be effective for predicting the need for massive transfusion (Krumrei et al., 2012; Nunez et al., 2010).	C
	Prince of Wales Hospital/Rainer (PWH/Rainer) may be effective for predicting the need for massive transfusion (Brockamp et al., 2012; Rainer et al., 2011).	C
	Traumatic Bleeding Severity Score (TBSS) may be effective for predicting the need for massive transfusion (Ogura et al., 2014).	C
	Vandromme Score may be effective for predicting the need for massive transfusion (Brockamp et al., 2012; Vandromme et al., 2011a; Vandromme et al.,2011b).	C
	Emergency Room Transfusion Score (ETS) has limited ability to predict the need for massive transfusion (Chico-Fernandez et al., 2011; Kuhne et al., 2008).	N/R

Level A (High)	Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.
Level B (Moderate)	There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.
Level C (Weak)	There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.
N/R	Not recommended based upon current evidence.
I/E	Insufficient evidence upon which to make a recommendation.
N/E	No evidence upon which to make a recommendation.

	Massive Transfusion Scoring System							
Clinical Measures/Variables	ABC	TASH	SI	McLaughlin	PWH/Rainer	TBSS	Vandromme	ETS
Systolic BP	X	X	X	X	X	X	X	X
Heart Rate	X	X	X	X	X		X	
Gender		X						
Hemoglobin		X			X		X	
FAST	X				X	X		X
Fast or CT		X			X			
Pelvic Fractures		X			X	X		
Femur Fracture		X						X
pH				X				
Hematocrit				X				
Blood Lactate						X	X	
INR							X	
GCS					X			
Base Excess		X						
Penetrating Trauma	X							
Age (years)						X		X
Admission from Scene								X
Injury Mechanism – Fall								X
Injury Mechanism – Traffic Accident								X

Krumrei et al., 2012; Nunez et al. 2009, Ogura et al., 2014; 2016; Rainer et al., 2011; Ruchholtz et al., 2006; Vandromme, 2011a, b; Yűcel et al., 2006

Level A (High)	Based on consistent and good quality of evidence; has relevance and applicability to emergency nursing practice.
Level B (Moderate)	There are some minor inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice.
Level C (Weak)	There is limited or low-quality patient-oriented evidence; has relevance and applicability to emergency nursing practice.
N/R	Not recommended based upon current evidence.
I/E:	Insufficient evidence upon which to make a recommendation.
N/E:	No evidence upon which to make a recommendation.

Clinical Practice Guideline:
Massive Transfusion Scoring Systems

ENA Clinical Practice Guidelines (CPGs) are evidence-based documents that facilitate the application of current evidence into everyday emergency nursing practice. CPGs contain recommendations based on a systematic review and critical analysis of the literature about a clinical question. CPGs are created following the rigorous process described in ENA's Requirements for the Development of Clinical Practice Guidelines. The purpose of CPGs is to positively impact patient care in emergency nursing by bridging the gap between practice and currently available evidence.

Access the full CPG at: www.jenonline.org

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