Which mass transfusion scoring systems are most useful and effective in predicting the need for massive transfusion in adult non-combat Emergency Department trauma patients?
Background/Significance

Injury is a global healthcare problem. In 2011, injury was reported to be the leading cause of death among people ages 1-44 (Centers for Disease Control and Prevention [CDC], 2014). Annually, an estimated 32.4 million people are treated for injury in emergency departments (ED) within the United States (CDC, 2014). Globally, hemorrhage is a common cause of 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, Fischbacher, Lefering, & Ruchholtz, 2008; 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 and therefore will be utilized for the purpose of this CPG.

In order 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 (Nunez, Young, Holcomb & 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 prompt identification of the patient in need of MT, which should occur during the initial trauma assessment. Although there are independent variables or triggers related to blood pressure, international normalized ratio (INR) value, hemoglobin and hematocrit, temperature and base deficit, there are no universal guidelines for MT (Davis, Johannigman, & Pritts, 2012). Blood products are a finite and expensive resource; therefore, EDs have an obligation to utilize accurate assessment and judicial decision making in the ordering and administration of blood products (Kuhne et al., 2008). Guidelines for the management of bleeding and coagulopathy for major trauma patients suggest that scoring systems for hemorrhagic shock may be useful for guiding treatment (Spahn et al., 2013).

Some MT scoring systems were derived with the use of civilian databases, comprising predominantly blunt trauma; while others were derived from military/combat databases comprising penetrating trauma (Brockamp et al., 2012). The population that forms the basis of this CPG is the adult non-combat ED trauma patient; therefore, only MT scoring systems that have been validated in the non-combat setting are reviewed in this CPG. Although the McLaughlin score was initially developed for combat use, it was compared to civilian scoring systems using civilian databases in some studies and is being included in this review (Krumrei et al., 2012, Nunez et al., 2010).

In order to critically examine the evidence regarding existing MT assessment strategies in the adult non-combat ED trauma patients, a literature search was performed and yielded the following scoring systems for review: The Trauma Associated Severe Hemorrhage (TASH) Score, Assessment of Blood Consumption (ABC) Score, Emergency Transfusion Score (ETS), McLaughlin Score, Prince of Wales Hospital (PWH)/Rainer Score, Vandromme Score, and Traumatic Bleeding Severity Score (TBSS). These scoring systems are based on physiological parameters and/or triggers and were developed to predict the risk of MT during the initial assessment of the trauma patient. Each MT scoring system utilizes specific variables or components (Appendix 1).

Methodology

This CPG was created based on a thorough review and critical analysis of the literature following ENA's Requirements for the Development of Clinical Practice Guidelines. Via a comprehensive literature search, all articles relevant to the topic were identified. The following databases were searched: MEDLINE, PubMed, OVID, CINAHL, Proquest, EBSCOhost, and BIOMED Central. Searches were conducted using the search terms of: massive transfusion, trauma, emergency department, civilian, non-combat, scoring systems, mass transfusion scoring systems, TASH, ABC, transfusion, transfusion protocols, Prince of Wales 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, ETS model, massive transfusion protocol, massive transfusion AND prediction, massive transfusion AND triage, and massive transfusion AND screening. Searches were limited to English language articles on human subjects from 2009-May 2014. This search yielded limited results; therefore, the search was further expanded to 2004. In addition, the references of the selected articles were scanned for pertinent research findings. Meta-analyses, systematic reviews, and research articles from emergency department settings, non-ED settings, position statements and guidelines from other sources were reviewed. Clinical findings and levels of recommendations regarding patient management were made by the Clinical Practice Guideline 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 2.
### 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 available using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005)
- 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 using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005)
- There are some minor or inconsistencies in quality evidence; has relevance and applicability to emergency nursing practice
- Is likely to be beneficial

#### Level C recommendations: Weak
- Level V, VI and/or VII evidence available using Melnyk & Fineout-Overholt grading system (Melnyk & Fineout-Overholt, 2005) - Based on consensus, usual practice, evidence, case series for studies of treatment or screening, anecdotal evidence and/or opinion
- There is limited or low quality patient-oriented evidence; has relevance and applicability to emergency nursing practice
- Has limited or unknown effectiveness

#### 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

Trauma Associated Severe Hemorrhage (TASH) Score
The Trauma Associated Severe Hemorrhage (TASH) score incorporates seven independent 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 male gender (Yűcel 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, Yűcel 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 AUR 0.842 - 0.889 (Brockamp et al., 2012; Nunez, Young, Holcomb, & Cotton, 2009; Chico-Fernandez et al., 2011; Ogura et al., 2014), and as low as 0.51 in one study (Krumrei, Park, Cotton, & Zielinski, 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) determined 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 by utilizing the TASH score in order to rapidly identify trauma patients at risk for MT (Borgman et al., 2011). One benefit of the TASH score is that 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 (Krumrei, 2012; Vandromme, 2011). An additional limitation for the use of the TASH score is the potential for a more experienced physician to be better able to predict the risk of MT for an individual patient than prediction/risk score, such as TASH (Yűcel et al., 2006).

Assessment of Blood Consumption (ABC)
The 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 obtainable at the bedside during the assessment phase of the trauma patient and includes 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 of each variable to independently predict MT. SBP less than 90 (odds ratio 13.0, p < 0.001, CI 6.93-24.52), positive FAST (odds ratio 8.2, p < 0.001, CI 4.34-5.30), and HR greater than 120 (odds ratio 3.9, p < 0.001, CI 2.00-6.85) were significantly associating with predicting MT. While less significant, a penetrating mechanism of injury demonstrated an odds ratio of 1.9 (p < 0.02, 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) calculated on the same population. The ABC score was found to be 75% sensitive and 86% specific (correctly classified 85%). Additional studies were conducted to provide additional validation to the initial study. In a study by Cotton et al (2010), the ABC score was validated across 3 demographically diverse trauma centers. MT rate was similar between the centers (14-15%).
AUROC, sensitivity and specificity were all relatively similar. 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, the ABC score was validated and compared against the TASH and McLaughlin scores. The ABC score was the only one of the three that was found to be predictive of MT.

Three international studies offered some limitations and varied results when comparing the ABC score to other scoring tools (Chico Fernandez et al., 2011; Brockamp et al., 2012; Nunez et al., 2009). 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 significant 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 (Brockcamp et al., 2012). The ABC score was found to have 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 (Brockcamp et al., 2012). One particular difference in the study sample in this study was that 95% of the sample has a blunt trauma mechanism of injury. This is significantly higher than the initial study population by Nunez et al (2009), which was only 82.8%. Finally, a study was conducted in Japan to compare the effectiveness of the TBSS tool compared to the ABC and TASH scores when used in elderly patients (Ogura et al., 2014). The AUROC, sensitivity and specificity of the ABC score were lower when compared to the TASH and TBSS. The simplicity of the ABC score was noted as a major advantage.

The ABC score has been extensively validated using retrospective studies both in the United States and internationally. The international studies did identify possible limitations with a heavily blunt trauma population and with the elderly trauma population. While some studies have 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 all items of the score are obtainable during the initial assessment at the bedside. Like other MT scoring tools, all studies to date have been retrospective limiting the strength of the studies. Future prospective studies are recommended to validate the prospective use of this scoring tool.

Emergency Transfusion Score (ETS)

The Emergency Transfusion Score (ETS) was derived from the clinical need for a valid and accurate tool defining quickly assessed parameters for the use in predicting and requesting packed red blood cells (pRBCs) early for 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 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 3m, fall from stairs, fall from a horse, gunshots, burns), SBP on admission, abdominal ultrasound, and pelvic ring stability (Ruchholtz et al., 2006).

Using the parameters and assigned values, the emergent need for a transfusion can be stratified (Kuhne et al., 2008). In tool development, risk for transfusion was stratified into low-risk (less than 3 points), intermediate-risk group (3 points), and high-risk groups (greater than 3 points) (Ruchholtz et al., 2006). In initial tool evaluation, the low risk group was associated with a 1.6% transfusion need, compared to 8.5% in the intermediate group and 34.6% in the high risk group (Ruchholtz et al., 2006). In further research, the tool was validated with a sensitivity of 97.5% and a specificity of 68% for prediction of immediate transfusion of 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), the cutoff of an ETS score of 3 is the clinical recommendation for ordering pRBCs with the use of clinical discretion for hemodynamic need.

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 having 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 only was found to have a PPV of 26%, while the TASH score, with a cut-off of greater than 16 or greater than 18, was associated with a PPV of 78% and 85%; when increased to an ETS of greater than 6 the PPV increases to 66%, but is above the validated clinical parameters.
for use by Ruchholtz et al. (2006) and Kuhne et al. (2008) (Chico-Fernandez et al., 2011). There were no significant statistical differences noted between the 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 the penetrating trauma population; however, a low ETS score is predictive for excluding a patient’s need for MT. In development, the low-risk group, ETS less than 3, 98.5%, were not transfused (Ruchholtz et al., 2006). In comparison with 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 NPV of 91% and 92%, respectively of MT (Chico-Fernandez et al., 2011).

The ETS has appropriate clinical application, particularly in smaller hospitals, which may not have blood products/blood bank readily available or those with limited resources. The tool has a limited scope for predicting the need for immediate blood transfusion. It does not provide strength for the prediction or the degree of resuscitation required nor does it provide insight into patient morbidity or mortality (Kuhne et al., 2008; Ruchholtz et al., 2006). As a tool for predicting and screening patients for MT, the ETS is a comparable tool with 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 at risk for immediate blood transfusion (Kuhne et al., 2008; Ruchholtz et al., 2006). While the ETS is an easy to use, reliable tool in the non-combat 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 when utilized in the validated patient population based on readily available, ACS required parameters, for assessing the need for immediate blood product availability for emergent transfusion (Kuhne et al., 2008; Ruchholtz et al., 2006). The simplicity of its use and absence of laboratory values are strengths and its high NPV may be beneficial as an early assessment strategy for excluding patients from MT. Its use in clinical practice should be limited to predicting the need for emergent transfusion as is not specific or sensitive for predicting the need for MT. (Chico-Fernandez et al., 2011).

McLaughlin Mass Transfusion Score
The McLaughlin MT Scoring System is non-weighted using 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 represented a 20% chance of the need for MT to a maximum of 80% (Krumrei et al., 2012; Nunez et al., 2009). The McLaughlin system, initially developed for combat 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 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 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 having a higher predictability of need for mass transfusion than the McLaughlin.

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, whose availability may vary, based on resources. This ease of calculation and basic components provides a tool which can have applicability in smaller facilities or those 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 (PWH)/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, which consists of seven components: HR greater than or equal to 120, SBP less than or equal to 90 mmHg, 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 5mmol/l, and hemoglobin less than or equal to 7g/dl or 7.1 – 10.0 g/dl (Rainer et al., 2011). These components were selected as they were readily available in the ED with primary outcomes measure of MTs within the initial 24 hours after injury. Rainer (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.
Strengths of the PWH/Rainer include the ability to obtain the score within the ED and a weighted scoring system. The acquisition of the scoring system components is also a limiting factor as this requires multidepartment interactions and additional skills. While validation of this score has occurred, this was a retrospective study (Brockamp 2012). A significant weakness is the lack of real-time application of the scoring system. This tool would have applicability in facilities where competent resources were available.

**Vandromme Score**

Vandromme et al. (2011), sought to develop a predictive model for MT for use in civilian trauma patients. The Vandromme score is a non-weighted scoring system and adaptable from MT scoring systems in the combat arena (Vandromme et al., 2011). This system consists of the following five components: blood lactate, HR, hemoglobin, INR, and SBP (Brockamp, 2012; Vandromme et al., 2011). These components can be easily obtained in the ED either by clinical assessment or point-of-care testing. Vandromme et al. (2011) reported they were unable to develop a predictive model to identify civilian trauma patients at risk for MT. However, they did conclude that the most effective predictive model included three or more positive clinical measures, sensitivity of 53%; specificity of 98%; PPV of 33%; NPV of 99% (Vandromme et al., 2011). When all clinical measures were positive, there was an increased PPV (Vandromme et al., 2011). One additional study found, as with other non-weighted scoring systems, the sensitivity of 78.9% and specificity of 76.2% of the Vandromme score is lower than the weighted systems (Brockamp, 2012).

A strength to the utilization of the Vandromme scoring system is that in an ED with point-of-care testing this scoring system is readily obtainable. Weaknesses include it being a non-weighted system, requiring laboratory or specialized equipment and the need to have prospective utilization.

**Trauma Bleeding Severity Score (TBSS)**

The Trauma Bleeding Severity Score TBSS 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 the elderly in a Japanese trauma center (Ogura et al., 2014). The mean age during development for TASH was 39.2 and 40 for the ABC. With the rising number of elderly and their different physiologic responses to trauma, the TBSS uses a mean age of 57.6 years. The TBSS is a score derived from the following 5 components: age, SBP, number of region points on FAST scan, pelvic fracture, and serum lactate, with scores ranging from 0 to 57 (Ogura et al., 2014). Derived retrospectively from a single institution in Japan using adult blunt trauma injuries and excluding isolated head trauma, the TBSS was created during a development phase and then validated during a secondary phase (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 aging Japanese population, 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 possibility for a more sensitive assessment tool, particularly in the geriatric population, and further studies may demonstrate a decrease in mortality (Ogura et al., 2014).

The initial research shows great promise, especially for ease of use and integration into practice, but further validation is warranted. The use of a single institute limits the applicability, as does the validation in the adult blunt force patient population (Ogura et al., 2014).

All of the studies reviewed for this CPG were performed retrospectively with the use of 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-combat ED trauma patients.
Description of Decision Options/Interventions and the Level of Recommendation

The use of a massive transfusion scoring system during the initial assessment of adult non-combat emergency department trauma patients is recommended. **Level B-Moderate** (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; Maegle et al., 2011; Nunez et al., 2009; Ogura et al., 2014; Rainer et al., 2011; Rucholtz et al., 2006; Vandromme et al., 2011; Yücel et al., 2006).

Massive Transfusion Scoring Systems

1. Trauma Associated Severe Hemorrhage Score (TASH) is useful and effective for predicting the need for massive transfusion. **Level B-Moderate** (Borgman et al., 2011; Brockamp et al., 2012; Borgman, Chico-Fernandez et al., 2011; Krumrei et al., 2012; Maegle et al., 2011; Nunez et al., 2009; Ogura et al., 2014; Yücel et al., 2006).

2. Assessment of Blood Consumption (ABC) is useful and effective for predicting the need for massive transfusion. **Level B-Moderate** (Brockamp et al., 2012; Chico-Fernandez et al., 2011; Cotton et al., 2010).

3. McLaughlin Score may be effective for predicting the need for massive transfusion. **Level C-Weak** (Krumrei et al., 2012; Nunez et al., 2009).

4. Prince of Wales Hospital/Rainer (PWH/Rainer) may be effective for predicting the need for massive transfusion. **Level C-Weak** (Brockamp et al., 2012; Rainer et al., 2011).

5. Vandromme Score may be effective for predicting the need for massive transfusion. **Level C-Weak** (Brockamp et al., 2012; Vandromme et al., 2011).

6. Traumatic Bleeding Severity Score (TBSS) may be effective for predicting the need for massive transfusion. **Level C-Weak** (Ogura et al., 2014).

7. Emergency Room Transfusion Score (ETS) is useful, but limited for predicting the need for massive transfusion. **Not Recommended for Practice** (Chico-Fernandez et al., 2011; Kuhne et al., 2008).
Bibliography

Authors

2014 ENA Clinical Practice Guideline Committee
Constance M. Bowen, DNP, RN, APN-C, CEN, CPEN, CCNS, CCRN
Caitlin Healy, BSN, RN, CEN, CCRN
David R. McDonald, MSN, RN, APN-C, CEN, CCNS
Mary Alice Vanhoy, MSN, RN, CEN, CPEN, NRP, FAEN
Jennifer A. Williams, PhD, RN, CNS, CEN, CCRN
Sherri-Lynne A. Almeida, DrPh, MSN, MEd, RN, CEN, FAEN
Susan Barnason, PhD, RN, APRN, CNS, CS, CEN, CCRN
Janis M. Farnholtz-Provinse, MS, RN, CNS, CEN
Suzanne N. Franzoni-Kleeman, MSN, RN, CEN
Marylou Killian, DNP, MS, RN, CEN, FNP-BC
Cindy Lefton, PhD, RN
Anne M. Renaker, DNP, RN, CNS, CPEN
Lisa Wolf, PhD, RN, CEN, FAEN
Mary Ellen Zaleski, MSN, RN, CEN

ENA 2014 Board of Directors Liaison:
Ellie Encapera, RN, CEN

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### Appendix 1: Mass Transfusion Scoring Systems Chart

**Description of Decision Options/Interventions and the Level of Recommendation:**

The use of a massive transfusion scoring system during the initial assessment of adult non-combat emergency department trauma patients is recommended

<table>
<thead>
<tr>
<th>MT Scoring System</th>
<th>TASH</th>
<th>ABC</th>
<th>McLaughlin</th>
<th>PWH/Rainer</th>
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<td>Injury Mechanism-Fall</td>
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<td>Injury Mechanism-Traffic Accident</td>
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Krumrei et al., 2012; Nunez et al. 2009, Ogura et al., 2014; 2009; Rainer et al., 2011; Ruchholtz et al., 2006; Vandromme, 2011; Yücel et al., 2006
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<tr>
<td>Borgman, M. A., Spinella, P.C., Holcomb, J.B., Blackburne, L.H., Wade, C.E., Lefering, R.,...Maegle, M. (2011). The effect of FFP:RBC ratio on morbidity and mortality in trauma patients based on transfusion prediction score. <em>Vox Sanguinis, 101</em>(1), 44-54. doi: 10.1111/j.1423-0410.2011.01466.x</td>
<td>To determine if a prediction model (TASH) could be used upon admission to rapidly determine which patients might have a survival benefit with the use of a high fresh frozen plasma: red-blood-cells (FFP:RBC) resuscitation and which patients may have an increased risk of multi-organ failure (MOF) and other morbidities.</td>
<td>Retrospective analysis of a prospective multi-center database. Trauma Registry of the Deutsche Gesellschaft für Unfallchirurgie, German Trauma Society. 100 Trauma centers contributing to the database 2002-2007. 2474 primary admissions (70% male) Age 43 +/-19</td>
<td>Univariate analysis was conducted to compare baseline characteristics &amp; outcomes between four (score) groups. T-test and chi-squared test. SPSS v15.0</td>
<td>TASH score &gt; 15 (40-54% predictive of MT), those who received high FFP:RBC ratio relative in-hospital mortality reduction of 42.5% (P = 0.009). TASH score &gt; 15 In-hospital mortality was 34.8% for the high-ratio group, compared to 47.7% in the low-ratio group. Sepsis and MOF similar. TASH score &lt; 15 overall mortality 19.1%. Overall in-hospital mortality was not statistically significant. High FFP:RBC ratio of &gt;1:2 transfused on average &lt;5 h from admission, is independently associated with improved survival in trauma patients that have a TASH score of &gt;15. TASH score &gt; 15 and high ratio FFP:RBC associated with survival. TASH score &lt; 15 increased MOF.</td>
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<td>Kuhne C.A., Zettl, R.P., Fischbacher, M., Lefering, R., &amp; Ruchholtz, S. (2008). Emergency transfusion score (ETS): A useful instrument for prediction of blood transfusion requirement in severely injured patients. <em>World Journal of Surgery, 32</em>(6), 1183-1188. doi: 10.1007/s00268-007-9425-4</td>
<td>Analysis of the clinical practice of Emergency Transfusion Score (ETS), to predict the need for BT in major trauma patients during early care</td>
<td>Prospective analysis. IRB University Hospital of Essen (Germany) approved study. N=481 patients requiring trauma team activation 2003-2004. Level I urban trauma center -covers region &gt; than 1 million people</td>
<td>Sensitivity, specificity, negative and positive predictive value of the ETS were validated prospectively in a different cohort. Also calculated sensitivity, specificity, positive and negative predictive value for ETS &gt; 2 and ETS &gt; 4 points. Patient groups were then compared mutually using the χ²-test. The two-tailed statistical significance level set at 5%. p&lt;0.05 was used to determine statistical significance.</td>
<td>ETS &lt; 3 in 306 pts (64%) and &gt; 3 in 175 pts (36%). 40 patients (8.3%) received blood (8 ± 8 PRBC) after 23 ± 9 min during ER treatment, and 39 of these patients had an ETS of &gt; 3 (5.4 ± 1.5 points). Sensitivity of the ETS = 97.5%; specificity= 68%. Positive predictive value = 0.222; negative predictive value= 0.998. Conclusion: ETS is a safe and highly sensitive to detect severely injured patients in need of blood products. ETS is highly predictive for pts not in need of PRBC. Saved $109,296/yr by reducing the costs for crossmatching, transportation, and wasted blood products.</td>
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<td>Rainer, T.H., Ho, A.M.H., Yeung, J.H.H., Cheung, N.K., Wong, R. S.M., Tang, N.,..., Graham, C.A. (2011). Early risk stratification of patients with major trauma requiring massive blood transfusion. <em>Resuscitation</em>, 82(6), 724-729. doi: 10.1016/j.resuscitation.2011.02.016</td>
<td>Purpose “develop a predictive model for identifying early need for MT in civilian patients with major trauma”</td>
<td>Retrospective study retrieving data from the OWH Trauma Registry. Ethical approval from the joint Chinese University of Hong Kong/New Territories East Cluster Clinical Research Ethics Committee in Hong Kong. N = 4336 sample from Jan 1 2001–Aug 31 2009, 1891 met inclusion criteria; university tertiary referral centre in Hong Kong.</td>
<td>Variables underwent univariate analysis and multivariate logistic regression model; receiver operator curves generated to evaluate overall predictive strength</td>
<td>1891 pts included in data analysis with 138 receiving 6-9 units and 92 &gt;10 units within 24 hours. From data - 10 point scoring using 7 variables: score of 0-5 receiving a MT 3.4%; while a score of 6-10 correlated with 82.9% requiring a MT</td>
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<tr>
<td>Ruchholtz, S., Pehle, B., Le- wan, U., Lefering, R., Müller, N., Oberbeck, R., &amp; Waydhas, C. (2006). The emergency room transfusion score (ETS): Prediction of blood transfusion requirement in initial resuscitation after severe trauma. <em>Transfusion Medicine</em>, 16(1), 49-56.</td>
<td>Purpose “defining reliable and quickly assessable parameters for an early request pRBC for transfusion in the ER”</td>
<td>Prospective data collection. Retrospective data analysis. All consecutive trauma patients requiring trauma team activation May 1998 - January 2002 were included. N = 1103 pts admitted May 1998 - Jan 2002 at the University Hospital of Essen.</td>
<td>Patients were retrospectively divided into group A (no transfusion) and group B (transfusion). Parameters were tested for standard deviations and compared with Pearsons’ chi-square Test. Stepwise logistic regression analysis was performed.</td>
<td>Using linear regression calculated probability of pRBC transfusion based on sum of score points. At an ER Transfusion score of 1, probability for blood transfusion in the ER is 0.7%, 3 points, 5%, Max score of 9.5, 97% probability for the need of immediate pRBC. From data: 3 Risk Groups. Low Risk &lt;3pts; &lt;5% need (1.6% sample required transfusion while 98.4% did not); Intermediate Risk 3pts; 5-10% (8.5% received transfusion while 91.5% did not). High Risk &gt;3pts; &gt;10% risk (34.6% received transfusion while 64.4% did not)</td>
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Study correlates data retrospective correlation with MT.

Chinese population strength - civilian trauma population.

No mention of IRB approval.

Limitations - Study design retrospective data analysis; data analysis for the creation of a tool for predicting pts requiring blood product in the ER, not MT. Old study.
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<tr>
<td>Yücel, N., Lefering, R., Maegle, M., Vorweg, M., Tjardes, T., Ruchholtz, S.,...Rixen, D. (2006). Trauma associated severe hemorrhage (TASH)-Score: Probability of mass transfusion as surrogate for life threatening hemorrhage after multiple trauma. <em>Journal of Trauma</em>, 60(6), 1228-1236.</td>
<td>&quot;To develop a simple scoring system that allows an easy and reliable estimation for the probability of MT as a surrogate for life threatening hemorrhage following multiple trauma&quot;</td>
<td>Prospective multi-center database from 100 participating hospitals - Germany. Prediction and validation model test TASH score via logistic regression analysis. 1993 - 2003; total of 17,200 patients anon. Prediction model developed N = 1810 logistic regression on selected predictors identifying 7 variables to independently predict MT (sex - male, SBP, HR, Hgb, BE, and relevant injury abd/extremity AIS &gt; 3) second step the final step was created - multivariate logistic regression on 7 predictor values N=4527 patients</td>
<td>Prediction model used to identify 7 variables; the second step the final score was created using multivariate logistic regression. The TASH-score prediction risk was calculated using logistic regression; calibration assessed using Hosmer-Lemeshow goodness-of-fit statistic</td>
<td>Using a TASH-Score &gt;16 as a cut-off for a binary prediction rule; probability of MT &gt;50%, 88.8%/89.6% of patients classified correctly in the development/validation set. Using &gt;10 and &gt;16 as TASH-score positive predictive value of 36 to 61% validation set. Additionally &gt;27 (max score) 100% prediction value</td>
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<td>Chico-Fernandez, M., Garcia-Fuentes, C., Alonso-Fernández, M. A. Toral-Vázquez, D., Bermejo-Aznárez, S., &amp; Altad-López, E. (2011). [Massive transfusion predictive scores in trauma: Experience of a transfusion registry]. <em>Medicina Intensiva</em>, 35(9), 546-551. doi: 10.1016/j.medin.2011.06.010</td>
<td>Validate previously described MT scoring in our Transfusion Trauma Registry. ABC, ETS &amp; TASH</td>
<td>A retrospective cohort of adult trauma patients. Met confidentiality criteria applied in their hospital, anonymous, and encoded. Trauma and Emergency Intensive Care Unit of a tertiary hospital- urban &amp; rural setting. Pts severe trauma ISS &gt; 15, admitted 10/06-7/09. Pts &gt;15 yrs old Excluded pts deceased upon admission &amp; pts who rejected blood product. trauma affecting fewer anatomical regions (e.g., severe orthopedic trauma requiring surgery) were excluded. transfusions. N=568 77.6% male</td>
<td>Calculated the sensitivity, specificity, positive and negative predictive value negative predictive, positive and negative likelihood ratio. Fagan nomogram. Comparative inferential statistical analysis- Chi-squared test, with a level of significance of p &lt; 0.05. The SPSS version 15.0. Different cutoff points (CPs) were assessed for each concrete score: TASH with high CPs (values of 16---18) has been found better predictor of the need for MT. TASH poses the difficulty of having to deal with a large number of variables in comparison with ABC. The scores are useful for discarding subjects at low risk of requiring MT, as reflected by the high NPV of the different scores and for the different CPs. All results in chart and graph. Very specific</td>
<td>% of pts receiving MT higher due to selected pt sample with high ISS scores. trauma affecting fewer anatomical regions (e.g., severe orthopedic trauma requiring surgery) were excluded. Definition of MT using an α posterior rather than an α priori time concept (with the capacity to determine massive bleeding). Some techniques (FAST) imply inter-operator variability, &amp; there is some ambiguity in the definition of certain score variables---these factors could affect reproducibility when applying the scores.</td>
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### Evidence Table

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<td>Ogura, T., Nakamura, Y., Nakano, M., Izawa, Y., Nakamura, M., Fujizuka, K.,...Lefor, A.T. (2014). Predicting the need for massive transfusion in trauma patients: The traumatic bleeding severity score. The Journal of Trauma and Acute Care Surgery, 76(5), 1243-1250. doi: 10.1097/TA.0000000000000200</td>
<td>To create a scoring system to predict the need for MT in severely injured trauma pts. To create a new scoring system and compare it to TASH and ABC</td>
<td>Development phase - scoring system created- reviewed data severely injured trauma pts 2008-2009. MT predictors identified by comparing parameters in pts who received MT and those who did not. Scoring system developed. Next phase reviewed data 1/10-3/12 used OS application developed to rapidly calculate score. Single institution Japan ~1250 severely injured pts per year (ISS &gt;16). Only blunt traumatic injuries. Out of hospital cardiac arrest and isolated head trauma excluded. Development phase data N=119. Validation phase N=113.</td>
<td>Multivariant logistic regression analysis; odds ratio; Mann Whitney U test; level of significance p &lt; 0.05; Cox Snell R2 and Nagelkerke R2 tests. Statistical analysis MedCalc.</td>
<td>Development phase 5 predictors of MT- age, SBP, FAST, severity of pelvic fracture, lactate. MAX=57 points. Average TBSS in pts who received MT was significantly higher than those who did not receive MT. Operator characteristic curve, sensitivity and specificity 0.985, 97.4% and 96.2 %. TASH 0.892, 91.6%, 78.2%; ABC 0.813, 79%, 78.2%</td>
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<td>Brockamp, T., Nieanber, U., Mutschler, M., Wafaisade, A., Peiniger, S., Lefering, R.,...Maegele, M. (2012). Predicting on-going hemorrhage and transfusion requirement after severe trauma: A validation of six frequently used scoring systems and algorithms on the TraumaRegister DGU. Critical Care. 16(4), R129 (10 pages). doi: 10.1186/cc11432</td>
<td>Compare six frequently used scoring systems and algorithms with the potential to early identify trauma patients at risk for MT and to validate all six scores on one dataset, including severely injured trauma patients derived from the TraumaRegister DGU® (TR-DGU, Trauma registry of the German Trauma Society)</td>
<td>Retrospective internal and external validation. Data from 56,573 patients were screened to extract one complete dataset matching all variables needed to calculate all systems assessed. Germany</td>
<td>Scores were applied and area-under-the-receiver-operating-characteristic curves (AUCs) were calculated. From the AUC curves the cut-off with the best relation of sensitivity-to-specificity was used to recalculate sensitivity, specificity, positive predictive values (PPV), and negative predictive values (NPV).</td>
<td>Compared TASH, PWH (Prince of Wales Hospital), Vandromme, ABC, Military - Schreiber &amp; Parson Findings; TASH (AUC 0.889) and the PWH (AUC 0.860) scores perform superiorly to other tested scores. Weighted and more sophisticated systems including higher numbers of variables perform better than simple non-weighted models.</td>
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<td>Krumrei, N., Park, M., Cotton, B., &amp; Zielinski, M. (2012). Comparison of massive blood transfusion predictive models in the rural setting. <em>The Journal of Trauma and Acute Care Surgery</em>, 72(1), 211-215. doi: 10.1097/TA.0b013e318240507b</td>
<td>Validate MT predictive models in rural Level I trauma center patient population, using all major trauma victims, regardless of blood product requirements</td>
<td>Review of all Level I trauma patients admitted in 2008 to 2009 was performed. ABC, TASH, and McLaughlin scores were calculated using 80% probability for the need for MT. Sample: 373 (190 from scene and 183 transfers). Setting: Rural Level 1 Trauma center. IRB approved</td>
<td>Chart review of patients admitted from 2008-2009. TASH, ABC score and McLaughlin were calculated on each patient. Used predictive values validated in other settings but not in rural setting</td>
<td>The ABC score correctly identified 89% of MT patients and was predictive of MT in major trauma patients at our rural Level I trauma center; the TASH and McLaughlin scores were not. The ABC score is simpler, faster, and more accurate. Based on this work, we strongly recommend adoption of the ABC score for MT prediction</td>
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<td>Maegele, M., Lefering, R., Wafaisade, A., Theodorou, R., Wutzler, S., Fischer, P., Paffrath, T. (2011). Revalidation and update of the TASH-Score: A scoring system to predict the probability for massive transfusion as a surrogate for life-threatening haemorrhage after severe injury. <em>Vox Sanguinis</em>, 100(2), 231-238. doi: 10.1111/j.1423-0410.2010.01387.x</td>
<td>To revalidate the TASH-Score using the most recent 2004–2007 TR-DGU database and to adapt the score to the current clinical situation</td>
<td>Retrospective analysis of registry data. Sample: 18, 070. Setting: German speaking trauma registry</td>
<td>Multi-variable. Logistic function to calculate the probability for MT was modified for score adjustment.</td>
<td>Predicted rate for MT within the development dataset was 13.9% while the observed incidence was 14.1%. In contrast, the predicted rate for MT within the revalidation dataset was 11.7%, while the observed rate was 8.4%. Score can be calculated quickly upon arrival of the patient in the emergency department and may be supportive to correct coagulopathy, to activate logistics and for research</td>
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<td>Cotton, B.A., Dossett, L.A., Haut, E.R., Shafi, S., Nunez, T.C., Au, B.K.,... Young, P.P. (2010). Multicenter validation of a simplified score to predict massive transfusion in trauma. <em>The Journal of Trauma</em>, 69(Supple 1), S33-S39. doi: 10.1097/TA.0b013e3181e42411</td>
<td>To validate the ABC score in predicting MT in three separate Level I trauma centers.</td>
<td>Retrospective observational study; IRB approval by all institutions involved. Sample: N = 1,018 (513/372/133 from VUMC/PMH/JHH respectively); convenience sample meeting eligibility criteria (7/1/06-6/30/07; transported from POI; received 1 unit blood during hospital stay). Setting: 3 US Level I trauma centers.</td>
<td>ABC Score - 1 point for each element (penetrating trauma; ED systolic BP &lt; 90; ED HR &gt; 120; Positive FAST); ABC score ≥ 2 was a considered a positive indicator for MT; ABC score of 0 or 1 was considered a negative indicator for predicting MT; Sensitivity, specificity, PPV, NPV, correct classification, and AUROC of ABC were calculated for each individual patient at each center; Centers were evaluated for differences in AUROC curves using x2 analysis; STATA version 10.1 was used for data management/analysis.</td>
<td>ABC prediction of MT in 24 hours -- 75-90% sensitivity, 67-88% specificity, correctly classified 84-87%, PPV 55%, NPV 97%, no difference in AUROC by center; ABC prediction of MT in 6 hours (VUMC only) -- 87% sensitivity, 82% specificity, correctly classified 79%, PPV 38%, NPV 98%; CONCLUSION: ABC score is a valid instrument to predict MT early in patient’s care and across various demographically diverse trauma centers.</td>
<td>I Retrospective study -- not trialed to be used as a predictive tool to forecast treatment; poor PPV may lead to overtriage, but excellent NPV would minimize understriage; ABC prediction of MT in 6 hours only used patients from VUMC versus all centers -- compared with previous study group at the same center</td>
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<td>Nunez, T.C., Voskresensky, I.V., Dossett, L.A., Shinall, R., Dutton, W.D., &amp; Cotton, B.A. (2009). Early prediction of massive transfusion in trauma: Simple as ABC (assessment of blood consumption). <em>The Journal of Trauma</em>, 66(2), 346-352. doi: 10.1097/TA.0b013e3181961c35</td>
<td>Validate the TASH and McLaughlin scores as well as compare them to the authors-developed ABC score</td>
<td>Retrospective observational study; IRB approved. SAMPLE: N = 596 patients, convenient sample of eligible patients (all patients admitted to VUMC between 7/1/05-6/30-06 who were Level I trauma activations, received from POI, and received any blood during hospitalization) - those who died within 30 minutes of arrival were excluded. SETTING: single US-based Level I trauma center</td>
<td>ABC score was developed based upon 1 pt given for each variable (penetrating trauma, ED SBP ≤ 90, ED HR ≥ 120, Positive FAST). ABC, TASH and McLaughlin scores were calculated for each patient. Logistical regression coefficients were used for weighting the ABC score variables to determine if the score could be improved upon. The ability of each score to predict MT was estimated by AUROC.</td>
<td>ABC SCORE: Multiple logistic regression as follows: Positive FAST (OR 8.2, p &lt; 0.001, CI 4.34-5.30), HR ≥ 120 (OR 3.9, p &lt; 0.001, CI 2.09-6.85), SBP ≤ 90 (OR 3.9, p &lt; 0.001, CI 6.93-24.52), penetrating trauma (OR 1.9, p = 0.02, CI 1.15-3.44). Conclusions -- Based upon sensitivity and specificity (75%, 86% respectively), ABC score ≥ 2 most reliable cut point for positive indicator for MT. Predictive value could be improved with weighting or adding additional variables, but not without sacrificing ease of use and not needing lab results. SCORE COMPARISON: AUROC: ABC (0.859), TASH (0.842), McLaughlin (0.767) -- difference in scores NOT statistically significant.</td>
<td>II Retrospective study -- not trialed to be used as a predictive tool to forecast treatment; single center study - not trialed across different populations or randomized</td>
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Does not assess a valid MT scoring system.