

Massive Transfusion Scoring Systems: Appendices to Clinical Practice Guideline

Appendix 1. Evidence Table

Reference	Research Purpose/ Questions/Hypothesis	Design/Sample/Setting	Variables/Measures/ Analysis	Findings/Implications	Quality of Research	Level of Evidence
Blackmore, C., Cummings, P., Jurkovich, G., Linnau, K., Hoffer, E. & Rivara, F. (2006). Predicting major hemorrhage in patients with pelvic fracture. <i>Journal of Trauma, Injury, Infection and Critical Care</i> , 61(2), 346–352. https://doi.org/10.1097/01.ta.0000226151.88369.e9	To develop a prediction rule for hemorrhage due to pelvic arterial bleeding based upon observations made on initial patient presentation to the emergency department, prior to any radiology.	Retrospective cohort study, IRB approved, adults with pelvic fracture due to blunt force, n = 627, Level I trauma center, single site, urban.	Pelvic X-ray interpreted by radiologists, retrospective review of ED chart that included age, gender, MOI, pulse, BP, HCT, and outcome of hemorrhage due to pelvic trauma (arterial extravasation on angiography, high volume pelvic hematoma on CT, high transfusion requirement [6 units] in absence of another source of bleed). Bivariate logistic regression to determine clinical and radiographic factors related to hemorrhage, multiple logistic regression models.	Measures indicative of blood loss were significant predictors of hemorrhage {HR ≥ 100 (RR 3.0, p < 0.001, 95% CI [1.7,5.1], Kappa =0.90); HR ≥ 130, (RR 3.7, p < 0.001, 95% CI [2.7,5.0], Kappa =0.78); HCT ≤ 30% (RR 5.6, p < 0.001, 95% CI [3.9,8.1], p < 0.001, Kappa = 1.0); HCT ≤ 25% (RR 4.1, p < 0.001, 95% CI [3.1,5.5], Kappa = 1.0); HCT drop 20% (RR 1.8, p < 0.001, 95% CI [1.3,2.6], Kappa = 1.0); SBP ≤ 90 (RR 3.4, p < 0.001, 95% CI [2.6,4.6], Kappa=1.00)}. Significant radiographic predictors of hemorrhage were displaced fracture of sacroiliac joint (RR 2.6, p < 0.001, 95% CI [1.8,3.9], Kappa = 0.42); displaced fracture of sacrum (RR 2.6, p < 0.001, 95% CI [1.8,3.9], Kappa = 0.03); displaced pubic symphysis fracture (RR 2.8, p < 0.001, 95% CI [2.0,3.9], Kappa = 0.50); displaced obturator ring fracture (RR 2.5, p < 0.001, 95% CI [1.9,3.4], Kappa = 0.51). The final statistical predictive model categorized patients into groups with probability of hemorrhage ranging from < 2% (0 predictors) to over 60% (3 or more predictors).	1	IV
Borgman, M. A., Spinella, P.C., Holcomb, J. B., Blackburne, L. H., Wade, C. E., Lefering, R., ... Maegele, M. (2011). The effect of FFP: RBC ratio on morbidity and mortality in trauma patients based on transfusion prediction score. <i>VoxSanguinis</i> , 101(1), 44–54. https://doi.org/10.1111/j.1423-0410.2011.01466.x	To determine whether 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.	Retrospective analysis of a prospective multi-center database. Trauma Society Trauma Registry of the Deutsche Gesellschaft für Unfallchirurgie, German Trauma Society approved by the review board of the German Trauma Society. One hundred trauma centers contributing to the database from 2002–2007 with 2474 primary admissions (70% male/ age 43 years +/- 19 year).	Univariate analysis was conducted to compare baseline characteristics and outcomes between four (score) groups using t-test and χ^2 test. SPSS v15.0.	TASH score > 15 (40–54% predictive of MT), for those who received high FFP:RBC ratio relative in-hospital mortality reduction of 42.5% (p = 0.009). TASH score > 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 < 15 overall mortality 19.1%. Overall, in-hospital mortality was not statistically significant. High FFP:RBC ratio of > 1.2 transfused on average < 5 h from admission is independently associated with improved survival in trauma patients that have a TASH score of > 15. TASH score > 15 and high ratio FFP:RBC associated with survival. TASH score < 15 increased MOF.	1	VI
Brockamp, T., Nianber, U., Mutschler, M., Wafaisade, A., Peiniger, S., Lefering, R., ... Maegele, M. (2012). Predicting ongoing hemorrhage and transfusion requirement after severe trauma: A validation of six scoring systems and algorithms on the TraumaRegister DGU. <i>Critical Care</i> , 16(R129). https://doi.org/10.1186/cc11432	Compare six frequently used scoring systems and algorithms with the potential to early identify trauma patients at risk for massive transfusion 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).	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.	Scores were applied and AUCs were calculated. From the AUC curves the cut-off with the best relation of sensitivity-to-specificity was used to calculate sensitivity, specificity, positive predictive values (PPV), and negative predictive values (NPV).	Compared TASH, PWH (Prince of Wales Hospital), Vandromme, ABC, Military - Schreiber & Parson Findings; TASH (AUC 0.889) and the PWH (AUC 0.860) performed better than the other tested measures. Weighted and more sophisticated systems including greater numbers of variables perform better than simple, non-weighted models.	1	VI
Burkhardt, M., Holstein, J., Moersdorf, P., Kristen, A., Lefering, R., Pohlmann, T., ... TraumaRegister DGU (2014). Proper coding of the Abbreviated Injury Scale: Can clinical parameters help as surrogates in estimating blood loss? <i>European Journal of Trauma and Emergency Surgery</i> , 40(4), 473–479. https://doi.org/10.1007/s00068-013-0335-x	To determine whether HGB and SBP could be used as proxies for blood loss and enable an objective estimation of % blood loss to be used in AIS coding. It is hoped that this will provide a “rule of thumb” to estimate blood loss when using this tool, preventing over or under estimation of blood loss that would affect the overall AIS score.	Secondary analysis of trauma database in Germany. Used HGB, SBP, base excess, Quick’s value on arrival to emergency department, # units PRBC’s transfused before admission to ICU, and mortality in first 24 hours as potential proxies for % blood loss. Approved by IRB. Included 11,574 trauma patients with Type B and C pelvic ring fracture who were admitted to the primary hospital (not transferred).	Frequencies and %, mean and SD for continuous variables. Categorical variables analyzed using χ^2 , continuous using Mann-Whitney U, p < 0.05 significant.	Only in type C pelvic fracture was a HGB <7, SBP <90, BE < -9, <35% Quick’s value, >15 units PRBC and death within 24 h positively predictive value of 47% and a sensitivity of 62% for AIS of 5. These cut-off values were not significant in Type B fractures. Did not generate a “rule” to help objectively estimate blood loss.	2	IV

<p>Callcut, R., Johannigman, J., Kadon, K., Hanselman, D. & Robinson, B. (2011). All massive transfusion criteria are not created equal: Defining the predictive value of individual transfusion triggers to better determine who benefits from blood. <i>The Journal of Trauma and Acute Care Surgery</i>, 70(4), 794–801. https://doi.org/10.1097/TA.0b013e3182127e40</p>	<p>To identify the predictive value of chosen triggers for predicting transfusion and the quantity needed for trauma patients requiring OR immediately.</p>	<p>Cohort study with retrospective analysis of trauma database, IRB approval. $n = 170$, consecutive trauma patients at urban, academic Level I trauma center from 10/1/07–9/30/08.</p>	<p>All trauma patients (critically ill or injured needing immediate attention) or unstable patient with life-threatening injury without prehospital VS, excluded those surviving less than 15 minutes upon arrival to the emergency department, and those with cervical spine injury, urban shock trauma medical center variables compared between survivors and non-survivors, categorical variables analyzed with χ^2 and continuous with t-test, significance of $p < 0.05$. Triggers for transfusion studied SBP < 90, HGB < 11, temp < 35.5C, INR > 1.5, BD ≥ 6. MT defined as > 10 units RBC in 6hM.</p>	<p>Mean ISS was 19, average age 33, majority were men and had penetrating injury. 45% required RBC transfusion, 36% received MT in first 6 hours. Triggers had high specificity and negative predictive value; INR (95% specificity, 92% NPV, likelihood of MT OR 11.3 ($p = 0.002$, 95% CI [2.7,47.3])); SBP (89% specificity, 90% NPV, likelihood of MT OR 8.5 ($p < 0.0001$, 95% CI [3.4,21.1])); HGB (specificity 83%, NPV 089%, OR 3.1 ($p = 0.03$, 95% CI [1.2,8.4])); temperature (specificity 86%, NPV 89%, OR 4.1 ($p = 0.004$, 95% CI [1.6,10.1]) with the exception of BD (specificity 59%, NPV 97%) INR predicted need for MT 88% of time ($p = 0.002$). INR and SBP were highly predictive of need for MT (OR 11.3, $p = 0.002$, 95% CI [2.7,47.3]; OR 8.5; $p < 0.0001$, 95% CI [3.4,21]).</p>	<p>2</p>	<p>IV</p>
<p>Charbit, J., Mahul, M., Roustan, J., Latory, P., Millet, I., Taourel, P., ... Capdevila, X. (2013). Hemoperitoneum semiquantitative analysis on admission of blunt trauma patients improves the prediction of massive transfusion. <i>The American Journal of Emergency Medicine</i>, 31(1), 130–136. https://doi.org/10.1016/j.ajem.2012.06.024</p>	<p>To determine whether semiquantitative analysis of hemoperitoneum size (minimal, medium, large) increases accuracy of prediction of need for mass transfusion.</p>	<p>Retrospective chart review; consecutive trauma patients with blunt abdominal trauma admitted to TICU between Jan 2005 and Dec 2009. Level I trauma center in France.</p>	<p>Simplified Acute Physiology Score II, abdominal Abbreviated Injury Scale, Injury Severity Scale, clinical parameters commonly indicative of need for MT: ED SBP ≤ 90; base deficit ≥ 6, open/complex femur fracture; complex pelvic fracture. Then factors of care collected: # units of PRBC, FFP and platelets, patient outcome, hospital LOS, mortality; Federlescore for hemoperitoneum (3+ compartments = large, 2 = moderate, minimal or none) or 0 compartments) Comparisons of categorical data (χ^2); comparison between groups for continuous data (one-way analysis of variance); MT = 10 or more PRBC/24 hours; association between MT and med or large hemoperitoneum with logistic regression.</p>	<p>Patients with large hemoperitoneum received significantly more blood products than those with a moderate or mild/no ($p < 0.001$). Size of hemoperitoneum and clinical parameters significantly associated with transfusion (large (OR 6.2, $p < 0.001$, 95% CI [3.3,11.7]); moderate (OR 2.7, $p < 0.01$, 95% CI [1.4,5.2]); ED SBP (OR 11.2, $p < 0.001$, 95% CI [5.7,22]); complex pelvic fracture (OR 2.3, $p < 0.01$, 95% CI [1.3,4.1]); open/complex femur fracture (OR 4, $p < 0.001$, 95% CI [2.3,6.9]); base deficit [OR 6.7, $p < 0.001$, 95% CI [3.9,11.6]). Rate of transfusion higher in patients with large or moderate hemoperitoneum than those with moderate or none (41%, 23%, 10%, $p < 0.001$). Large and moderate hemoperitoneum associated with MT (OR 6.2, $p < 0.001$, 95% CI [3.3,11.7]; OR 2.7, $p < 0.01$, 95% CI [1.4,5.2]) as compared to those with mild or none. After adjustments, only large associated with MT (OR 6.4, $p < 0.001$, 95% CI [0.6,2.7]). Large had a statistically higher positive likelihood ratio than moderate 2.5 (95% CI [1.8,3.2]); 1.1 (95% CI [0.8,1.6]); NPVs were not significantly different. The more clinical parameters present, the higher the requirement for MT ($p < 0.001$). Large hemoperitoneum is statistically associated with need for MT; large predicted need for MT significantly better than moderate regardless of BP. Large significantly increases accuracy of MT prediction, particularly with 2 to 3 clinical parameters.</p>	<p>1</p>	<p>IV</p>
<p>Chico-Fernandez, M., Garcia-Fuentes, C., Alonso-Fernandez, M. A., Toral-Vazquez, D., Bermejo-Aznarez, S., & Alted-López, E. (2011). Massive transfusion predictive scores in trauma: Experience of a transfusion registry. <i>Medicina Intensiva</i>, 35(9), 546–551. https://doi.org/10.1016/j.medint.2011.06.010</p>	<p>Validate previously described MT scoring in Transfusion Trauma Registry, ABC, ETS, and TASH.</p>	<p>A retrospective cohort of adult trauma patients. Approved by hospital's IRB equivalent. Trauma and Emergency Intensive Care Unit of a tertiary hospital-urban and rural setting. Pts severe trauma ISS ≥ 15, admitted 10/06–7/09. Patients > 15 yrs old. Excluded patients deceased upon admission and pts who rejected blood product. Trauma affecting fewer anatomical regions (e.g., severe orthopedic trauma requiring surgery) were excluded. $n = 568$, 77.6% male.</p>	<p>Calculated the sensitivity, specificity, PPV, NPV, positive and negative likelihood ratio. Fagan nomogram. Comparative inferential statistical analysis – χ^2 test, with a level of significance of $p < 0.05$. SPSS version 15.0. Different cutoff points were assessed for each concrete score.</p>	<p>TASH with high cutoff points (values of 16–18) has been found better predictor of the need for MT. TASH poses the difficulty of having to deal with a greater 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 cutoff points.</p>	<p>2</p>	<p>VI</p>

<p>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. <i>Journal of Trauma</i>, 69(1), S33–S39. https://doi.org/10.1097/TA.0b013e3181e42411</p>	<p>To validate the ABC score in predicting MT in three separate Level I trauma centers.</p>	<p>Retrospective observational study; IRB approval by all institutions involved. <i>n</i> = 1018 (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). 3 US Level I trauma centers.</p>	<p>ABC Score – 1 point for each element (penetrating trauma; ED systolic BP <90; ED HR>120; Positive FAST); ABC score ≥ 2 was 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 χ^2 analysis; STATA version 10.1 was used for data management/analysis.</p>	<p>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.</p>	<p>1</p>	<p>VI</p>
<p>De Jong, A., Deras, P., Martinez, O., Latry, P., Jaber, S., Capdevila, X., & Charbit, J. (2016). Relationship between obesity and massive transfusion needs in trauma patients, and validation of TASH score in obese population: A retrospective study on 910 trauma patients. <i>PLoS ONE</i>, 11(3), e0152109. https://doi.org/10.1371/journal.pone.0152109</p>	<p>Two-fold: 1. assess for relationship between obesity and need for mass transfusion in trauma, 2. Is the TASH scale a valid tool for predicting the need for MT in obese patients?</p>	<p>Retrospective Study; IRB equivalent requirement not required per the COGAR – ethics committee. Sample: <i>N</i>= 119 obese and 791 non-obese patients. Setting: Level I Regional Trauma Center in France.</p>	<p>1. Comparison between Obese and Non-obese – t-test for quantitative variables, χ^2 test for qualitative variable, logistic regression to assess strength of relationship between obesity and MT. 2. ORC and AUC used to predict TASH score ability to predict MT in obese and non-obese groups, Youdens Index used to validate classifications.</p>	<p>1. Obese patients required a higher rate of MT. 2. TASH scores were comparable in obese and non-obese patients.</p>	<p>1</p>	<p>VI</p>
<p>DeMuro, J., Simmons, S., Jax, J., & Gianelli, S. (2013). Application of the shock index to the prediction of need for hemostasis intervention. <i>American Journal of Emergency Medicine</i>, 31, 1260–1263. https://doi.org/10.1016/j.ajem.2013.05.027</p>	<p>Initial hypothesis is that the cutoff SI of 0.9 used with trauma patients may be too high for the geriatric trauma subpopulation. They do not mount the same response in their vital signs to hemorrhage. A secondary question was if the SI cutoff should be different in blunt versus penetrating trauma, as the penetrating patients generally have a higher risk of bleeding.</p>	<p>Retrospective data review; IRB approved; <i>n</i>= 4277 over 11 years, >16 year tertiary care facility and a regional trauma center.</p>	<p>Sensitivity, specificity, PPV, and NPV were calculated for each case using a self-designed program in the Fortran language. Sensitivity is defined here as the percentage of bleeders who were correctly identified using the SI test alone, while specificity is the percentage of non-bleeders who were correctly identified.</p>	<p>When the standard SI cutoff for bleeding (>0.9) is decreased to ≥ 0.8, the SI sensitivity increases while specificity decreases. This lowered threshold for SI can aid in the identification of trauma patients requiring hemostasis.</p>	<p>2</p>	<p>VI</p>
<p>Dente, C., Shaz, B., Nicholas, J., Harris, R., Wyrzykowski, A., Ficke, B., ... Ingram, W. L. (2010). Early predictors of massive transfusion in patients sustaining torso gunshot wounds in a civilian Level I trauma center. <i>Journal of Trauma and Acute Care Surgery</i>, 68(2), 298–304. https://doi.org/10.1097/TA.0b013e3181ef7f2a</p>	<p>To identify factors that would be easily found in the emergency department that would correctly assess/predict the need for MT in order to use the MTP correctly in patients with penetrating trauma.</p>	<p>Prospective study. IRB approved. <i>n</i> = 131, trauma victims who received MT, urban academic Level I trauma center.</p>	<p>Comparisons between groups made with Student's t-test for continuous data, and with χ^2 for categorical data. <i>p</i> <0.05 significant.</p>	<p>78 torso GSW pts, 56 received MT. Patients receiving MT were more apt to be hypotensive (<i>p</i> = 0.012) and tachycardic (<i>p</i> = 0.005). Their initial base deficit was significantly worse (<i>p</i> <0.001), there was no significant difference in average number of organs damaged in MT versus non-MT (<i>p</i> = 0.26). Injury to abdominal vascular structure was significantly higher in MT group (46% versus 5%, no <i>p</i> value). All high-risk trajectory injuries (thoracic+peritonealcavity; transpelvic trajectory) required MTP. In patients with low risk trajectories (patients without multicavity or transplevic trajectory) MT patients were hypotensive (58% versus 18%, <i>p</i> <0.01), 27 had initial BD less than -10 (92% vs 3%; <i>p</i> <0.01). In patients with high risk trajectory, initiation of MTP appropriate due to high risk for multiple sources of bleeding (no significance stats noted) in those with low risk trajectory, massive blood loss can be assumed and use of MTP can be guided by hypotension and BD.</p>	<p>1</p>	<p>IV</p>

Fligor, S. C., Hamill, M. E., Love, K. M., Collier, B. R., Lollar, D., & Bradburn, E. H. (2016). Vital signs strongly predict massive transfusion need in geriatric trauma patients. <i>The American Surgeon</i> , 82(7), 632–636.	Determine whether arrival VS are useful in predicting the need for mass transfusion in geriatric trauma patients.	Retrospective analysis of database with IRB approval; $n = 200$ trauma patients 65 and older who were assigned the highest trauma activation, 194 analyzed, 16 received MT Level I trauma center, small urban area surrounded by large rural area from 2010-2013.	Reviewed chart for MOI, BP, HR, ISS, TRISS, PRBC administration and mortality, SI calculated. MT defined as requiring $>+ 5$ u PRBC within 24 hour: t-test, χ^2 and AUROC used for comparison.	BP, pulse pressure, shock index are predictors for MT, but heart rate was not	2	IV
Hagemo, J. S., Christiaans, S. C., Stanworth, S. J., Brohi, K., Johansson, P. I., Goslings, J. C., ... Gaarder, C. (2015). Detection of acute traumatic coagulopathy and massive transfusion requirements by means of rotational thromboelastometry: An international prospective validation study. <i>Critical Care</i> , 19(97). https://doi.org/10.1186/s13054-015-0823-y	Reevaluate findings from previous study: to identify cut-off values that predict need for MT using rotational thrombo elastometry.	Multi center, observational, cohort. IRB approved. $n = 808$ from four trauma centers in the UK, Denmark, and Norway from Jan 2007 to Nov 2011.	Serum samples collected within 20 min of arrival, measured PT, fibrinogen concentration and platelet count along with ROTEM assays FIBTEM and EXTEM, number of transfused units in first 24 hours, demographics, VS, MOI, ISS, defined MTas ≥ 10 units in 24 hours. Compared normal group with traumatic coagulopathy (INR-1.2) group and group that required MT using t-test and Mann-Whitney U, ROC and AUC used to compare test accuracy.	49 pts received MT. ROTEM parameters and clotting times differed significantly between MT group and non-MT group ($p < 0.001$). Detecting need for MT was highest for INR (51.1%) and EXTEM assay (45.5%). All ROTEM assays, fibrinogen concentration, INR and platelet counts significantly predicted MT. ROTEM predicts need for MT; EXTEM threshold of < 40 detects MT in 72.7% of cases and FIBTEM threshold of < 9 detects MT in 77.5%.	1	IV
Hsu, J., Hito, K., & Fletcher, J. (2013). Identifying the bleeding trauma patient: Predictive factors for massive transfusion in an Australasian trauma population. <i>Journal of Trauma and Acute Care Surgery</i> , 75(3), 359–364. https://doi.org/10.1097/TA.0b013e31829c2248	To determine whether there are predictors of need for MT in order to facilitate early identification of patients needing MT.	Prospective, descriptive study of trauma database. $n = 1546$ adult trauma patients between Jan 1985–Dec 2010, large trauma center Australia.	Demographic, clinical and injury related variables and Abbreviated Injury Scale collected. χ^2 to compare groups, multivariate logistic regression.	BD (OR 1.5, CI 1.3–1.7, $p < 0.0001$), INR (OR 2.2, $p < 0.0001$, 95% CI [1.1, 4.1]), hemoperitoneum or laparotomy (OR 2.5, $p < 0.013$, 95% CI [1.1, 4.0]) significantly predictive of MT. In predictive model, most predictive was BD of 5 or more (OR 21.8) when combined with coagulopathy or hemoperitoneum OR 51.6. AUROC was 0.859, indicating that model has good predictability. Sensitivity of mode 189.7 and specificity 73.9.	1	VI
Krumrei, N., Park, M., Cotton, B., & Zielinski, M. (2012). Comparison of massive blood transfusion predictive models in the rural setting. <i>Journal of Trauma</i> , 72(1), 211–215. https://doi.org/10.1097/TA.0b013e318240507b	Validate MT predictive models in rural Level I trauma center patient population, using all major trauma victims, regardless of blood product requirements.	IRB approved. Chart review of all Level I trauma patients admitted in 2008 to 2009 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 I trauma center.	Chart review of patients admitted from 2008 to 2009. TASH, ABC score and McLaughlin were calculated on each patient. Used predictive values validated in other settings, but not in rural setting.	The ABC score correctly identified 89% of MT patients and was predictive of MT in major trauma patients at 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, strongly recommend adoption of the ABC score for MT prediction.	2	VI
Kuhne, C. A., Zettl, R. P., Fischbacher, M., Lefering, R., & Ruchholtz, S. (2008). Emergency transfusion score (ETS): A useful instrument for prediction of blood transfusion requirement in severely injured patients. <i>World Journal of Surgery</i> , 32(6), 1183–1188. https://doi.org/10.1007/s00268-007-9425-4	Analysis of the clinical practice of Emergency Transfusion Score (ETS), to predict the need for BT in major trauma patients during early care.	Prospective analysis. IRB University Hospital of Essen (Germany) approved study $n = 481$ patients requiring trauma team activation 2003 to 2004. Level I urban trauma center – covers region > than 1 million people.	Sensitivity, specificity, NPV, and PPV of the ETS were validated prospectively in a different cohort. Also calculated sensitivity, specificity, PPV, and NPV for ETS > 2 and ETS > 4 points. Patient groups were then compared mutually using the χ^2 test. Two-tailed statistical significance level of $p < 0.05$ was used to determine statistical significance.	ETS < 3 in 306 pts (64%) and > 3 in 175 pts (36%). 40 patients (8.3%) received blood (8 ± 8 PRBC) after 23 ± 9 min during ED treatment, and 39 of these patients had an ETS of > 3 (5.4 ± 1.5 points). Sensitivity of the ETS = 97.5%; specificity = 68%. PPV = 0.222; NPV = 0.998. Conclusion: ETS is a safe and highly sensitive method for detecting severely injured patients in need of blood products. ETS is highly predictive for pts not in need of PRBC. Saved \$109,296/year by reducing the costs for crossmatching, transportation, and wasted blood products.	1	III
Mackenzie, C., Wang, Y., Hu, P., Chen, S., Chen, H., Hagegeorge, G. ... The ONPOINT Study Group. (2014). Automated prediction of early blood transfusion and mortality in trauma patients. <i>Journal of Trauma and Acute Care Surgery</i> , 76(6), 1379–1385. https://doi.org/10.1097/TA.000000000000235	Determine whether pulse oximetry readings could predict need for blood transfusion and mortality as accurately as other VS in trauma patients.	Prospective cohort; IRB approval; $n=481$ patients requiring trauma team activation 2003 to 2004. Level I urban trauma center – covers region > than 1 million people.	Continuous VS, EKG, HR, NIBP, blood use tracked by observation and blood bank records, mortality was obtained from traumaregistry, participants divided into groups based on age and sex adjusted VS. Ran multiple logistic regression models to predict.	First 15 min of VS (prehospital HR, continuous PPG, SpO2, HR) best predicted transfusion at 1–3 hours, need for MT and mortality. This was no more precise than a model that included BP. Monitoring 30 and 60 minutes further demonstrated no difference from 15 minutes in ability to predict. SI, PPG and SpO2 did not predict any differently than pulse oximetry signals alone.	1	VI

<p>Mina, M., Winkler, A., & Dente, C. (2013). Let technology do the work: Improving prediction of massive transfusion with the aid of a smart phone application. <i>Journal of Trauma and Acute Care Surgery</i>, 75(4), 669–675. https://doi.org/10.1097/TA.0b013e3182a12ba6</p>	<p>Hypothesis: A smart phone application could provide an additional tool for clinicians as a statistically powerful and accurate predictor of massive transfusion.</p>	<p>Retrospective study, IRB approval obtained. $n = 10,900$ trauma activations identified by hospital's trauma registry since Feb. 2007.</p>	<p>All analyses, development, and validation were done using the R statistical environment. Student's t-tests, LASSO regression, and AUROC were also used.</p>	<p>Manually tally scoring systems (ABC and TASH scoring systems) leaves room for error and are either cumbersome or over simplified. An MTP predictive model was developed with the use of LASSO regression and made into a smart phone app where MOI, HR, SBP and BD are entered, and the app performs all of the calculations. The smart phone app predictive model was developed and has 97% accuracy of predicting MTP activation. It is recommended that no one tool be used as the sole clinical decision maker.</p>	<p>2</p>	<p>IV</p>
<p>Moore, H., Moore, E., Chapman, M., Huebner, B., Eimersen, P., Solimon, O., ... Sauaia, A. (2017). Viscoelastic tissue plasminogen activator challenge predicts massive transfusion in 15 Minutes. <i>Journal of American College of Surgeons</i>, 225(1), 138–147. https://doi.org/10.1016/j.jamcollsurg.2017.02.018</p>	<p>Modified thrombelastography + exogenous tPA predicts risk for MT better than other methods (SI, HR/SBP, TASH, ABC).</p>	<p>Prospective, cross-sectional, IRB approved. $n = 10,900$ trauma activations with $n = 324$ high level trauma activations in an urban area.</p>	<p>Patient demographics (mechanism of injury, lab results, transfusion requirements, abbreviated Injury Scale, ISS and GCS), assay results, TASH, ABC. Used Mann-Whitney U and χ^2, AUROC curves to predict.</p>	<p>The TASH had the highest AUROC (0.84, 95% CI [0.79,0.90]) therefore was best predictor but requires multiple variables that can be time consuming. Low dose tPA challenge had best performance of all tPA challenges with AUROC of 0.86 (95% CI [0.79,0.93]) sensitivity 84% and specificity 82%, however it takes 50 minutes to run. INR also had good negative predictive value and could be used to rule out need for MT (97%).</p>	<p>1</p>	<p>IV</p>
<p>Nunez, T. C., Voskresensky, I. V., Dossett, L. A., Shinall, R., Dutton, W. D., & Cotton, B. A. (2009). Early prediction of massive transfusion in trauma: Simple as ABC (assessment of blood consumption)? <i>Journal of Trauma</i>, 66(2), 346–352. https://doi.org/10.1097/TA.0b013e3181961c35</p>	<p>Validate the TASH and McLaughlin scores as well as compare them to the authors-developed ABC score.</p>	<p>Retrospective observational study; IRB approved. $n = 596$ patients, convenience sample of eligible patients (all patients admitted to VUMC between 7/1/05 and 6/30/06. Single US-based Level 1 trauma center.</p>	<p>ABC score was developed based upon 1 point 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 whether the score could be improved upon. The ability of each score to predict MT was estimated by AUROC.</p>	<p>ABC SCORE: Multiple logistic regression as follows: Positive FAST (OR 8.2, $p < 0.001$, 95% CI [4.34,5.30]), HR ≥ 120 (OR 3.9, $p < 0.001$, 95% CI [2.00,6.85]), SBP ≤ 90 (OR 3.9, $p < 0.001$, 95% CI [6.93,24.52]), penetrating trauma (OR 1.9, $p = 0.02$, 95% 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.</p>	<p>2</p>	<p>VI</p>
<p>Nunez, T., Dutton, W., May, A., Holcomb, J., Young, P., & Cotton, B. (2010). Emergency department blood transfusion predicts early massive transfusion and early blood component requirement. <i>Transfusion Practice</i>, 50, 1914–1920. https://doi.org/10.1111/j.1537-2995.2010.02682.x</p>	<p>Transfusion of uncrossmatched RBC's in the emergency department is predictor of need for MT and may be used as early indicator for MT protocols.</p>	<p>Retrospective review of trauma registry from 7/1/05–6/30/07. IRB approved. $n = 1441$. Regional Level 1 trauma center.</p>	<p>Demographics, ISS, weighted revised trauma score, ED transfusion of RBC's, MT (10+ units RBC in first 24 hours; plasma 6+ units in first 24 hours; PLT 2+ first 24 hours) early MT RBC (10+ in first 6 hours), early MT plasma (6+ units in first 6 hours) early PLT (2+ units in first 6 hours), initial analysis compared early MT between those receiving uncrossmatched blood in the emergency department (ED RBC+) and those who did not (ED RBC-), comparisons made with Wilcoxon rank sum test, Kruskal-Wallis test, Spearman's rho test, χ^2, or Fisher's exact test. Logistic regression models to study ED transfusion of uncrossmatched blood on early MT.</p>	<p>Sample divided into those who did and did not receive uncrossmatched RBC in the emergency department. Patients who received uncrossmatched blood were younger ($p = 0.009$) more likely male ($p = 0.004$) and more likely to have penetrating injury ($p < 0.001$), had higher ISS ($p < 0.001$), worse revised trauma score ($p < 0.001$) than RBC- group. Sensitivity for receiving RBC in the emergency department for MT by 24 hours was 80% and specificity was 55%, for MT by 6-hour sensitivity was 83% and specificity was 53%. PPV was 54% and NPV was 82%. Receiving uncrossmatched blood was a predictor of early MT of RBC (OR 3.52, $p = 0.001$, 95% CI [1.36,7.59]) plasma (OR 2.75, $p < 0.001$, 95% CI [1.66,4.39], $p < 0.001$) and PLT (OR 1.92, $p = 0.025$, 95% CI [1.08,3.41]).</p>	<p>1</p>	<p>IV</p>
<p>Ogura, T., Lefor, A., Masuda, M., & Kushimoto, S. (2016). Modified traumatic bleeding severity score: Early determination of the need for massive transfusion. <i>American Journal of Emergency Medicine</i>, 34, 1097–1101. https://doi.org/10.1016/j.ajem.2016.02.072</p>	<p>The aim of this study was to evaluate accuracy of the modified TBSS compared to the original TBSS and TASH.</p>	<p>Retrospective analysis of severely injured patients admitted between Jan 2010 and Mar 2014. IRB approval was obtained. $n = 300$ patients. Convenience sample. Setting: single institution in Japan.</p>	<p>AUROC analysis was used to evaluate predictive value of the need for MT. Bonferroni correction was used to adjust p values for each AUC comparison among the 3 groups.</p>	<p>The Modified TBSS, which uses SBP on arrival compared to systolic blood pressure after 1L of crystalloid solution, showed high accuracy of predicting MT with an AUC of 0.915, a sensitivity of 80%, and a specificity of 91.1%. The Modified TBSS was not as accurate as the original TBSS, which had an AUC of 0.956, sensitivity of 93.3%, and specificity of 92.4%. It was slightly more accurate than the TASH score, which had an AUC of 0.912, sensitivity of 96.7%, and specificity of 83.6%. While not as accurate as the original TBSS, the Modified TBSS was found to be an accurate scoring tool for earlier prediction of the need for mass transfusion protocols to be activated.</p>	<p></p>	<p>VI</p>

<p>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. <i>Journal of Trauma and Acute Care Surgery</i>, 76(5), 1243–1250. https://doi.org/10.1097/TA.0000000000000200</p>	<p>The aim of this study was to create a new scoring system for initiation of massive blood transfusion protocols.</p>	<p>Retrospective analysis. Chart reviews done for both phases of study. IRB approval. Phase 1: n = 119 patient charts from Jan 2008 to Dec 2009. Phase 2: n = 113 patient charts from January 2010 to March 2012. All patients had blunt force trauma from single hospital in Japan that admitted an average of 140 trauma patients per year. Mean age 56.5 years with 81% males.</p>	<p>Mann-Whitney U-test and χ^2 test used for parameter comparison. ROC was used to compare accuracy of the TBSS, TASH, and ABC scoring systems. High accuracy was defined as >0.9, moderate accuracy was <0.9 and >0.7, low accuracy was <0.7. Cox-Snell R2 and NagelkerkeR2 tests were used to test the goodness of fit of models.</p>	<p>The TBSS showed higher accuracy than both the TASH and ABC. The ROC value for the TBSS was 0.985 with a sensitivity of 97.4% and specificity of 96.2%. The ROC for the TASH was 0.892 with a sensitivity of 81.6% and specificity of 78.2%. The ROC for the ABC scoring systems was 0.813 with a sensitivity of 79.0% and specificity of 78.2%. The TBSS is a 5-component scoring system that is easily and quickly computed at bedside. Of the three scoring systems discussed in the article, it was the only one that took age into consideration.</p>	<p>1</p>	<p>IV</p>
<p>Ogura, T., Nakano, M., Izawa, Y., Nakamura, M., Fujizuka, K., & Lefor, A. T. (2015). Analysis of risk classification for massive transfusion in severe trauma using the gray zone approach. <i>The American Journal of Emergency Medicine</i>, 33(9), 1146–1151.</p>	<p>Evaluate initiation of MT protocols for gray zones based on use of TBSS.</p>	<p>Retrospective. IRB approval. n = 300 patients. Convenience sample. Setting: single institution in Japan.</p>	<p>TBSS and TASH were calculated based on clinical presentation. 95% specificity for high risk and 95% sensitivity for low risk group. Gray zone defined between high and low cut off.</p>	<p>Low risk TBSS with score 10 or less had a sensitivity of 96.5% with 3.4% receiving MT. High risk TBSS with score 17 or higher with specificity 97.8% with 94.4% receiving MT. Gray zone score was determined to have a score of 11–16 with 6.1% receiving MT.</p>	<p>1</p>	<p>VI</p>
<p>Ohmori, T., Kitamura, T., Ishihara, J., Onishi, H., Nojima, T., Yamamoto, K., ... Tokioka, T. (2017). Early predictors for massive transfusion in older adult severe trauma patients. <i>Injury</i>, 48(5), 1006–1012. https://doi.org/10.1016/j.injury.2016.12.028</p>	<p>Determine the effectiveness of MT scoring tool for the older severe trauma patient.</p>	<p>Prospective observational data analysis. n = 1259. Single site in a Trauma center in Kochi, Japan.</p>	<p>MT defined as >10 U PRBC within 24 hours. Utilized TASH, ABC, and PWH scoring tools. Scoring tools were applied to each age group. Analysis divided into 2 parts: 1. Score calculated – AUC, 2. looked at early predictors using multivariable logistic regression using multiple variables including SI, age, HR, systolic BP, GCS, labs, FAST, Unstable pelvic ring fracture, long bone fracture and mortality.</p>	<p>Scoring tools accurate in young but less predictable in older. Younger/older AUC TASH 0.881 (95% CI [0.83,0.93]), 0.793 (95% CI [0.74,0.85]); ABC 0.792 (95% CI [0.72,0.86]), 0.655 (95% CI [0.59,0.72]); PWH 0.858 (95% CI [0.81,0.91]), 0.764 (95% CI [0.71,0.82]). Anatomical factors including FAST results (OR 5.58, 95% CI [2.10,14.99]), unstable pelvic fracture (OR 21.56, 95% CI [6.05,90.78]), and long bone open fracture of the lower limbs (OR 12.21, 95% CI [4.04,39.09]), along with pre-injury anticoagulant agent use (OR 5.22, 95% CI [1.30,19.61]), antiplatelet agent use (OR 3.81, 95% CI [1.57,9.04]), lactate levels (OR 1.20, 95% CI [1.04,1.39]) and SI (OR 2.67, 95% CI [1.05,6.84]).</p>	<p>2</p>	<p>VI</p>
<p>Olaussen, A., Blackburn, T., Mitra, B., & Fitzgerald, M. (2014). Review article: Shock Index for prediction of critical bleeding post-trauma: A systematic review. <i>Emergency Medicine Australasia</i>, 26(3), 223–228. https://doi.org/10.1111/1742-6723.12232</p>	<p>To explore the predictability of MT by the prehospital and trauma SI.</p>	<p>Single-center, retrospective, comparative study. n = 6990 with 360 MT at three major trauma services in Australia.</p>	<p>Normally distributed continuous variables used the mean (standard deviation) with skewed data using the median (inter-quartile range). For statistical significance, Student's t-test was used to assess the difference between two means, Wilcoxon Rank Sum was used to compare the difference between two medians, and the χ^2 test was used between two proportions. Logistic regression was used to determine the relationship between MT and pre-hospital SI and trauma care SI.</p>	<p>Dichotomized Higher positive predictive value than the trauma SI with a further 5 per 100 patients identified. Formulae – log Odds (MT) = 2.16 trauma + 0.89 prehospital SI – 5.42 Combination prehospital SI 0.5 + Trauma SI, performed equally (AUROC 0.83 versus 0.83, $\chi^2 = 0.86$, p = 0.35). Formulae – marginally, but statistically significantly, more accurate than the trauma SI alone (AUROC 0.83 vs. 0.82, $\chi^2 = 6.89$, p < 0.01). Upward Trending SI – 1758 patients, revealing a 4.6-fold univariate association with MT (OR 4.55; 95% CI [2.64,7.83]), and an AUROC of 0.79 (95% CI [0.74,0.83]). Downward Trending SI – protective against MT (OR 0.44, 95% CI [0.34,0.57]). The initial pre-hospital SI is associated with MT. Did not clinically augment MT decision when combined with the in-hospital SI.</p>	<p>1</p>	<p>VI</p>

<p>Parimi, N., Hu, P., Mackenzie, C., Yang, S., Bartlett, S., Scalea, T., ... Stein, D. M. (2016). Automated continuous vital signs predict use of uncrossmatched blood and massive transfusion following trauma. <i>Journal of Trauma and Acute Care Surgery</i>, 80(6), 897–906. https://doi.org/10.1097/TA.0000000000001047</p>	<p>To compare the need for transfusion following a trauma using noninvasive vital signs before and after admission to a trauma center.</p>	<p>Formulaic – logistic regression analysis. (iii) Combination – the logistic regression. (iv) Trending – Trauma minus Prehospital SI. 3 Major Trauma Services in Australia. $n = 10,636$ with > 5 million continuous VS data points within the first 15 minutes after admission. Large, urban Level 1 trauma center.</p>	<p>Three transfusion outcomes were evaluated over a 4-year period: 1. Uncrossmatched RBC.2. (MT1) > 4 units PRBC within 4 hours and 3. (MT2) ≥ 10 units PRBC within 24 hrs. Vital signs included heart rate, systolic blood pressure, and SI at 5, 10, and 15 minutes after admission. Five models were developed:1. Preadmission VS, 2. Admission VS, 3.–5. used continuous VS features after admission over 5, 10, and 15 minutes, respectively, to predict the use of Uncrossmatched RBC. Models were evaluated for their predictive performance via AUROC, PPV, and NPV.</p>	<p>Model using preadmission and admission VS had similar ability to predict uncrossmatched RBC, MT1, or MT2. Compared with these two models, predictive ability was significantly improved as duration of VS monitoring increased. Continuous VS for 5 minutes had ROCs of 0.83 (95% CI [0.83,0.84]), 0.85 (95% CI [0.84,0.86]), and 0.86 (95% CI [0.85,0.88]) to predict uncrossmatched RBC, MT1, and MT2, respectively. Similarly, continuous VS for 10 minutes had a ROCs of 0.86 (95% CI [0.85,0.86]), 0.87 (95% CI [0.86,0.88]), and 0.88 (95% CI [0.87,0.90]) to predict uncrossmatched RBC, MT1, and MT2, respectively. Continuous VS for 15 minutes achieved the highest ROCs of 0.87 (95% CI [0.87,0.88]), 0.89 (95% CI [0.88,0.90]), and 0.91 (95% CI [0.91,0.92]) to predict uncrossmatched RBC, MT1, and MT2, respectively.</p>	<p>1</p>	<p>VI</p>
<p>Pottecher, J., Ageron, F., Fauché, C., Chemla, D., Noll, E., Duranteau, J., ... Bouzard, P. (2016). Prehospital shock index and pulse pressure/heart rate ratio to predict massive transfusion after severe trauma: Retrospective analysis of a large regional trauma database. <i>Journal of Trauma and Acute Care Surgery</i>, 81(4), 713–722. https://doi.org/10.1097/TA.0000000000001191</p>	<p>To assess the accuracy of prehospital SI versus pulse pressure in predicting MT using the gray- zone approach.</p>	<p>Retrospective of data from trauma registry of TRENAU (France) from 1/1/9 to 12/31/11. Approval from the Ethics committee. $n = 3689$ with $n = 2557$ (excluding cardiac arrest and missing data).</p>	<p>Descriptive stats – frequencies, 95% confidence level. Medians for continuous variables. Comparison between patients with complete and equal data sets, utilized student t or Mann-Whitney U, Fisher's exact, ROC. For gray zone – ROC and Youden index Identify gray area (range where no conclusion can be made). To define, first determine best threshold, then define value for inconclusive information – sensitivity $< 90\%$ Gray zone assessed using z-test.</p>	<p>Primary endpoint MT Prediction results were pulse pressure and SI equally predicted MT AUC = 0.77 (95% CI [0.70,0.80]) and 0.80 (95% CI [0.74,0.87]). Gray zone PPH (61%) and SI (40%) pulse pressure and SI failed in younger, predominately women and higher severity scores – False positives $n = 589$. Secondary endpoint mortality, total blood transfusion and LOS lower severity Pulse pressure/SI AUC = 0.91/0.987 for MT1 For MT2 pulse pressure AUC = 0.72 (95% CI [0.59,0.84]) versus SI 0.54 (95% CI [0.33,0.74]).</p>	<p>1</p>	<p>IV</p>
<p>Rainer, T. H., Ho, A. H., Yeung, J. H., Cheung, N. K., Wong, R. M., Tang, N., ... Graham, C. A. (2011). Early risk stratification of patients with major trauma requiring massive blood transfusion. <i>Resuscitation</i>, 82(6), 724–729. https://doi.org/10.1016/j.resuscitation.2011.02.016</p>	<p>Create a model that identifies early need for MT.</p>	<p>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 center in Hong Kong.</p>	<p>Variables underwent univariate analysis and multivariate logistic regression modeling; ROC generated to evaluate overall predictive strength.</p>	<p>1891 pts included in data analysis with 138 receiving 6–9 units and 92 > 10 units within 24 hours. Developed a 10- point scoring system using 7 clinical variables (SBP < 90, GCS ≤ 8, HR ≥ 120, displaced pelvic fracture, +CT or FAST, Base Deficit > 5, Hgb < 7): Chance of those with a score of 0–5 receiving a MT was 3.4%, while a those with a score of 6–10 had an 82.9% chance of requiring a MT.</p>	<p>2</p>	<p>VI</p>
<p>Rau, C., Wu, S., Kuo, S., Kuo, P., Hsu, S., Chen, Y., ... Liu, H. (2016). Prediction of massive transfusion in trauma patients with shock index, modified shock index, and age shock index. <i>International Journal of Environmental Research and Public Health</i>, 13, 683–694. https://doi.org/10.3390/ijerph13070683</p>	<p>Investigate the SI and alternate modified SI's potential as predictors of MT in trauma patients who present to the emergency department of a Level 1 trauma center.</p>	<p>IRB approval. Retrospective study with IRB approval. $n = 20,106$ hospitalized patients registered in the Trauma Registry System of level 1 regional trauma center from Jan 1, 2009 to Dec 31, 2014.</p>	<p>Odds ratios for associated conditions and injuries of patients calculated with 95% CIs. Adjusted odds ratios for mortality adjusted by age, sex, and ISS with 95% CIs. SPSS version 20.0, 2-sided Fisher's exact test, Pearson χ^2 test, unpaired Student t-test, Mann-Whitney U-test, and AUROC were all used for statistical analysis.</p>	<p>SBP, BD, SI, and MSI had discriminating power of moderate accuracy. HR, HGB, and Age SI were not acceptable predictors of MT. HR (beats/min) cutoff: 109.50, sensitivity: 0.475, specificity: 0.853, AUC 0.671; SBP cutoff: 120.5, sensitivity: 0.725, specificity: 0.636, AUC 0.716; HGB cutoff: 11.50, sensitivity: 0.782, specificity: 0.485, AUC: 0.645; BD cutoff: 4.50, sensitivity: 0.693, specificity: 0.761, AUC: 0.784; SI cutoff: 0.950, sensitivity: 0.563, specificity: 0.876, AUC: 0.760; MSI cutoff: 1.150, sensitivity: 0.615, specificity: 0.823, AUC: 0.756; Age SI cutoff: 36.95, sensitivity: 0.542, specificity: 0.723, AUC: 0.627.</p>	<p>1</p>	<p>IV</p>

<p>Reed, M., Glover, A., Byrne, L., Donald, M., McMahon, N., Hughes, N., ... Rawlinson, P. (2016). Experience of implementing a national pre-hospital code red bleeding protocol in Scotland. <i>International Journal of the Care of the Injured</i>, 48(1), 41–36. https://doi.org/10.1016/j.injury.2016.09.020</p>	<p>Do current pre-hospital activation criteria predict the need for in-hospital transfusion or death due to hemorrhage? Determine the admission coagulation profile of prehospital code red trauma patients in Scotland and whether or not they are receiving appropriate treatment of coagulation problems; establish the current PRBC: FFP ratio used in prehospital code red trauma patients; does use of pre-hospital code red protocol lead to waste of blood products?</p>	<p>Prospective cohort, trauma patients who were activated as a code red pre-hospital as determined by physician upon EMS call (suspected or confirmed bleeding, SPB <90, patient unresponsive to fluid boluses) country-wide study using three national EMS systems in Scotland, deemed a "service evaluation" by South East Scotland Research Ethics Committee and did not require full IRB.</p>	<p>Standardized case report form with patient information, code red number, descriptive statistics, D'Agostino-Pearson normality tests, significance set at 5%, mean cumulative ratio.</p>	<p>Code red activation is sensitive for predicting need for transfusion in trauma patient (89%) but SBP <90 (part of code red) was less sensitive at 63%; 19% were coagulopathic (PT>14), 53% had low HGB, 7% had high PTT (>37), 27% low fibrinogen(<1.5). No difference in the amt of pre or in hospital fluid given to coagulopathic patients. ($p = 0.43$, Mann-Whitney); 71% received tranexamic acid. PRBC:FFP ratios did not drop to below 2:1 until after 150 minutes after arrival (likely due to time needed to thaw FFP). 16 units PRBC, 33 units FFP and 6 units platelets wasted, this number is not significantly higher since the code red program established and may be slightly lower. (PRBC: 5.3% vs 8.2%; FFP 7.3% vs 9.7%, platelets 0% versus 11.9%).</p>	2	IV
<p>Ruchholtz, S., Pehle, B., Lewan, U., Lefering, R., Mueller, N., Oberbeck, R., & Waydhas, C. (2006). The emergency room transfusion score (ETS): Prediction of blood transfusion requirement in initial resuscitation after severe trauma. <i>Transfusion Medicine</i>, 16, 49–56. https://doi.org/10.1111/j.1365-3148.2006.00647.x</p>	<p>Purpose "defining reliable and quickly accessible parameters for an early request PRBC for transfusion in the ER".</p>	<p>Retrospective data analysis. $N = 1103$ pts admitted May 1998–Jan 2002 at the University Hospital of Essen.</p>	<p>Patients were retrospectively divided into group A (no transfusion) and group B (transfusion). Parameters were tested for standard deviations and compared with χ^2 test. Stepwise logistic regression analysis was performed.</p>	<p>Using linear regression calculated probability of PRBC transfusion based on sum of score points. At an ED Transfusion score of 1, probability for blood transfusion in the emergency department 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 < 3 pts; <5% need (1.6% sample required transfusion while 98.4% did not); Intermediate Risk 3 pts; 5–10% (8.5% received transfusion while 91.5% did not). High Risk >3pts; >10% risk (34.6% received transfusion while 64.4% did not).</p>	2	VI
<p>Schöchl, H., Cotton, B., Inaba, K., Nienaber, U., Fischer, H., Voelckel, W., & Solomon, C. (2011). FIBTEM provides early prediction of massive transfusion in trauma. <i>Critical Care</i>, 15(6), R265. https://doi.org/10.1186/cc10539</p>	<p>Determine capability of ROTEM parameters to predict MT in trauma patients treated with coagulation factor concentrates.</p>	<p>Retrospective analysis of pts admitted to trauma center from 1/05–12/10. IRB approved. $n = 323$ trauma patients from Salzburg, Austria.</p>	<p>Measured ROTEM assays at bedside, PTT, pH, BD, lactate, H&H, fibrinogen concentration, platelet count, MT (> 10 units in 24 hours). Continuous variables presented as mean and SD or interquartile range, and % for categorical variables. Students t test used to find differences between groups or Mann Whitney U, group differences compared with ANOVA or Fisher's exact test for categorical data. Correlation was calculated using Spearman's correlation coefficient ρ. $p < 0.05$ significance level.</p>	<p>78 of 323 were in MT group, 245 in the non-MT group. median ISS significantly higher for those in MT group (42, $p < 0.0001$) than those in non-MT group (27, $p < 0.0001$). EXTEM and INTEM clotting time and clot formation time was significantly longer in MT group ($p < 0.0001$) than in non-MT group. Best predictors of MT were HGB and Quick value (AUROC 0.87 for both). FIBTEM MCF (AUC 0.84) and FIBTEM A10 (AUC 0.83) best predictive values of ROTEM parameters. Therefore, these ROTEM parameters have a similar predictive capability for MT as HGB and quick value.</p>	1	IV
<p>Shackelford, S., Yang, S., Hu, P., Miller, C., Anazodo, A., Galvagno, S., ... ONPOINT Study Group. (2015). Predicting blood transfusion using automated analysis of pulse oximetry signals and laboratory values. <i>Journal of Trauma and Acute Care Surgery</i>, 79(4 Suppl 2), S175–S180. https://doi.org/10.1097/TA.0000000000000738</p>	<p>Development of an algorithm that incorporates BP and HR (pre-arrival by EMS), pulse oximetry and lab values that would better predict need for transfusion than any of those components alone.</p>	<p>Prospective cohort study, IRB approved. $n = 1103$ pts admitted May 1998–Jan 2002 at the University Hospital of Essen. $n = 852$ adult (over 18) trauma pts with shock index 0.62 or higher based on VS from EMS in field, identified as "priority 1" by EMS (critically ill or injured needing immediate attention) or unstable patient with life-threatening injury without prehospital VS, excluded those surviving less than 15 minutes upon arrival to the emergency department and those with cervical spine injury, urban shock trauma medical center.</p>	<p>Collected 1st HR and SBP from EMS as "triage VS", pulse oximetry waveforms q 2 sec for 1 hour from time of arrival to unit; labs upon arrival included: HCT, glucose, K, Cl, HCO3, PT, INR, lactate; number of units blood transfused, stepwise logistic regression with $p = 0.05$ for forward selection and $p = 0.1$ for backward selection, AUROC curves for HR+SBP, pulse oximetry and lab values.</p>	<p>Triage VS predicted transfusion within 3 hours with AUROC curve 0.59, rapid transfusion (5+ units in first 4 hours) predicted with AUROC curve 0.71, MT predicted with AUROC curve 0.70, pulse ox signal predicted transfusion within 3 hours with AUROC curve 0.74, rapid transfusion with AUROC curve 0.82 and MT with AUROC curve 0.88. HCT+electrolytes predicted transfusion within 3 hours significantly better than PT/INR ($p = 0.02$) or lactate ($p = 0.04$). Combination of all 3 labs did not predict 3-hour transfusion better than HCT+electrolytes alone. Using the multivariate logistic regression models that combined VS, lab values and pulse oximetry, an algorithm was developed that improved accuracy of 3-hour transfusion prediction with AUROC curve 0.84 and 0.91 for MT. Combination of all measures was significantly better than VS and pulse ox alone ($p < 0.05$ for both) but not better than all labs combined ($p > 0.05$).</p>	1	IV

<p>Tonglet, M., Minon, J., Seidel, L., Poplavsky, J., & Vergnion, M. (2014). Prehospital identification of trauma patients with early acute coagulopathy and massive bleeding: Results of a prospective, non-interventional clinical trial evaluating the Trauma Induced Coagulopathy Clinical Score (TICCS). <i>Critical Care</i>, 18(6), 648–656. https://doi.org/10.1186/s13054-014-0648-0</p>	<p>To evaluate the effectiveness of TICCS in differentiating between major trauma patients who need damage control resuscitation and those who do not.</p>	<p>Prospective, non-interventional, non-controlled clinical trial. Approved by the Ethics Committee of authors' hospital. n = 82 after exclusions. Single hospital in Belgium.</p>	<p>Kruskal-Wallis test was used for group comparisons. Fisher's exact test was used for categorical variables. Cutoff values were obtained by ROC curve analysis. Calculations done using SAS version 9.3.</p>	<p>According to ROC curve analysis, TICCS could differentiate severe and non-severe patients with AUC of 0.98 (95% CI [0.92,1.0]) with a sensitivity of 100% and specificity of 95.9%. The TICCS cutoff value of 10 produced the best tradeoff between true and false positives. ABC and TASH scores were obtained during this study as well to compare to TICCS for statistical analysis. ABC with a cutoff value of greater than or equal to 2 had an AUC of 0.97, sensitivity of 100%, and specificity of 94.6%. The TASH with a cutoff of value of greater than or equal to 16 had an AUC of 0.81, sensitivity of 100%, and specificity of 62.5%.</p>	<p>2</p>	<p>IV</p>
<p>Umemura, T., Nakamura, Y., Nishida, T., Hoshino, K., & Ishikura, H. (2016). Fibrinogen and base excess levels as predictive markers of the need for massive blood transfusion after blunt trauma. <i>Surgery Today</i>, 46(7), 774–779. https://doi.org/10.1007/s00595-015-1263-7</p>	<p>To compare ABC and TASH to fibrinogen and base excess levels in accuracy of predicting need for MT.</p>	<p>Retrospective analysis of single center study, data from 6/09–12/11. IRB approved. n = 153 blunt trauma, 114 non MT, 39 MT, single center, Japan.</p>	<p>χ^2 or Wilcoxon test to compare groups, univariate or multiple logistic regression models, ROC.</p>	<p>In MT patients: RR ($p < 0.05$), HR ($p < 0.0001$), ISS ($p < 0.01$), +FAST ($p < 0.01$), unstable pelvic fracture rate ($p < 0.001$), ABC ($p < 0.0001$), TASH ($p < 0.0001$), INR ($p < 0.001$), PTT ($p < 0.01$), transfusion number ($p < 0.0001$), pelvic external rotation rate ($p < 0.05$), thoracotomy ($p < 0.01$), laparotomy (NS), IVR rate ($p < 0.001$), 24h ($p < 0.0001$) and 28 day ($p < 0.0001$) mortality rate significantly higher, but SBP ($p < 0.01$), hGB ($p < 0.0001$), BE ($p < 0.0001$) and fibrinogen ($p < 0.0001$) levels significantly lower in MT group. Male gender (OR 0.355, $p < 0.01$, 95% CI [0.166,0.751]), HR > 120 (OR 6.005, $p < 0.001$, 95% CI [12.170,17.692]), SBP < 90 (OR 0.193, $p < 0.001$, 95% CI [0.072,0.501]), +FAST – positive vs negative (OR 3.571, $p < 0.01$, 95% CI [1.490,8.589]), unstable pelvic fracture (OR 6.207, $p < 0.001$, 95% CI [2.129,19.606]) hGB (OR 0.716, $p < 0.0001$, 95% CI [0.605,0.834]), BE (OR 0.767, $p < 0.0001$, 95% CI [0.681–0.847]), fibrinogen (OR 0.987, $p < 0.0001$, 95% CI [0.981–0.992]), are predictors of MT. BE had highest AUC (0.845), TASH (0.833), Fibrinogen (0.765) ABC (0.716). BE and TASH significantly better predictors than ABC score ($p < 0.01$) but not better than fibrinogen level. Concluded that BE and fibrinogen levels independent predictors of need for MT.</p>	<p>2</p>	<p>IV</p>
<p>Vandromme, M. J., Griffin, R. L., Weinberg, J. A., Rue, L. W., III, & Kerby, J. D. (2010). Lactate is a better predictor than systolic blood pressure for determining blood requirement and mortality: Could prehospital measures improve triage? <i>Journal of the American College of Surgeons</i>, 210(5), 861–867. https://doi.org/10.1016/j.jamcollsurg.2010.01.012</p>	<p>To study the predictive value of serum lactate in identifying patients who will need MT in a population with SBP ranging from 90–110 mm Hg (because there is some evidence that an SBP less than 110 may more accurately reflect hypoperfusion).</p>	<p>Retrospective study. IRB approved. n = 2413. UAB trauma center with an academic medical center.</p>	<p>Serum lactate from initial resuscitation phase, pts categorized into groups: (≤ 2.5; $>2.5-5.0$; $>5.0-7.5$; >7.5). Patients then classified by # RBC received within 1st 24 hours (< 6 or ≥ 6). Used AUROC to predict need ≥ 6RBC. $p < 0.05$, proportional hazards regression for risk ratios.</p>	<p>Mean serum lactate 3.2, mean ISS 17.5, 10.9% of the sample received ≥ 6 RBC's in 1st 24h. Serum lactate better predictor of MT than ED BP (AUC 0.76 vs 0.60, $p < 0.0001$) or pre-hospital BP (AUC 0.72 vs 0.61, $p = 0.0025$). In those with ED BP, two-fold increase in risk of MT for patients with serum lactate of $\geq 2.5-5.0$ as compared to those with lactate of ≤ 2.5 (RR 1.9, $p < 0.0001$, 95% CI [1.3,2.7]) Increases in risk also observed for patients with lactate $>5.0-7.5$ (RR 3.2, $p < 0.0001$, 95% CI [2.2,4.7]) and >7.5 (RR 5.2, $p < 0.0001$, 95% CI [3.5,7.7]). In patients with prehospital SBP, two-fold increase in risk for MT in those with lactate in range of $\geq 2.5-5.0$ (RR 1.7, $p < 0.0001$, 95% CI [1.1,2.7]), in patients with lactate $>5.0-7.5$ (RR 3.1, $p < 0.0001$, 95% CI [1.8,5.2]) and >7.5 (RR 4.2, $p < 0.0001$, 95% CI [2.6,6.9]), ($p < 0.0001$) Serum lactate is better predictor than SBP prehospital or on arrival.</p>	<p>1</p>	<p>IV</p>
<p>Vandromme, M. J., Griffin, R. L., Kerby, J. D., McGwin, G., Jr., Rue, L. W., III, & Weinberg, J. A. (2011a). Identifying risk for massive transfusion in the relatively normotensive patient: Utility of the Prehospital Shock Index. <i>Journal of Trauma and Acute Care Surgery</i>, 70(2), 384–390. https://doi.org/10.1097/TA.0b013e3182095a0a</p>	<p>Determine the relationship between shock index and need for MT in patients who are considered normotensive (SBP ≥ 90).</p>	<p>Cohort study of trauma registry. IRB approved. n = 8111. Urban trauma center that serves 7 counties in Alabama, patients in trauma registry between 1/2000 and 10/2008.</p>	<p>Collected demographics, ISS, mortality, prehospital and post admission clinical characteristics including HR, SBP, # units PRBC transfused in 1st 24h, LOS in hospital, in hospital mortality, MT defined as 10+ PRBC in 1st 24h, Shock index = ratio of prehospital HR to prehospital SBP and on ED vs. SI categorized as ≤ 0.5; $>0.5-0.7$; $>0.7-0.9$; $>0.9-1.1$; $>1.1-1.3$; >1.3. demographic, injury and clinical characteristics compared among the shock index categories with χ^2 and ANOVA, proportional hazards regression used to estimate risk ratios.</p>	<p>Majority (38%) of pts had prehospital SI $>0.5-0.7$ or >0.7 and 0.9 (35%), male gender and age inversely related to SI, groups with highest SI ($>1.1-1.3$; and >1.3) had highest mean ISS (18.5 and 20.3), mean PRBC units (3.6 and 5.3), mean hospital LOS (9.4 and 10.8 days), highest mortality (6.5% and 10.3%) ($p < 0.0001$). Compared to patients with normal SI, no significant increase in risk for MT among pts with SI ≤ 0.5 (RR 1.41, 95% CI [0.90,2.21]) or $>0.7-0.9$ (RR 1.06, 95% CI [0.77,1.45]) A1.5 times higher risk for MT in patients with SI $>0.9-1.1$ (RR 1.61, 95% CI [1.13,2.31]). Increases in SI related to increased risk for MT, a 5+ times increased risk for patients with SI $>1.1-1.3$ (RR 5.57, 95% CI [3.74,8.30]) and 8 times increased risk for patients with SI >1.3 (RR 8.13, 95% CI [4.60,14.36]). A prehospital SI >0.9 identifies patients who would normally be considered normotensive, at risk for MT. The risk for MT increases as SI increases.</p>	<p>2</p>	<p>IV</p>

Vandromme, M.J., Griffin, R.L., McGwin Jr., G., Weinberg, J.A., Rue III, L.W., & Kerby, J.D. (2011b). Prospective identification of patients at risk for massive transfusion: An imprecise endeavor. <i>The American Surgeon</i> , 77(2), 155-161.	To develop a model that predicts MT in civilian trauma patients.	Prospective cohort. 2 cohorts—(subset of 12,000 pts) developmental (2005–2007) <i>n</i> = 306 and validation (2007–2008) <i>n</i> =2008.	Criteria – HR>105, SBP <110, Lactate >5, Hgb <11, INR>1.5 Logistic regression, Hosmer-Lemeshow goodness of fit test; odds ratio and confidence intervals calculated. Sensitivity, PPV and NPV.	Best fit predictive model included 3 or more clinical measures (sensitivity 53%; specificity 98%; increased 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.	1	IV
Vandromme, M., Griffin, R., Weinberg, J., Rue, L., & Kerby, J. (2010). Lactate is a better predictor than systolic blood pressure for determining blood requirement and mortality: Could prehospital measures improve trauma triage? <i>Journal of American College of Surgeons</i> , 210(5), 861–867. https://doi.org/10.1016/j.jamcollsurg.2010.01.012	To study the predictive value of serum lactate in identifying patients who will need MT in a population with SBP ranging from 90–110 mm Hg (because there is some evidence that an SBP less than 110 may more accurately reflect hypoperfusion).	Retrospective study. IRB approved. <i>n</i> = 2413. UAB trauma center with an academic medical center.	Serum lactate from initial resuscitation phase, pts categorized into groups: (<=2.5; >2.5–5.0; >5.0–7.5; >7.5. Patients then classified by # RBC received within 1st 24 hours (< 6 or >= 6). AUROC to predict need for >= 6 RBC. <i>p</i> < 0.05, proportional hazards regression for risk ratios.	Mean serum lactate 3.2, mean ISS 17.5, 10.9% of the sample received >= 6 RBC's in 1st 24 hours. Serum lactate better predictor of MT than ED BP (AUC 0.76 vs 0.60, <i>p</i> < 0.0001) or pre-hospital BP (AUC 0.72 vs 0.61, <i>p</i> = 0.0025). In those with ED BP, two-fold increase in risk of MT for patients with serum lactate of >2.5–5.0 as compared to those with lactate of <= 2.5 (RR 1.9; 95% CI 1.3–2.7) Increases in risk also observed for patients with lactate >5.0–7.5 (RR 3.2, 95% CI [2.2,4.7]) and >7.5 (RR 5.2, 95% CI 3.5–7.7) (<i>p</i> < 0.0001). In patients with pre hospital SBP, two-fold increase in risk for MT in those with lactate in range of >2.5–5.0 (RR 1.7, 95% CI [1.1,2.7]), in patients with lactate >5.0–7.5 (RR 3.1, 95% CI [1.8,5.2]) and >7.5 (RR 4.2, 95% CI [2.6,6.9]) (<i>p</i> < 0.0001) Serum lactate is better predictor than SBP prehospital or on arrival.	1	IV
Wijaya, R., Cheng, H., & Chong, C. (2016). The use of massive transfusion protocol for trauma and non-trauma patients in a civilian setting: What can be done better? <i>Singapore Medical Journal</i> , 57(5), 238–241. https://doi.org/10.11622/smedj.2016088	The aim was to study the efficacy and outcomes of a new MTP in acute surgical care units for trauma and nontrauma patients.	Retrospective chart review. IRB approved via email from author. <i>n</i> = 46 patients with MTP activation. Hospital in Singapore.	Used ABC to predict need for MTP.	Of 28 trauma patients, 19 had ABC score of 2 or higher. when an ABC score of 2 or higher used to predict MTP, had sensitivity of 82% and specificity of 41% in predicting need for MT.	2	VI
Yücel, N., Lefering, R., Maegele, 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. <i>The Journal of and Acute Care Surgery</i> , 60(6), 1228–1237. https://doi.org/10.1097/01.a.0000220386.84012.bf	“To develop a simple scoring system that enables an early and reliable estimation for the probability of massive transfusion (MT) as a surrogate for life threatening hemorrhage following multiple trauma”.	Prospective multi-center database from 100 participating hospitals. Approved by the German Trauma Society Review Board. Trauma Registry Society. 1993–2003; <i>n</i> = 4527 patients.	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.	Using a TASH-Score >16 as a cut-off for a binary prediction rule; probability of MT > 50%, 88.8%/89.6% of patients classified correctly in the development/validation set. Using >10 and >16 as TASH-score positive predictive value of 36 to 61% validation set. Additionally, >27 (max score) 100% prediction value.	1	VI
Yumoto, T., Iida, A., Hirayama, T., Tsukahara, K., Shiba, N., Yamanouchi, H. ... Yoshihito, U. (2014). Immediate screening method for predicting the necessity of massive transfusions in trauma patients: A retrospective single-center study. <i>Journal of Intensive Care</i> , 2(1), 54. https://doi.org/10.1186/s40560-014-0054-3	Create a simplified screening tool to predict MT at early point in trauma case.	Retrospective cohort, data from 2011–2013. IRB approved. <i>n</i> = 259. University hospital in Japan, university hospital IRB.	MT= 10 >= units PRBC in first 24 hours after arrival to hospital. age, sex, MOI, HR, SBP, base excess, lactate, HGB on arrival, results of FAST exam, any pericardial effusion, intrathoracic fluid or intraabdominal fluid, ISS, total amount transfused products, outcome at discharge. Categorical variables compared with Fisher's exact test, continuous with t-test if normal distribution and Mann Whitney U if non-normal, multiple logistic regression for independent predictors of need for MT and AUROC curve. <i>p</i> < 0.05 significant.	High SI (OR 259.81 [95% CI 17.85–3782.4], <i>p</i> < 0.001], reduced BE (OR 0.72 [95% CI [0.58,0.89], <i>p</i> < 0.02]) and + FAST (OR 7.28 [95% CI [2.24,23.61], <i>p</i> < 0.001]) exam predictors of MT. Developed scoring system where each element given one point, overall score 0–3.	1	IV

GRADING THE QUALITY OF THE EVIDENCE

1. Acceptable Quality: No concerns
2. Limitations in Quality: Minor flaws or inconsistencies in the evidence
3. Major Limitations in Quality: Many flaws and inconsistencies in the evidence
4. Not Acceptable: Major flaws in the evidence

GRADING THE LEVELS OF THE EVIDENCE (MELNYK & FINEOUT-OVERHOLT, 2015)

- I. Evidence from a systematic review or meta-analysis of all relevant, randomized, controlled trials or evidence-based clinical practice guidelines based on systematic reviews of RCTs
- II. Evidence obtained from at least one properly designed, randomized, controlled trial
- III. Evidence obtained from well-designed controlled trials without randomization
- IV. Evidence obtained from well-designed case control and cohort studies
- V. Evidence from systematic reviews of descriptive and qualitative studies
- VI. Evidence from a single descriptive or qualitative study
- VII. Evidence from opinion of authorities and/or reports of expert committees

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. <i>Expert Review of Hematology</i> , 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 = increased 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 are 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. <i>The Journal of Trauma and Acute Care Surgery</i> , 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 MTS 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. <i>Journal of Trauma and Acute Care Surgery</i> , 74(1), 59–68. https://doi.org/10.1097%2FATA.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, $p < 0.0005$, 95% CI [2.6,5.8]).
Cantle, P., & Cotton, B. (2017). Prediction of massive transfusion in trauma. <i>Critical Care Clinics</i> , 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.A., Faz, G., Hatch, Q.M., Radwan, Z.A., Podbielski, J., Wade, C., ... Holcomb, J.B. (2011). Rapid thromboelastography delivers real-time results that predict transfusion within 1 hour of admission. <i>Journal of Trauma, Injury, Infection and Critical Care</i> , 71(2), 407–417. https://doi.org/10.1097/TA.0b013e31821e1b70	Evaluate the timeliness of rapid thromboelastography (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. <i>European Journal of Trauma and Emergency Surgery</i> , 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 severe 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. <i>Vox Sanguinis</i> , 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 emergency department. 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 patient.	Increased incidence of acute post-traumatic coagulopathy is present upon emergency department 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. <i>Transfusion Medicine and Hemotherapy</i> , 39(2), 85–97. https://doi.org/10.1159/000337243	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. <i>Injury</i> , 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 center.	Median ISS 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 ISS, 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. <i>Vox Sanguinis</i> , 102(4), 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. <i>Journal of Intensive Care</i> , 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 increased 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. <i>Journal of Trauma and Acute Care Surgery</i> , 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. <i>Injury</i> , 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. <i>Critical Care</i> , 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. <i>Archives of Trauma Research</i> , 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. <i>The American Surgeon</i> , 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.