Key components of an effective massive transfusion protocol

Kellie Katherine Schoenlein

The University of Toledo
Key Components of an Effective Massive Transfusion Protocol

Kellie Katherine Schoenlein

The University of Toledo

2012
Dedication

I would like to dedicate this paper first and foremost to our amazing God for His ever present strength and guidance. To my amazing fiancé, William, I dedicate this for his ever persistent encouragement to always do my best and to never give up. Lastly, I dedicate this to my family and friends for their continued and unconditional love and support as I have been incessantly blazing the academic trail to achieve my dream of becoming a Physician Assistant.
Acknowledgments

Very special thank you to my Project Advisor, Karen Brenner, RN, BSN for her patience, input, and support as the project evolved over the last year. Also, thank you to my fiancé, William, for his dedicated proofreading and encouragement.
Table of Contents

Introduction…………………………………………………………………………………………1

Methods……………………………………………………………………………………………5

Ideal Ratio of FFP:PRBCs…………………………………………………………………………6

Transfusion Triggers…………………………………………………………………………………9

Performance Improvement Initiatives…………………………………………………………14

Conclusion………………………………………………………………………………………17

References………………………………………………………………………………………19

Abstract…………………………………………………………………………………………23
Introduction

Trauma is still a leading cause of death and disability in adults today despite advances in medical resuscitation and surgical management (Mathers & Loncar, 2006). The “lethal triad” of trauma consists of acidosis, hypothermia, and coagulopathy which when present simultaneously suggest an imminent death (Holcomb et al, 2007). Blood loss accounts for 51% of trauma related deaths occurring during the initial 48 hours after admission (Teixeria et al., 2009). Massive transfusion, defined as receiving >10 units of packed red blood cells (PRBCs) within 24 hours, contributes to high mortality rates in patients with trauma. Only 3-5% of all trauma patients require massive transfusion, however the rate of mortality is 39% for those receiving >10 units of PRBCs in the first 24 hours (Nunez, Young, Holcomb, & Cotton, 2010; Shaz, Dente, Harris, MacLeod, & Hillyer, 2009).

In the past, most attempts at resuscitation of patients requiring massive transfusion have been targeted at correcting only acidosis and hypothermia with initial resuscitation efforts. These past massive transfusion strategies treated coagulopathy only after major aggressive resuscitation attempts. Until recent years, it was thought that the third component of the lethal triad, coagulopathy, could only be acquired in trauma patient due to medical attempts to resuscitate such as hemodilution via the administration of crystalloids, colloids, and stored blood. A study by Maegele and colleagues in 2007 demonstrated that >40% of patients who received >2L and >70% of patients who received >4L of crystalloid prior to admission demonstrated coagulopathy upon presentation to the Emergency Department (ED) (Maegele et al., 2007). In the same group, researches identified that 10% of patients who received <500mL crystalloid before presenting to the ED also demonstrated significant coagulopathy upon admission (Maegele et al., 2007). A similar study done in 2003 found that 25% of trauma patients present to the ED with
coagulopathy even before any significant fluid administration (Brohi, Singh, Heron, & Coats, 2003).

There is now significant data suggesting that coagulopathy in some instances may be due to the trauma itself rather than simply acquired through aggressive attempts at fluid resuscitation. This concept of Early Trauma Induced Coagulopathy (ETIC) has been found to be a significant predictor of mortality when present and must be treated by Emergency and Trauma personnel quickly and appropriately (Shaz et al., 2009). The discovery of ETIC called for changes to past strategies for resuscitation of massively hemorrhaging trauma patients which relied largely on the early administration of crystalloid and colloid to correct for acidosis and hypothermia with correction of coagulopathy only much later. Coagulopathy in trauma is now understood to be associated with larger and more costly blood product consumption and a greater incidence of multi-organ dysfunction and death. The development and implementation of a massive transfusion strategy that effectively manages coagulopathy much earlier in the resuscitation of massively hemorrhaging trauma patients is crucial to improving mortality and decreasing blood product consumption.

Much of what is known and practiced in the resuscitation of trauma patients today comes from research done by Military Physicians in the resuscitation of military personnel with combat injuries in Iraq and Afghanistan. Military Physicians have reported that specific resuscitation protocols that involve early delivery of standardized ratios of Fresh Frozen Plasma (FFP): PRBC with minimal use of crystalloids results in a significant reduction in combat-related mortalities in Iraq and Afghanistan (Cotton et al., 2008). One study done at a combat support hospital even suggests implementing a protocol that administers a ratio of FFP:PRBC as high as 1:1 (Borgman et al., 2007). This theory is based on the concept of transfusing an FFP:PRBC ratio more similar
to the composition of whole blood and would subsequently contain many of the necessary clotting factors needed to adequately correct for ETIC.

It has been suggested that the development and implementation of similar Massive Transfusion Protocols (MTPs) with standardized transfusion ratios of FFP:PRBC in civilian trauma centers would result in many of the same benefits demonstrated in the military setting such as appropriate volume and blood product ratio availability, effective management of coagulopathy, and decreased mortality rates. Many Level I Trauma Centers throughout the country and world have established such protocols based somewhat loosely on combat facility research regarding MTPs. Despite significant amounts of retrospective studies, to date there is limited prospective data available to guide clinicians in regards to the optimal ratio of blood products for massive transfusion (Nunez et al., 2010). Additionally, the implementation of MTPs in civilian hospitals and trauma centers seem to be much more complex than in combat facilities with the requirement of a multidisciplinary approach involving surgeons, anesthesiologists, transfusion medicine specialists, and critical care personnel (Cotton et al., 2008). Standardized MTPs that efficiently correct for coagulopathy are difficult to establish and ultimately resuscitation protocols continue to vary widely between trauma centers with ratios of FFP:PRBC ranging from 1:1 to 1:10 (Hirshberg et al., 2003; Cotton et al., 2008; Gonzalez et al., 2007).

Despite the significant evidence of the adverse effects of coagulopathy on morbidity, mortality, and blood product consumption, there has yet to be a universal standardized protocol effectively guiding the management of acute blood loss and the associated coagulopathies in trauma patients. Massively transfused trauma patients account for 75% of all blood products consumed in trauma centers (Nunez et al., 2010). The development of a universal massive transfusion strategy that would promote communication between clinical and transfusion
personnel and allow for effective and early identification of patients requiring mass transfusion would ensure that the blood products are ready without overuse, waste, or delay in preparation (Sherman & Macivor, 2012). The trauma community continues working toward the development of a massive transfusion strategy that decreases mortality and blood product consumption. This article aims to identify the key components of an effective Massive Transfusion Protocol.
Methods

Many peer-reviewed journals from years 2003-2012 were reviewed via PubMed for current massive transfusion strategies. Journals were selected based on relevance to the clinical topic: Key Components for the Development of an Effective Massive Transfusion Protocol. Keywords included: Massive Transfusion Protocol, ETIC, Trauma, Damage Control Resuscitation, TASH, and Performance Improvement. All studies from 2003-2012 that matched the search criteria were considered for use in this review article. Due to limited randomized, controlled clinical trials regarding this clinical topic, many retrospective cohort studies were utilized. Exclusion criteria included studies that evaluated or included the use of cryoprecipitate or rFVIIa as there is not yet enough data to support their use in MTPs. Studies including the use of platelets were included, however recommendations as to the incorporation of platelets into MTPs is not included in this research article due to insufficient data and focused nature of this article.
Ideal Ratio of FFP:PRBCs

Much of what is known and practiced in the resuscitation of massively hemorrhaging trauma patients today comes from research done by Military Physicians in the resuscitation of military personnel with combat injuries in Iraq and Afghanistan. Before the research done by Military Physicians, many massive transfusion strategies did not implement the transfusion of FFP until the massively hemorrhaging patient had received >6 units of PRBC. Previously, it was believed that post-traumatic coagulopathies developed only as a result of resuscitation-related hemodilution and consumption of clotting factors (Gonzales et al., 2007). Borgman et al. demonstrated the benefit of resuscitating with high ratios of FFP:PRBC through their study of massively hemorrhaging military personnel (2007). The researchers reported that those transfused with FFP:PRBCs at a ratio of 1:8 had a mortality rate of 65% while those transfused at a ratio of 1:1.4 experienced a significantly reduced mortality rate of only 19% (Borgman et al., 2007). Since then, multiple retrospective studies have shown similar results all indicating that using high ratios of FFP:PRBC early in the resuscitation of massively hemorrhaging patients leads to decreased mortality.

A study by Teixeria et al. sought to identify the optimal ratio of FFP:PRBC by retrospectively analyzing mortality rates and FFP:PRBC ratios for massively transfused trauma patients admitted to their facility from 2000-2005 (2009). Using logistic regression analysis, the researchers identified that ratios of FFP:PRBC of >1:3 offered decreased mortality and predicted survival with 80% sensitivity and 65% specificity (Teixeira et al., 2009). For their cohort, the average FFP:PRBC was 1:2.1 for survivors and 1:3.7 for non-survivors demonstrating the significant survivor benefits of high ratios of FFP:PRBC. In 2008, another small cohort study utilizing multivariate analysis was performed by Gunter et al. using 30-day survival as an
outcome variable to determine if the ratio of FFP:PRBC had an effect on mortality (2008). The group found that patients who received ratios of FFP:PRBC of ≥2:3 had a 21% reduction in 30-day mortality as compared to patients who received a ratio of <2:3 (Gunter et al., 2008). Interestingly, patients who received FFP:PRBC at ratios of 1:1 did not have any further reduction in mortality than those patients transfused at a ratio of 2:3 (Gunter et al., 2008). This study suggests that although transfusing a ratio of ≥2:3 has statistically significant benefits on mortality, there may be no additional benefit to transfusing even higher ratios of FFP:PRBC such as 1:1.

Multiple studies have retrospectively demonstrated the benefits of transfusing high ratios of FFP:PRBC in patients with laboratory demonstrated coagulopathy. Experts in the field have expressed skepticism regarding the benefits of correcting for coagulopathy via high ratios of FFP:PRBC in all trauma patients being that only 1 in 4 have been shown to demonstrate laboratory confirmed coagulopathy at admission. In 2011, Brown et al. set out to determine if standardized MTPs utilizing high ratios of FFP:PRBCs at ≥1:2 would have beneficial effects for all trauma patients requiring massive transfusion regardless of laboratory confirmed coagulopathy (2011). The researchers used the International Normalized Ratio (INR) in order to evaluate degree of coagulopathy and compare it with the ratio of FFP:PRBC utilized and the probability of death after 24 hours. After correcting for Injury Severity Score (ISS), which is known to be associated with increased rates of coagulopathy and higher mortality, the researchers demonstrated that the probability of death after 24 hours was decreased in all patient groups despite variations in INR on admission when ratios of ≥1:2 of FFP:PRBC were achieved. This finding confirms the suspected benefits of correcting for coagulopathy via a standardized
MTP that utilizes high ratios of FFP:PRBC in all trauma patients requiring massive transfusion early in the resuscitation process despite normal coagulation parameters on admission.

Much more research needs to be undertaken in order to identify the single best ratio of FFP:PRBC for the correction of ETIC in massively hemorrhaging trauma patients. Until such research can be undertaken, currently available data clearly indicates the benefits of transfusing FFP:PRBC in ratios between 1:2 and 2:3. Such ratios should be the transfusion target for the resuscitation of all massively hemorrhaging trauma patients and incorporated into all Massive Transfusion Protocols at this time.
Transfusion Triggers

The beneficial effects of high FFP:PRBC transfusion ratios on combating mortality in a massively hemorrhaging trauma patients is clear; however, specific indicators that would trigger clinicians to initiate an MTP remains a significant challenge in the development of an effective protocol (Maegele et al., 2011). The ability to rapidly and consistently recognize need for massive transfusion and correction of ETIC would allow for activation of an MTP much earlier in the resuscitative process and subsequently lead to decreased overall blood product consumption (Davis, Johannigman, & Pritts, 2012). Currently, criteria for the initiation of MTPs are highly center and provider dependent with no standardized algorithms or key laboratory values that indicate a definitive need for massive transfusion (Callcut, Johannigman, Kadon, Hanseman, & Robinson, 2011). In the past, transfusion triggers such as hemoglobin (Hgb) <8 g/dL, Protime (PT) >1.5 times normal, platelet count <50,000/μL, and fibrinogen <100 g/dL were used to indicate the need for massive transfusion (Shaz et al., 2009). Unfortunately, these transfusion triggers were established in patients undergoing elective surgery and are most likely not applicable to patients with severe trauma who are experiencing massive blood loss and subsequent coagulopathy (Borgman et al., 2007).

Today, most MTPs are activated by trauma attending physicians who anticipate the need for massive transfusion based primarily on clinical judgment. Geeraedts et al. retrospectively analyzed the effects of this so-called “blind” transfusion consisting of resuscitation based on clinical assessment of need without regard to laboratory data (2007). The study reviewed data on 17 patients who died from massive hemorrhage within 24 hours of admission and had received >12 units of PRBCs. When analyzing the actual transfused ratio of FFP:PRBC, researchers found that 82% of patients had received less than the recommended 1:2 ratio of FFP:PRBC at
that facility (Geeraedts et al., 2007). Many hospitals practice this form of clinical assessment to identify need for mass transfusion; however, clinicians often underestimate the need for replacement of coagulation factors.

There has been a call by the trauma community in recent years to identify a more reliable system for predicting the need for massive transfusion so as to allow for appropriate preparation of blood products and consistent activation amongst trauma centers. One suggested transfusion trigger is the ISS, an easily calculable score ranging from 0-75 assigned to all trauma patients based on anatomical injury severity and location. In 2007, Maegle et al. utilized the German Trauma Registry to compare ISS with the presence of coagulopathy upon admission (2007). In the study of 8724 trauma patients, researchers found coagulopathy was present on admission in 26% of patients with ISS of 16-24, 42% of patients with ISS of 25-49, and 70% of patients with ISS >50 (Maegele et al., 2007). ISS is already being used in hospitals across the world and has been shown in the study by Maegele et al. and multiple others to be associated with higher rates of coagulopathy and subsequent mortality. Research analysis of ISS thus far has only concluded that there is an association between the presence of coagulopathy with increasing scores and has failed to demonstrate any usefulness in predicting actual need for massive transfusion.

Military physicians have similarly been attempting to standardize protocols so as to recognize the need for massive transfusion more consistently and readily. Combat research has reported the potential usefulness of five transfusion triggers: INR >1.5, Systolic Blood Pressure (SBP) <90 mmHg, Hgb <11 g/dL, Base Deficit (BD) ≥6, and Temperature <35.5°C. A study by Calcutt et al. sought to evaluate the usefulness of these five potential transfusion triggers in civilian hospitals (2011). Of the five variables, researchers identified SBP <90 mmHg and INR >1.5 as being the most useful with 89% and 95% specificity in predicting actual need for
massive transfusion respectively (Callcut et al., 2011). Although highly specific, the sensitivities for these transfusion triggers were only 50% and 39% for SBP and INR respectively (Callcut et al., 2011). Based on these low sensitivities, one can conclude that if SBP or INR were used as a sole transfusion trigger many patients who would actually require massive transfusion would be missed. Additionally, using laboratory data such as the INR that requires an average of 40 minutes to obtain demonstrates obvious pitfalls to the usefulness of such transfusion triggers. Death occurs within the first 15 minutes of arrival to the hospital in 35% of trauma patients so any delay in assessment of need for massive transfusion has potentially catastrophic outcomes (Nascimento et al., 2011). Although the concept of a transfusion trigger seems promising in that it would allow for the standardization of MTP implementation and utilization, more research needs to be done to conclude if single trigger can be both specific and sensitive enough to predict need for massive transfusion.

With no single transfusion trigger proving to date to be an effective sole predictor of a need for massive transfusion, it has been suggested that the development and implementation of a specific massive transfusion predictive model that would identify, treat, and correct for coagulopathies very early and consistently in the resuscitation process may be another possible solution. The trauma associated severe hemorrhage score (TASH-Score) is a specific massive transfusion predictive model developed in 2006 by Yucel et al. that uses seven variables readily available within 15 minutes of arrival to the Emergency Room and has been proven to easily and quickly determine the likelihood of a trauma patient to require a mass transfusion (Maegele et al., 2011). The predictive model comes out of a study that utilized data collected from the German Trauma Registry on 6044 severely injured patients from 1993-2003. Bivariate and multivariate analysis of clinical and laboratory data identified seven variables as independent
predictors for a need for massive transfusion: sex (male), SBP, HR, Hgb, BD, and relevant injuries to the abdomen and extremities (AIS >3). These seven variables were then used to develop the TASH-Score, which assigns patients a score from 0-28 based on the seven aforementioned variables, where each score correlates to a certain percent risk for mass transfusion (Maegele et al., 2011). In both the development and validation stages, the TASH-Score predictions for requiring massive transfusion were found to be 88.8% and 89.6% accurate in predicting actual need for massive transfusion (Yucel et al., 2006). In a revalidation study of the TASH-score using data again from the German Trauma Registry from 2004-2007, Maegele et al. found that a TASH-Score >18 indicated a 50% chance of a patient to require a massive transfusion while a score ≥24 indicated a >85% chance for requiring mass transfusion (2011).

A standardized predictive model that utilizes readily available data and would indicate the potential need for massive transfusion as early as possible would allow for the following steps that lead up to actual transfusion to be initiated as early as possible (Yucel et al., 2006). The TASH-score is validated and appears to be easily calculable further supporting the implementation of such a user-friendly scoring system into MTPs in order to initiate resuscitation efforts much more rapidly and consistently. Additionally, the score has potential usefulness not only in trauma centers but also smaller hospitals being that the data used in the score does not require sophisticated equipment or a significant time delay to obtain (Yucel et al., 2006).

Despite the score’s potential benefits at predicting need for mass transfusion, the predictive model has only been evaluated in a retrospective manner. Prospective clinical trials evaluating the usefulness of a scoring system, like TASH, need to be undertaken. If the effectiveness of such a scoring system can be shown to consistently decrease mortality rates and
blood product consumption then it could be used more confidently in Trauma Centers and Emergency Departments.
Performance Improvement Initiatives

Developing an MTP that maintains not only an adequate ratio of FFP:PRBCs but also is easily and consistently activated when necessary and appropriate is difficult to establish. Such a protocol requires rapid communication amongst the Trauma Team, Emergency Room Physicians, Anesthesiologists, and Blood Bank personnel. Additionally, it has been proposed by Gunter and colleagues that an effective Massive Transfusion Protocol requires a Performance Improvement (PI) initiative which entails continuous reviews of all activations of the MTP via a PI program (Gunter et al., 2008). It has been suggested that establishing a PI initiative at every institution that utilizes an MTP would allow for real-time evaluation and continuous improvements to be made to MTPs (Nunez et al., 2010).

The effectiveness of such a PI process at improving MTP compliance and outcomes on blood product consumption and mortality was investigated by Cotton and colleagues in a study done at Vanderbilt University Medical Center (VUMC). The PI program initiated at VUMC involved the prospective data collection on all MTP activations at their facility including patient demographics, laboratory data, blood product utilization data, ISS, and outcome data (Cotton et al., 2009). The data was then evaluated by the Blood Bank Director on a weekly basis and forwarded to Trauma and Anesthesia personnel who evaluated the data for any urgent issues that needed immediate attention or correction. The aforementioned multidisciplinary team would then meet on a quarterly basis to evaluate each individual MTP activation for any case-by-case issues. The team would also assess overall quarterly protocol compliance with the specific MTP requirements established at their institution. Following each quarterly review, the team would then conduct meetings and conferences or deliver specific provider education based on outcomes from the quarter in order to improve any areas of noncompliance. Prior to implementation of the
MTP at VUMC, the multidisciplinary team established seven protocol requirements which were deemed essential to the overall usefulness of the protocol. The team decided that in order for an activation to be considered compliant, all seven requirements must have been met.

Cotton et al. reported the findings of the PI initiative undertaken at VUMC evaluating 125 MTP activations during the two year, eight quarter study period (2009). Researchers found that only 27% of all activations during the two year study period satisfied all seven protocol requirements and were classified as being compliant. Of the non-compliant activations, 73% had at least one violation and 46% had more than one. Although only about a quarter of the activations during the two year study were considered compliant, the benefits of utilizing a PI process to improve MTP compliance were demonstrated. By comparing overall compliance with eighth quarter compliance rates, researchers demonstrated that six out of the seven protocol requirements were improved in the eighth quarter compared to the overall (Cotton et al., 2009). It can be assumed that the workshops, meetings, and individual provider education all helped to increase protocol awareness and encourage compliance.

The benefits of protocol compliance at VUMC on mortality and blood product consumption were also demonstrated. Researchers found a significant improvement in 30-day survival rates between the compliant versus the noncompliant group at 88% versus 45% 30-day survival respectively (Cotton et al., 2009). Blood product consumption during the initial 24 hours was also decreased in the compliant group with 14 units transfused versus 20 units transfused in the non-compliant group (Cotton et al., 2009). As predicted, simply remaining compliant with the established MTP achieved decreased mortality and blood product consumption.
Initiating a PI program that continuously evaluates an MTP is certainly a key component of an effective MTP. Protocol compliance alone demonstrated a significant decrease in both mortality and blood product consumption and PI initiatives demonstrated the ability to improve protocol compliance. Such an initiative would provide opportunities for prospective data collection promoting environments conducive for clinical research involving MTP outcomes and ideal transfusion ratios. Without a review system that continuously evaluates key MTP outcomes, the effectiveness of a protocol cannot be determined and the facility is no better off with a protocol than without one.
Conclusion

In 2009, Riskin et al. evaluated mortality and blood product consumption for two years before and two years after an MTP was implemented at their Level I Trauma Center (2009). The researchers found that although both the pre and post-MTP groups transfused FFP:PRBC at a 1:1.8, the mortality rates actually decreased from 45% in the pre to 19% in the post-MTP group (Riskin et al., 2009). The time it took from patient arrival to the ED to transfusion of the first cross-matched PRBC was also significantly decreased from 115 minutes in the pre to 75 minutes in the post-MTP group, demonstrating a 39% improvement (Riskin et al., 2009). Being that both groups utilized the same FFP:PRBC ratio known to independently decrease mortality, it seems as though simply having an MTP in place offered beneficial effects on mortality. The implementation of an MTP at a Trauma Center or Hospital increases awareness amongst health care personnel regarding the importance of implementing resuscitation strategies early in the acute hemorrhagic process and improves communication amongst all health care disciplines involved in the transfusion of trauma patients.

Developing and defining a single best massive transfusion strategy is difficult if not nearly impossible to achieve. Trauma patients present in many different ways and with many different injuries. Additionally, prospective, randomized controlled research trials are difficult to complete and still find valuable data as only 3-5% of all trauma patients actually require massive transfusion (Holcomb et al., 2007). Until randomized, controlled clinical trials can be undertaken, all MTPs should utilize at least a 1:2 ratio of FFP:PRBC in order to adequately correct for coagulopathy in massively hemorrhaging trauma patient based on the beneficial findings of previous retrospective cohort studies. It is difficult to establish a predictive model without a randomized, controlled clinical trial, but the TASH-Score seems very promising. Until
sufficient data can be obtained to support the clinical usefulness of predictive scoring systems like the TASH-Score and other transfusion triggers, Trauma Attendings should continue using their clinical judgment. Timely notification of the blood bank regarding need for massive transfusion as early as possible remains essential so as to allow adequate blood product preparation. To eliminate further delays in transfusion due to thawing of FFP, all Trauma Centers should maintain a minimum 4 units of thawed AB plasma at all times. Lastly, to ensure MTP effectiveness at individual institutions, all MTP activations should be reviewed on a case-by-case and quarterly basis by a multidisciplinary Performance Improvement committee.

Massive transfusion protocols are very complex and require extensive planning and communication amongst those who utilize the strategy. An efficient and effective MTP must allow for adequate control of coagulopathy, early assessment and identification of patients who may potentially require an MTP, and a solid foundation for communication amongst health care personnel. Ensuring that adequate FFP:PRBC ratios are being utilized, analyzing turnaround times for blood products and laboratory results, and evaluating of the effectiveness of the protocol at decreasing mortality and blood product consumption via Performance Improvement initiatives will all contribute to continued improvements to current MTPs. The significant benefits of a Massive Transfusion Protocol are evidenced in the current literature and the need for a standardized protocol at trauma centers across the US and world remains. Until a protocol can be proven beneficial by prospective, randomized controlled clinical trials, variations will continue to persist amongst Massive Transfusion Protocols.
References


Maegele, M., Lefering, R., Yucel, N., Tjardes, T., Rixen, D., Paffrath, T., . . . Bouillon, B.
(2007). Early coagulopathy in multiple injury: an analysis from the German Trauma
Registry on 8724 patients. Injury, 38(3), 298-304.

2002 to 2030. PLoS Medicine, 3(11), e442.

Nascimento, B., Rizoli, S., Rubenfeld, G., Lin, Y., Callum, J., & Tien, H. C. (2011). Design and
preliminary results of a pilot randomized controlled trial on a 1:1:1 transfusion strategy:
the trauma formula-driven versus laboratory-guided study. Journal of Trauma, 71(5
Suppl 1), S418-426.

Nunez, T. C., Young, P. P., Holcomb, J. B., & Cotton, B. A. (2010). Creation, implementation,
and maturation of a massive transfusion protocol for the exsanguinating trauma patient.
Journal of Trauma, 68(6), 1498-1505.

Riskin, D. J., Tsai, T. C., Riskin, L., Hernandez-Boussard, T., Purtill, M., Maggio, P. M., . . .
versus product ratio in mortality reduction. Journal of the American College of Surgeons,
209(2), 198-205.

Shaz, B. H., Dente, C. J., Harris, R. S., MacLeod, J. B., & Hillyer, C. D. (2009). Transfusion


Abstract

**Objective:** The purpose of this clinical review was to identify the key components of an effective massive transfusion protocol. **Method:** PubMed database was reviewed with keywords including “Massive Transfusion Protocol”, “ETIC”, “Trauma”, “Damage Control Resuscitation”, “TASH”, and “Performance Improvement”. **Results:** Research shows that an effective MTP should maintain a transfusion ratio of FFP:PRBC between 1:2 and 2:3. Although the future looks promising for the utilization of transfusion triggers and scoring systems, clinical judgment should continue to be the mainstay for predicting need for massive transfusion. All MTPs should be implemented along with a Performance Improvement initiation so as to evaluate the effectiveness of the resuscitation strategy. **Conclusion:** Retrospective data shows definitive advantages to implementing an effective MTP when certain key components are met. Until further prospective, randomized clinical trials can be undertaken, MTPs will continue to vary widely amongst Trauma Centers.