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MASSIVE TRANSFUSION FOR COAGULOPATHY AND HEMORRHAGIC SHOCK

Evidence Based Medicine Guideline

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SUMMARY

Exsanguination is a leading cause of early death following traumatic injury. Protocol-driven transfusion strategies that approach a 1:1:1 [packed red blood cell (PRBC), fresh frozen plasma (FFP), and platelet (PLT)] ratio in patients who require massive transfusion improve patient survival, reduce hospital / intensive care unit (ICU) length of stay, decrease ventilator days, and reduce patient care costs.

RECOMMENDATIONS

- **Level 1**
  - **Recombinant factor VIIa may reduce blood product administration, but does not improve survival.**

- **Level 2**
  - **Administer blood products in a ratio of 1:1:1 (PRBC:FFP:PLT).**
  - **In patients requiring massive transfusion of blood products, minimize crystalloid resuscitation to prevent dilutional coagulopathy.**
  - **Platelet transfusions are indicated in the following situations:**
    - **Neurosurgical procedures with PLT count <100,000.**
    - **Surgical / obstetric patients with microvascular bleeding and PLT count <50,000.**
    - **Any surgical patient with PLT count <20,000.**
  - **FFP (10-15 ml/kg) is indicated in the following situations:**
    - **Hemorrhage with elevated PT or PTT (> 1.5 times normal).**
    - **Urgent reversal of warfarin therapy (see "Warfarin Reversal Guideline")**
  - **Cryoprecipitate should be administered in the following situations:**
    - **Hemorrhage with fibrinogen concentrations <100 mg/dL**
    - **Bleeding patients with von Willebrand's disease.**
  - **Tranexamic acid should be considered in patients with significant hemorrhage**
    - **Initial dose: 1 gram IV over 10 minutes**
    - **A second gram of TXA (either bolus or continuous infusion over 8 hours) may be considered in the presence of ongoing transfusions or hyperfibrinolysis**
  - **Patient arterial pH, temperature, platelet count, and blood pressure should be optimized prior to considering administration of recombinant Factor VIIa for refractory hemorrhage.**

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

DISCLAIMER: These guidelines were prepared by the Department of Surgical Education, Orlando Regional Medical Center. They are intended to serve as a general statement regarding appropriate patient care practices based on the medical literature and clinical expertise at the time of development. They should not be considered to be accepted protocol or policy, nor are intended to replace clinical judgment or dictate care of individual patients.

INTRODUCTION

Patient mortality following traumatic injury has decreased over the past 30 years due to improved damage control procedures. Mortality rates continue to be elevated during the first hours following trauma center arrival, however, among patients with uncontrolled hemorrhage (1). This continued high mortality rate is attributable to ongoing hemorrhagic shock as a result of the self-perpetuating triad of coagulopathy, acidosis, and hypothermia (2). Measures to stop this process have long been a part of trauma resuscitation, including hypothermia management, surgical control of ongoing bleeding, and treatment of coagulopathy with blood products.

In the past decade, there has been a progressive trend towards increased use of blood products during trauma resuscitation, including plasma, platelets, and cryoprecipitate, due to the military experience with whole blood resuscitation in soldiers requiring "massive transfusion". Massive transfusion is universally accepted as the replacement of a patient's blood volume, or transfusion of ≥ 10 units of PRBCs, over a 24-hour period (3-9). Similar "damage control resuscitation" is required in approximately 2-5% of civilian trauma. Such early intervention has been demonstrated to translate into a significant improvement in patient outcome (5-9). Damage control resuscitation is designed to treat coagulopathy prior to its clinical manifestation, therefore stopping the self-perpetuating loop of coagulopathic hemorrhage or the "deadly triad".

The strategy of utilizing higher PRBCs:plasma:platelets ratios is not new and has been shown to have modest improvements in patient mortality (4-6). Most recently, there has been significant interest in protocolization of this transfusion process. Studies demonstrate improved patient outcome with implementation of a massive transfusion protocol (MTP) when compared to physician/lab driven resuscitation (4,5,8,9). This improved mortality has been attributed to reduced time to first transfusion of products, thus addressing the fundamental problem of coagulopathy. Riskin et al. have shown that a protocol-driven process improves communication among departments, improves the availability of and reduces delays in obtaining blood products, and improves patient outcome (5). Additionally, improved outcomes can be attributed to reducing the use of uncrossmatched blood which has been shown to be an independent predictor of mortality (10).

Multiple military and civilian trauma studies of massive transfusion protocols suggest that a 1:1:1 ratio of PRBC to FFP and platelets is optimal and associated with the best outcomes (4,5,8,11-16). Holcomb et al. suggested that trying to achieve a 1:1:1 ratio is optimal as this will most closely approximate a 1:2 goal PRBC:FFP given delays in treatment (6). As for platelets, most studies suggest that transfusing platelets at a 1:1 ratio with PRBCs and trying to achieve a platelet count of greater than 100,000/dL is most beneficial in stopping the coagulopathic cycle and increasing clot formation (5,6). There are a few studies addressing the need for cryoprecipitate and some suggest that transfusing with adequate amounts of FFP will obviate the need for cryoprecipitate (Table 1); however, most studies suggest checking fibrinogen levels in patients who continue to demonstrate coagulopathic hemorrhage with maintenance of a level greater than 100 mg/dL (5,11).

FIBRINOGEN CONTENT IN VARIOUS BLOOD PRODUCTS (11)

1 10 unit cryoprecipitate	2500 mg/150 ml
1 unit of FFP	400 mg/250 ml
1 unit of PRBC	<100 mg
1 six pack of platelets	480 mg
1 unit of apheresis platelets	300 mg
1 unit of whole blood	1000 mg

Identifying patients at risk early is a key difference between damage control resuscitation and MTP driven resuscitation. Patients who arrive at the hospital in profound hemorrhagic shock are easy to identify; it is the patients that arrive relatively stable who are more difficult. Nunez et al. reviewed 596 patients in whom 12.4% met MTP criteria. The need for MTP implementation was identifiable using simple non-laboratory values. Patients with SBP ≤ 90 mmHg or less, positive FAST exam, and heart rate ≥ 120 bpm were more likely to need massive transfusion (17). Mc Laughlin identified four independent factors that were associated with risk for massive transfusion: heart rate > 105 bpm, SBP <110 mmHg, pH < 7.25, and hematocrit < 32% (18). Specific injury patterns that should prompt consideration for implementation of a MTP include liver laceration with hemorrhage, emergent abdominal aortic aneurysm, pelvic fracture with overwhelming blood loss, massive gastrointestinal hemorrhage, and coronary artery bypass grafting.

LITERATURE REVIEW

Massive Transfusion Ratios
Holcomb et al. retrospectively reviewed 466 MTP trauma patients treated from June 2005 to June 2006 at one of 16 Level 1 trauma centers (6). They identified four groups of patients: (1) high plasma and high platelets, (2) high plasma and low platelets, (3) low plasma and high platelets, and (4) low plasma and low platelets. Survival at six hours, 24 hours, and 30 days was recorded. Survival, ICU stay, ventilator free days, and hospital free days were best amongst the high plasma-high platelet group. The best outcomes were in centers with an active MTP in place. Survival was best in patients with plasma to PRBC ratios >1:2 and with platelet ratios of >1:5 (Class II).

O'Keeffe et al. performed a prospective study of patients for two years after MTP implementation compared to patients from the year prior to MTP (4). Improved times to first transfusion were noted. The MTP patients received fewer blood products in the first 24 hours. Most significantly, the evaluation of differences in cost noted a $200,000 savings despite the more frequent use of factor VIIa as a part of their protocol (Class III).

Riskin et al. reviewed their experience two years prior to and post MTP implementation (5). They originally thought they would see a reduction in the ratio of PRBC to plasma, however, the ratios were similar (1:1.8). An increase in survival was noted following MTP implementation. This was attributed to improved communication with the blood bank improving the time to first transfusion of all products. They recommend activation of a MTP for patients with more than four units of PRBCs in one hour or more than 10 units in less than 12 hours. Resuscitation to hemodynamic stability is recommended instead of a particular hemoglobin or hematocrit target (Class III).

Shaz et al. investigated the relationship of plasma:PRBC, PLT:PRBC, and cryoprecipitate:PRBC transfusion ratios to mortality at a civilian Level 1 trauma center (14). This study looked prospectively from 2007 to 2009 at 214 trauma patients who received massive transfusions. High versus low transfusion ratios of FFP, platelets, and cryoprecipitate to PRBCs were associated with improved 30-day survival.

Inaba et al. studied the impact of platelet transfusion in trauma patients undergoing a massive transfusion (15). This study analyzed data from the institutional trauma registry and blood bank databases of a Level I trauma center. 657 trauma patients who received massive transfusion protocols were stratified into a spectrum of four ratios of platelets to PRBCs, lowest to highest. The higher the ratio of platelets to PRBC, the higher the correlated survival at 12 hours and 24 hours after admission, and survival to discharge from the hospital.

Hypothermia
Hypothermia is a frequent pathophysiologic consequence of severe injury and subsequent resuscitation (19). It is estimated that as many as 66% of trauma patients arrive in the emergency department with hypothermia (20).

Gregory et al. found that hypothermia developed at some point in 57% of the trauma patients studied, and that temperature loss was most severe in the emergency department setting (21).

Gentilello classified the severity of hypothermia in the trauma patient as mild (36°C to 34°C), moderate (33.9°C to 32°C), and severe (below 28°C) (19). Body temperatures less than 33°C produce a coagulopathy that is functionally equivalent to factor deficiency states seen when coagulation factor concentrations are less than 50% (19). Thrombin generation on platelets is reduced by 25% at 33°C. The average size of aggregates formed by thrombin-activated platelets was decreased by 40% at 33°C and platelet adhesion was reduced by 33% (20). Adverse clinical effects such as cardiac dysrhythmias, reduction in cardiac output, increase in systemic vascular resistance, and a left shift in the oxygen-hemoglobin saturation curve have been described. Mortality rates as high as 100% are seen in patients with severe hypothermia and severe injury. The most significant effect of hypothermia in trauma is coagulopathic bleeding due to prolonged clotting cascade enzyme reactions, dysfunctional platelets, and fibrinolysis (22,23).

Rewarming Strategies
Rewarming strategies initiated in the emergency department and operating room are aggressively continued in the intensive care unit. Strategies include passive and active external rewarming and active core rewarming.

Passive External Rewarming
Passive external rewarming involves removing blood- or saline-soaked dressings or blankets, increasing ambient room temperature, and decreasing air flow over the patient by keeping the room doors shut.

Active External Rewarming
Active external rewarming devices include fluid/air circulating blankets, aluminum space blankets and overhead radiant warmers. Conductive rewarming with fluid-filled heating blankets placed under the patient is relatively inefficient because of minimal body-blanket contact, estimated to be less than 30%. Convective-air and aluminum space blankets placed over the patient provide greater heat exchange by creating a 43°C microenvironment around the patient, which effectively stops heat loss. Superior warming is achieved when standard cotton blankets are placed over these blankets and the edges secured, although this limits patient access. Head covering is of prime importance; because significant vasoconstriction does not occur in scalp vessels, and as much as 50% of radiant heat loss occurs from the neck up (16). Aluminized caps are effective warmers, but their use is limited in head injured patients with intracranial pressure (ICP) monitors. The effectiveness of overhead radiant warmers is unclear. When aimed directly onto vasoconstricted skin, these warmers may cause inadvertent burns; yet when directed over a blanket, they provide no direct heat exchange to the patient. During laparotomy, it is recommended that covering exposed bowel with moist towels be avoided because it can increase evaporative heat loss by nearly 250% (19). Dry towels or plastic bags are superior.

Core Rewarming
The hypothermic trauma patient requires active core rewarming which may include airway rewarming, heated body cavity lavage, heated intravenous fluids, continuous arteriovenous rewarming (CAVR), and extracorporeal circulatory rewarming. Humidified ventilator circuits can be warmed to 41°C. Heated gastric, bladder, or colonic lavage is relatively ineffective because of the small surface area for heat transfer (19). Peritoneal lavage is generally not feasible in most trauma patients undergoing laparotomy. Rarely, pleural lavage has been used with the placement of two ipsilateral chest tubes enabling continuous flow of heated water.

Use of warmed intravenous fluids is one of the simplest and most effective means of providing heat to the core in patients requiring massive fluid resuscitation. Current fluid warmer technology allows large volumes of warmed fluids to be infused quickly at 42°C, the current standard recommended by the American Association of Blood Bank (24). Blood-warming methods include surface-contact warmers, counter-current warmers, and heated-saline admixture (25). In-line microwave blood-warming technology (in development) has been shown to heat blood safely to 49°C and shows great promise for the future (26).

Cardiopulmonary bypass has limited applicability in trauma patients due to the need for systemic anticoagulation. An alternative is continuous arteriovenous rewarming (CAVR) (27). In CAVR, percutaneously placed 8.5 French femoral arterial and venous catheters, and the patient's blood pressure, create an extracorporeal arteriovenous circuit that uses the heating mechanism of a counter-current fluid warmer. Early studies have shown the greater effectiveness of CAVR in comparison with traditional warming techniques in rapidly rewarming trauma patients with severe hypothermia (25). However, widespread use of this device has been limited due to: 1) the learning curve for involved personnel; 2) the infrequency of use at many trauma centers; 3) its negligible effect on long-term survival; and 4) its associated increase in respiratory distress

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syndrome, length of hospital stay, and cost. Veno-venous bypass, although more complex than arteriovenous systems, can also be performed by using a conventional roller pump to drive blood through a heat exchanger, however, this requires the constant attention of qualified personnel (29).

Acidosis
The association between high lactate levels and increasing risk of death was first described over 40 years ago by Broader and Weil (30). Since then, several investigators have demonstrated increasing risk of death with metabolic acidosis as demonstrated by arterial pH, lactate, and base deficit clearance (31). The deleterious effects of acidosis on the cardiovascular system include decreased cardiac contractility and cardiac output, vasodilation and hypotension, decreased hepatic and renal blood flow, bradycardia, and increased susceptibility to ventricular dysrhythmias (32). Acidosis directly reduces the activity of the extrinsic and intrinsic coagulation pathways as measured by PT and PTT and also diminishes platelet function as measured by platelet aggregation and platelet factor III release (19). These adverse effects are generally not seen until pH decreases below 7.2 (32).

Therapy for metabolic acidosis remains directed toward correcting the underlying hypoperfusion. Resuscitation endpoints include normalization of arterial pH, base deficit, and lactate. In clinical trials, researchers have failed to demonstrate any clear advantage of bicarbonate administration, whereas the potential adverse effects are well documented (24). Bicarbonate administration should be deferred until the pH persists below 7.2, despite optimal fluid loading and inotropic support (34).

Tranexamic Acid
Tranexamic acid is an antifibrinolytic agent that has historically been shown to decrease the need for blood transfusions in patients undergoing elective surgery. In 2010, a multi-national randomized, double-blind placebo-controlled trial (CRASH-2) analyzing 20,127 trauma patients was published. The trial included patients with significant hemorrhage (systolic blood pressure <90 mmHg or heart rate >110 beats per minute, or both) and if they were within 8 hours of injury. The patients received either 1 g of tranexamic acid over 10 min followed by an intravenous infusion of 1 g over 8 hours or placebo. The tranexamic acid group had a significantly lower all-cause mortality at 28 days than the placebo group [14.5% vs. 16%; relative risk (RR) 0.91, 95% CI 0.85-0.97; p=0.0035] (35).

In 2011, the CRASH-2 investigators published an exploratory analysis of the previous trial that specifically evaluated the effect of tranexamic acid on death due to bleeding subdivided by time from treatment to injury. The results showed that earlier treatment with tranexamic acid is more effective in reducing the risk of death due to bleeding. Patients that received tranexamic acid within 1 hour of injury had a death rate due to bleeding of 5.3% versus 7.7% for placebo (RR 0.79, CI 0.64-0.97; p<0.0001). Similarly, patients that received treatment between 1-3 hours from injury also had a significantly lower risk of death due to bleeding. However, patients receiving tranexamic acid >3 hours from injury had a significantly increased risk of death compared to placebo, 4.4% vs 3.1%, respectively (RR 1.44, CI 1.12-1.84; p=0.004) (36).

Of note, only 50% of patients in the CRASH-2 trial received any blood products. A subsequent study, the MATTERs trial, evaluated the effect of tranexamic acid on mortality, blood product utilization and coagulopathy in a retrospective cohort of trauma patients with a combat-related injury requiring at least 1 unit of PRBC. They also evaluated the outcome of a subgroup of patients who required massive transfusion. Tranexamic acid was administered as a 1 gram bolus with repeat doses given as deemed necessary by the managing physician. The mean dose administered was 2.3 ± 1.3 grams. The overall cohort included 896 patients with 293 who received tranexamic acid. The massive transfusion subgroup included 231 patients with 125 that received tranexamic acid. The tranexamic acid group had a higher ISS, a higher incidence of GCS ≤ 8 and SBP ≤ 90 mmHg and more blood product utilization compared to the no-tranexamic acid group. Both the tranexamic group in the overall cohort and the massive transfusion subgroup received significantly more cryoprecipitate than the no-tranexamic acid group. There was significantly lower 48 hour and overall in-hospital mortality in the tranexamic acid group in both the overall cohort (48 hour: 11.3% vs. 18.9%, p=0.004; in-hospital: 17.4% vs. 23.9%, p=0.03) and in the massive transfusion group (48 hour: 10.4% vs. 23.5, p=0.003; in-hospital: 14.4% vs. 28.1%, p=0.004). Tranexamic acid was found to be a significant predictor of survival in the massive transfusion cohort (OR 7.2 [95% CI 3.0-17.3], p<0.001). This study also demonstrated increased coagulation in both the overall and massive transfusion cohorts when comparing labs drawn on admission to the emergency room versus labs obtained on admission to the ICU after operative intervention. There was a higher incidence of pulmonary embolism (2.7% vs. 0.3%, p=0.001) and deep venous thrombosis (2.4% vs. 0.2%, p=0.001) in the tranexamic acid group; however, significant differences between the groups limit the ability to determine if this outcome was related to tranexamic acid administration (37). Given

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the potential confounder of more cryoprecipitate administration in the tranexamic acid group, a second study, the MATTERs II trial, was performed to determine the effect of cryoprecipitate administration in patients with combat injuries requiring at least 1 unit of PRBC. There were 1332 patients identified with 11.1% receiving tranexamic acid alone, 12.6% receiving cryoprecipitate alone, 19.4% receiving both and 56.9% receiving neither. Like the MATTERs trial, there were significant differences in ISS, total blood product administration, and GCS ≤ 8 between the groups. There was a higher mortality in the group that received neither tranexamic acid nor cryoprecipitate. Tranexamic acid alone, cryoprecipitate alone and administration of both were all found to be significant predictors of survival (38).

Hypocalcemia
Calcium plays a significant role in coagulation, platelet adhesion, and contractility of myocardial and smooth muscle cells. It is required by clotting factors II, VII, IX and X as well as proteins C and S for activation at the damaged endothelium. In addition, calcium plays a role in stabilizing fibrinogen and platelets in the developing thrombus (39). Hypocalcemia is known to be common during massive transfusion due to chelation of serum calcium and citrate. This interaction is usually insignificant due to the rapid hepatic clearance of citrate, but in the setting of hemorrhagic shock, the combination of rapidly infused blood products and decreased hepatic clearance due to hypoperfusion and hypothermia may impair the clearance of citrate (40). Severe, ionized hypocalcemia has been defined as <0.9 mmol/L and is associated with increased mortality in critically ill adults, while levels of <0.8 mmol/L have been associated with adverse cardiac effects. Therefore, a threshold ionized calcium [iCa] of <0.9 mmol/L has been proposed as a trigger for intravenous calcium supplementation in critically ill patients (41), however, there is limited data regarding the timing and dosage of calcium supplementation needed after administration of blood products.

In a retrospective study of 156 trauma patients requiring MTP, the incidence of hypocalcemia (iCa <1.12 mmol/L) and severe hypocalcemia (iCa <0.90 mmol/L) were 97% and 71% respectively. Patients received a median of 2 grams of calcium chloride after the initial iCa and neither the severe nor non-severe hypocalcemia groups achieved a normal iCa level on subsequent monitoring. In addition, the final iCa monitored within 24 hours of discontinuation of MTP in both groups did not reach normal levels. This study highlights the importance of vigilant monitoring for hypocalcemia and the need for aggressive supplementation (42).

Intravenous Calcium Products

Salt Form	Elemental Calcium Content per Gram	Considerations
Calcium Gluconate	4.65 mEq	
Calcium Chloride	13.6 mEq	Must be administered via central line

Recombinant Factor VIIa (NovoSeven®) (rFVIIa)
rFVIIa was widely utilized in years past as a treatment for uncontrollable hemorrhage based upon its use and perceived benefit on the battlefield. It is an expensive therapy with a typical dose of 90 mcg/kg costing over $10,000. Recent studies, however, have raised concern over its lack of efficacy and it is no longer considered a first-line therapy for hemorrhage shock. Cannon et al., through the Eastern Association for the Surgery of Trauma (EAST) Practice Guidelines Committee, carried out a meta-analysis in order to answer the following hypothesis: "Should rFVIIa be used as an adjunct to decrease mortality, total blood products used, or massive transfusion?" (43). Two randomized, prospective, placebo-controlled studies and three retrospective studies were investigated. Outcomes examined included hospital mortality, blood product administration, and the need for massive transfusion. In their analysis, rFVIIa did not improve all-cause mortality and the only demonstrated benefit was a possible reduced need for massive transfusion.

Hauser et al. performed a phase 3 randomized clinical trial in 573 patients evaluating the efficacy and safety of rFVIIa as an adjunct to direct hemostasis in major trauma (44). The inclusion criteria included patients who were transfused 4-8 red blood cell units within 12 hours of injury and were still bleeding despite damage control resuscitation and operative management. Enrollment was terminated early because of unexpected low mortality and difficulty consenting and enrolling sicker patients. Mortality was virtually equivalent between rFVIIa and placebo for both blunt (11% vs. 10.7%; p=0.93) and penetrating trauma (18.2% vs. 13.2%; p=0.40). They concluded that rFVIIa reduced blood product usage but did not affect overall mortality.

Knudson et al. performed a case registry report on 380 trauma patients who received rFVIIa and its impact upon death and hemorrhage control (45). Predictors of a poor response to rFVIIa were pH <7.2 (p< 0.0001), a platelet count <100,000 (p=0.046), and blood pressure ≤ 90 mmHg (p<0.0001) at the time of administration. They concluded that surgeons who choose to use rFVIIa as an adjunctive measure to reverse coagulopathy should first correct shock, acidosis, and thrombocytopenia.

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MASSIVE TRANSFUSION PROTOCOL

Patient at risk for uncontrolled hemorrhage

- [ ] Administration of 1 blood volume (~10 units) with need for continued transfusion
- [ ] Risk factors for continued transfusion (positive FAST exam, heart rate > 120 bpm, systolic blood pressure < 90 mmHg, pH < 7.24, hemoglobin < 8 gm)

Obtain laboratory data
Type & Cross, DIC screen, BMP, CBC, ABG, arterial lactate, Mg, ionized Ca, PO4

Establish adequate IV access
2 large bore IVs or central venous catheter

Maintain patient normothermia
Increase room temperature, use warm blankets, implement blood and intravenous fluid warmers

Monitor systemic & regional perfusion
Arterial line, urinary catheter, invasive hemodynamic monitoring as indicated

Activate the Massive Transfusion Protocol (MTP)

Massive blood loss with hemorrhagic shock or metabolic derangements? — No → **Active hemorrhage or coagulopathy?** — No → **Terminate MTP**

Yes ↓ (Massive blood loss)

Yes ↓ (Active hemorrhage)

Level I Resuscitation
- [ ] Blood Bank releases 1 MTP pack to patient's bedside
  - [ ] 6 units pRBC, 6 units FFP, 1 apheresis PLT pack
  - [ ] May be uncrossmatched if crossmatched blood unavailable (subsequent MTP packs should be crossmatched)
- [ ] Transfusion initiated per protocol in 1:1:1 ratio
- [ ] Blood Bank provides new MTP pack to patient bedside every 20 minutes until MTP is terminated by MTP Leader
- [ ] Give tranexamic acid 1 gm IVPB over 10 min
- [ ] Give 3 g CaCl at completion of each MTP pack
- [ ] Repeat labs as needed

Level II Resuscitation
- [ ] Blood Bank releases 1 MTP pack to patient's bedside
  - [ ] 6 units pRBC, 6 units FFP, 1 apheresis PLT pack
  - [ ] May be uncrossmatched if crossmatched blood unavailable (subsequent MTP packs should be crossmatched)
- [ ] Transfusion initiated per protocol in 1:1:1 ratio
- [ ] Blood Bank DOES NOT automatically provide additional MTP packs unless requested
- [ ] Give tranexamic acid 1 gm IVPB over 10 min
- [ ] Give 3 g CaCl at completion of MTP pack
- [ ] MTP pack may be split into component therapy by MTP Leader
- [ ] Repeat labs as needed

Re-evaluate patient for adequate hemorrhage control