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# Outcomes After Massive Transfusion in Trauma Patients: Variability Among Trauma Centers

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ABSTRACT

*Background:* Exsanguinating trauma patients often require massive blood transfusion (defined as transfusion of 10 or more pRBC units within first 24 h). The aim of our study is to assess the outcomes of trauma patients receiving massive transfusion at different levels of trauma centers.

*Methods:* Two-y (2013-2014) retrospective analysis of the American College of Surgeons Trauma Quality Improvement Program. We included all adult trauma patients who received massive transfusion (MT) of blood. Outcome measures were mortality, hospital length of stay, intensive care unit–free and ventilator-free days, blood products received, and complications.

*Results:* We analyzed a total of 416,957 patients, of which 2776 met the inclusion criteria and included in the study. Mean age was 40.6 ± 20 y, 78.3% were males and 33.1% of the injuries were penetrating. Median injury severity score [IQR] was 29 [18-40], median [IQR] Glasgow Coma Scale 10[4-15]. Mean packed red blood cells transfusion in the first 24 h was 20 ± 13 units and mean plasma transfusion was 13 ± 11 units. Overall in-hospital mortality was 43.5%. Receiving MT in level I trauma center was independently associated with lower rates of mortality (odds ratio [OR]: 0.75 [0.46-0.96], $P < 0.001$). Higher injury severity score (OR: 1.020 [1.010-1.030], $P < 0.001$) and increased units of packed red blood cells transfused (OR: 1.067 [1.041-1.093], $P < 0.001$) were independently associated with increased mortality. However, there was no association between teaching status, age, gender, emergency department vitals, and units of plasma transfused.

*Conclusions:* Hemorrhage continues to remain one of the most common cause of death after trauma. Almost half of the patients who received massive transfusion died. Patients who receive massive blood transfusion in a level I trauma centers have improved survival compared with level II trauma centers.



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## Background

Trauma accounts for a significant proportion of crude mortality rates around the globe. In 2000, for instance, the World Health Organization (WHO) reported that about 5 million people died as a result of injuries, accounting for about 9% of the annual worldwide mortality.[1] More specifically, mortality associated with hemorrhage can be as high as 40%; one-third to one-half of such deaths occur during the transition period from the scene of the injury to the hospital.[2] Persistent exsanguinating hemorrhage, coagulopathy of trauma, and/or inadequate resuscitation are primarily responsible for early mortality in the trauma bay or health care facility. Since the 1970s, "massive transfusion" (MT) refers to the transfusion of more than 10 units of blood in a 24-h period.[3] Over the past 2 decades, a significant improvement in massive transfusion survival rates is attributed to the ongoing refinement of the criteria used to define massive transfusion.[4] Massive transfusion protocols (MTPs) in trauma setting were first founded and revolutionized in military theaters to help coordinate large blood volume transfusion. Since then, they have been adapted to fit the civilian trauma setting and facilitate multilayered work processes within hospitals in the presence of a proper infrastructure and optimal resource allocation. Development and implementation of MTPs have been associated with a decrease in mortality and overall blood products consumption in trauma centers.[5] Prediction tools for MT in adult trauma patients have evolved with specificities that range between 80% and 90%. MTP is activated according to best practice guidelines.[6,7]

The American College of Surgeons (ACS) verifies level I, II, and III trauma centers via a standard set of criteria.[8] Currently, however, clinical outcomes of trauma patients are not included in the credentialing process. Moreover, within the trauma system, differences in outcomes between level I and level II trauma centers have not been well identified.[9] The aim of our study was to evaluate differences between level I and level II trauma centers regarding outcomes after a massive transfusion. We hypothesized that patients who received a massive transfusion at a level I trauma center would have improved outcomes compared with those who received a massive transfusion at a level II trauma center.

## Methods

### *Study design and population*

We conducted a 2-y (2013-2014) retrospective analysis of the ACS Trauma Quality Improvement Program (TQIP) database, identifying all trauma patients who received MT, which is defined as the replacement by transfusion of 10 units or more of packed red blood cells (pRBCs) within 24 h. The TQIP database, which includes data from more than 700 contributing hospitals around the nation, provides an opportunity for different trauma centers to compare their processes and quality of care—adjusted and risk-adjusted outcomes. Trained data collectors record more than 100 variables in this database, including patient demographics; comorbid conditions; type and mechanism of injury; injury severity score (ISS); abbreviated injury scale, prehospital and emergency department (ED) physiological variables; in-hospital procedures and complications; and outcome information that includes in-hospital mortality and discharge disposition. This study did not need institutional review board approval because the TQIP contains only de-identified data.

### *Inclusion and exclusion criteria*

The analysis included all adult trauma patients (age $\geq$ 18 y) who received MT in either a level I or level II trauma center. We excluded patients who were transferred from another facility or dead on arrival.

### *Data set*

We collected the following patient data points: demographics (age, gender, and race); mechanism of injury (blunt *versus* penetrating); ISS; ED vital parameters (systolic blood pressure [SBP], heart rate [HR], temperature); Glasgow Coma Scale (GCS); hospital length of stay (LOS); intensive care unit (ICU)—free days; ventilator-free days; mortality; complications (acute respiratory distress syndrome (ARDS), acute kidney injury (AKI), sepsis, venous thromboembolic (VTE) events, or unplanned return to the OR or ICU); and blood products received (pRBCs, plasma, platelets, or cryoprecipitate). Patients were stratified into two groups based on the type of trauma center where they received their primary care at (level I *versus* level II).

### *Outcome measures*

Our primary outcome was the comparative mortality between the two groups. Secondary outcomes included hospital LOS, ICU-free days, ventilator-free days, blood products received, and complications (ARDS, AKI, sepsis, and VTE).

### *Missing data analysis*

We treated missing data for vitals and injury parameters as missing at random, and we performed multiple imputations using a missing value analysis technique to account for the missing values. Multiple imputation is a useful statistical technique that has been used previously for dealing with data sets with missing values.[10] This technique, which has been founded back in 1987 by Rubin, works by replacement of each missing value with a set of reasonable values that represent the ambiguity about the right value to impute.[11] To impute the data sets, the original data set was analyzed for random missing data points using Little's missing completely at random test.

### *Statistical analysis*

We performed a descriptive statistical analysis and reported continuous data as mean $\pm$ standard deviation (SD), ordinal variables as median (interquartile range [IQR]), and proportions for categorical variables. We used the $\chi^2$ test, the Mann—Whitney U test, and the Student's t-test to assess the