How do we provide blood products to trauma patients?

Shan Yuan, Alyssa Ziman, Mary Anne Anthony, Elsa Tsukahara, Courtney Hopkins, Qun Lu, and Dennis Goldfinger

Trauma is the leading cause of death in individuals between the ages of 5 and 45 years worldwide and is expected to become the second leading cause of death by 2020 across all age groups.[1] Nationally, approximately 1 out of every 1000 Americans is hospitalized annually for injuries sustained secondary to trauma, with these patients receiving approximately 10% to 15% of the 14.6 million red blood cell (RBC) units transfused in the United States.[2,3] Exsanguination is an important cause of mortality for trauma patients, and the successful management of severely injured patients depends in part on adequate and timely transfusion support.[4] Therefore, it is not surprising that the provision of optimal transfusion support for trauma patients has generated much interest and discussion, especially in recent years with newly emerging data from both civilian and military settings.

Transfusion support in acute trauma can be challenging and demanding on the resources of the blood bank. The need for large volumes of blood components for some patients, particularly those with the greatest risk of mortality, can arise before or within minutes of their arrival to the hospital. Recent data from one large trauma center in the United States showed that 62% of all RBC units were administered in the first 24 hours of admission, with 18% given uncrossmatched due to the urgency of transfusion. Although the majority (91%) of trauma patients were not transfused, the few (3%) that were massively transfused (i.e., receiving more than 10 units of RBCs) received more than 71% of all RBC units given. Furthermore, this subgroup of patients also had a high mortality rate of 39%.[5] Occasionally, a single patient can require such massive transfusion support that a significant amount of available blood bank resources can be consumed with the patient's care. For example, at our center, among trauma victims who survived in the past 12 months, the maximum amount of blood products given to a single patient in 1 day was 112 units of RBCs, 70 units of plasma, 40 units of cryoprecipitate, and 6 units of apheresis platelets (PLTs). Such data illustrate that for acute trauma cases, the transfusion service needs to provide large amounts of appropriate blood products quickly and communicate effectively with the clinical team to allow for early recognition of patients with massive transfusion requirements to keep up with their blood product needs.

Although there has been much interest recently in what constitutes the optimal transfusion strategy for trauma patients (e.g., role of early plasma transfusion or use of alternative hemostatic agents), there is little information available addressing the logistic issues posed by trauma patients on the transfusion service. All blood banks supporting trauma patients face challenges that include how to minimize delays associated with patient registration and completion of requisition forms, how to provide adequate patient safety measures to avoid misidentification and mistransfusion, how to facilitate effective communication between the blood bank and the clinical team, how to rapidly deliver blood products to patient care locations, and finally, how to remain organized and well coordinated in the fast-moving and stressful environment of trauma care. We present here a description of our trauma transfusion program, which has evolved during the past two to three decades of supporting a Level I trauma center. It is our belief that features of our program, which address the common challenges listed above, can be adapted to suit the unique characteristics of other facilities. We also describe specific aspects of our trauma transfusion program that were identified as areas for improvement after we provided transfusion support to multiple victims from a recent train accident.

ABBREVIATIONS: BBID = blood bank identification; ED = emergency department; ID = identification; MRN = medical record number; RR-UCLA = Ronald Reagan UCLA Medical Center.

From the Division of Transfusion Medicine, Department of Pathology & Laboratory Medicine, David Geffen School of Medicine at UCLA, Los Angeles, California.

Address reprints requests to: Shan Yuan, MD, Department of Pathology & Laboratory Medicine, David Geffen School of Medicine at UCLA, 10833 Le Conte Avenue, Los Angeles, CA 90095; e-mail: syuan@mednet.ucla.edu.

Received for publication December 4, 2008; revision received January 16, 2009; and accepted January 23, 2009.

doi: 10.1111/j.1537-2995.2009.02150.x

TRANSFUSION 2009;49:1045-1049.

WHERE IT ALL HAPPENS: OUR BLOOD BANK AND TRAUMA SERVICE

The Ronald Reagan UCLA Medical Center (RR-UCLA) is a 520-bed academic hospital and a designated Level I adult and pediatric trauma center. The emergency department (ED) provides care to more than 1000 trauma patients annually. From July 2006 to June 2007, 283 or approximately 30% of all trauma patients admitted to the ED required transfusion support; 34 or 12% of those transfused received more than 10 units of RBCs within the first 24 hours.

For our trauma center, as part of our general inventory management, we reserve 30 units of O– RBCs at all times. During times of shortage, all orders for O– RBCs are prospectively audited using patient's hemoglobin concentration, clinical status, age, and sex. Furthermore, male and nonreproductive-aged (>50 years of age) female D– trauma and nontrauma patients can be switched to receive D+ RBCs. Only as a last resort, and after careful consideration of patient's clinical status and inventory level, do we switch younger female D– patients to receive D+ RBC products.

STREAMLINING PATIENT IDENTIFICATION AND BLOOD PRODUCT REQUISITION: THE TRAUMA PACKET

To avoid potential delays in treatment associated with registration and preparation of requisition forms, each trauma patient is assigned a premade gender-specific trauma packet upon arrival at the RR-UCLA ED. The trauma packet contains all essential forms, labels, and identification (ID) bands needed to complete registration and laboratory and radiology requisitions, as well as blood transfusion requests. Items pertinent to blood transfusion support in the trauma packet include the following:

- Hospital ID band with preassigned medical record number (MRN) and temporary gender-specific trauma ID. Information regarding gender is used by the blood bank in deciding whether D+ units can be supplied.
- Multiple self-adhesive encounter labels preprinted with preassigned MRN and temporary trauma ID.
- Blood bank order form with preaffixed encounter label.
- Nonstandard blood release request with preaffixed encounter label, which allows for expedited release of blood products without completion of routine compatibility testing.
- Blood bank ID (BBID) wristband (Typenex Medical LLC, Chicago, IL) as a second form of patient ID.

After both the hospital MRN and the BBID wristbands are placed on the patient, BBID labels removed directly from the BBID bracelet are affixed to the forms and the specimen tube, thus providing a link between the patient, specimens, and paperwork. The specimen and blood bank paperwork are sent to the blood bank via pneumatic tube to allow rapid processing.

DOING IT QUICKLY BUT SAFELY: PROVISION OF UNCROSSMATCHED RBCS AND PLASMA

Trauma patients often receive uncrossmatched group O RBCs before any compatibility testing can be completed. To meet the immediate needs of these patients, the RR-UCLA ED maintains a minimum of 4 units of O– RBCs in a monitored refrigerator in the trauma suite at all times. If multiple victims are expected, this number is increased to 12. This refrigerator is monitored by the blood bank with a door alarm and temperature sensor linked to the centralized wireless temperature monitoring system installed in the blood bank (Isensix, San Diego, CA). If the alarm sounds in the blood bank, blood bank staff calls the ED to ascertain the reason for the alarm and, if applicable, obtain patient identity and the trauma tier designation. Not uncommonly the door alarm is the blood bank's first notification of a bleeding trauma patient. When units are removed, ED staff affixes both patient encounter and BBID labels to the bottom portion of the transfusion slip attached to the unit and returns this portion to the refrigerator to allow inventory reconciliation and documentation by the blood bank.

In addition, two temporary storage coolers, each containing 4 units of group O– RBCs are maintained in the blood bank at all times. These units may be used to supply a specific patient requiring urgent transfusion regardless of location, or to quickly restock the ED refrigerator. For our most critical trauma patients (Tier III, described below), a cooler is immediately sent to the bedside in the ED.

With the emergence of data supporting early plasma transfusion for trauma patients, our blood bank maintains a prethawed inventory of 10 group A and 5 group O plasma units at all times to enable immediate release to group A and O patients (estimated to be 85% of our patient population). Owing to inventory limitations, frozen group B and AB plasma products are only thawed as needed.

If the need for urgent transfusion arises before the patient specimen is available, the blood bank will prepare and issue universal donor components (group O RBCs and/or AB plasma) as long as patient ID is provided. Transfusion requests in this type of scenario can be communicated to the blood bank through a completed blood bank order form with "no specimen" written on the form. If a specimen is available, the ABO/Rh type is determined in 5 minutes using the manual tube method, and

uncrossmatched but type-specific blood components are issued to conserve universal donor products.

When issuing uncrossmatched, type-specific units for transfusion, the potential for acute ABO-incompatible hemolytic transfusion reaction due to a mislabeled specimen for blood typing is a major concern, particularly when there are multiple patients. The use of two identifiers, hospital MRN and BBID on specimens and blood bank requisition forms, provides a safeguard. While the hospital MRN remains with the patient throughout the admission, the BBID wristband is usually removed as the patient is stabilized and transferred to the floor. Once the BBID is removed, and if there is no historical blood type on file, then a second separately drawn specimen ("check type") must be submitted to the blood bank to confirm the blood type before non–type O RBCs can be issued.[6] The check type requirement is waived if the trauma patient has received more than 10 units of type-specific RBCs without adverse event (i.e., biologic crossmatch-compatible) while wearing the BBID wristband.

STRATIFYING THE TRAUMA PATIENTS: THE TIER SYSTEM

The RR-UCLA Trauma Tier System facilitates communication between the trauma team and the blood bank about the severity of the patient's injuries and potential transfusion needs and allows for expedited preparation and delivery of blood products. The tier designation also allows the early recognition of patients who will likely receive massive transfusion, and therefore benefit from a 1:1 ratio of RBC and plasma transfusion. Based on the initial assessment by the ED trauma physician, each patient is assigned to a trauma tier. In general, stable patients with minor injuries are categorized as Tier I, stable patients who may need surgical interventions are assigned as Tier II, and unstable patients requiring immediate transfusion are assigned as Tier III.

Based on the tier designation, the trauma transfusion protocol is activated, which includes performance of stat type and screen and preparation of predetermined numbers of specific blood components for immediate delivery. In addition, tier-specific numbers of RBC and plasma units are prepared as "keep-ahead" orders in anticipation of additional transfusion needs. Until canceled by a physician, keep-ahead units are automatically replenished to ensure immediate product availability. RBC and plasma units are provided at 1:1 ratio, with 1 unit of apheresis PLTs supplied with every 10 units of RBCs. Pools of 10-unit cryoprecipitate are prepared upon request (see Table 1). Other hemostatic agents, such as recombinant FVIIa or antifibrinolytic agents can also be ordered from the pharmacy and be administered to suitable trauma patients.

FROM THE BLOOD BANK TO THE BEDSIDE: TRANSPORT OF BLOOD COMPONENTS

Several means of delivering blood products are available at our institution. For trauma patients, most RBC and plasma products are delivered in coolers. The coolers can be sent directly from the blood bank to the ED, interventional radiology, or operating room and then transported along with the patient to new locations. For the convenience of the clinical team, and to minimize unnecessary opening and closing, coolers are color-coded (red for RBC units and yellow for plasma units). Internal temperature is monitored with a credit card–sized device (LogTag Recorders Ltd, Hong Kong, China), so that if the temperature falls out of range, the indicator light turns from green to red. Furthermore, the device is programmed to capture and store temperature data every 5 minutes, and recordings are downloaded for subsequent analysis so the appropriate disposition of returned unused units can be determined. The coolers have been validated to store 6 units of RBCs or plasma for up to 8 hours.

TABLE 1. Actions taken by the blood bank based on the trauma tier designation*

Trauma tier	Initial actions	Follow-up actions
I	• Stat type and screen	• Prepare blood products only upon request.
II	• Stat type and screen • Prepare 4 units of RBCs • Assign 4 units of plasma; thaw if not available in prethawed inventory • Send above products upon request	• Keep ahead at all times 4 units of RBCs and 4 units of plasma.
III	• Stat type and screen • Immediately send 4 units of O– or O+ RBCs • Prepare 10 units of RBCs • Assign 10 units of plasma; thaw if not available in prethawed inventory • Send above products	• Keep ahead 10 units of RBCs and 10 units of plasma • Provide 1 unit of apheresis PLTs for every 10 units of RBCs • Prepare pooled cryoprecipitate upon request

* RBC products may be type O or type specific, crossmatched or uncrossmatched. Type-specific plasma is provided after blood type is determined. If blood type is not available, AB plasma is provided.

During a trauma case, RBC and plasma coolers are mainly transported by a dedicated blood bank courier, available at all times. If the courier is away making a delivery, and blood products are needed by another patient immediately, a blood bank staff member will serve as backup. Cryoprecipitate, PLT units, and single units of RBCs can be sent through a pneumatic tube system, which has been validated for blood component transportation.[7]

STAYING ORGANIZED AND INFORMED: THE DESIGNATED "TRAUMA TECH" AND TRAUMA TRANSFUSION CHECKLIST

Trauma cases can be associated with high work volumes and rapid paces; therefore, to avoid miscommunication and errors, careful planning and good organization are essential. To facilitate prompt preparation and delivery of blood products and communication with the clinical team as well as within the blood bank, two blood bank staff members are specifically assigned to each Tier II or III trauma case, one as the trauma tech and the other as the backup. The trauma tech serves as the coordinator for the case in the blood bank and the liaison with the trauma team, and is equipped with a cordless phone, which provides an exclusive hotline for the trauma team. The trauma tech's responsibilities are to:

- Answer all telephone calls regarding the trauma case, including receiving additional verbal orders and providing information regarding blood product availability if there are potential delays or shortages.
- Communicate with other blood bank technologists and supervisors on blood product needs of the patient(s).
- Coordinate blood product preparation and delivery.
- Ensure that all blood product keep-ahead levels are maintained.
- Maintain the trauma transfusion checklist and log of products issued.
- Sign off the case and communicate pertinent information about the trauma to the backup trauma tech when leaving the area for break or at the end of a shift.

Our trauma transfusion checklist, similar to checklists used in other areas of health care,[8-10] is designed to ensure that critical steps are taken at appropriate times (e.g., ensuring receipt of a type and screen specimen and maintaining keep-ahead blood products). The checklist can also serve as a communication tool to convey key information among blood bank staff members, such as the patient's blood type, trauma tier level, and patient location, particularly if the patient has been transported to a different patient care area. Additionally, a completed checklist allows retrospective review to provide valuable practice benchmark data, such as percentages of cases with timely submission of patient specimen and delivery of blood products. Such data can also be used for quality assurance and to identify opportunities for practice improvement.

WHAT WE LEARNED AND WHAT WE WANT TO CHANGE

On September 12, 2008, a Union Pacific freight train and a full Metrolink commuter train collided in Chatsworth, in Los Angeles County, California, killing 25 people on board and injuring 135. Eight of the injured victims were flown to the RR-UCLA, all of whom survived, including 4 who required transfusion support. This multivictim trauma provided a rare opportunity that not only put our trauma transfusion program to the test, but also helped us identify areas for improvement, especially when transfusion support for multiple patients is required. The insights we gained are summarized below:

1. While having a limited prethawed inventory of only 10 group A and 5 group O units of plasma meets the needs of patient care of our trauma center in most circumstances, the likelihood of needing group B or AB plasma increases with a multivictim trauma. Therefore, we decided that when multiple trauma victims are expected, AB plasma should be prethawed upon notification of their impending arrival to minimize delays associated with thawing additional type-specific plasma.
2. Cryoprecipitate is not part of our standard trauma transfusion protocol, but is being increasingly requested for trauma patients at our center. Currently we have only frozen single units of cryoprecipitate, which must be pooled first and then issued individually. To facilitate more rapid release of cryoprecipitate, we should maintain a stock of prepooled cryoprecipitate.
3. The dedicated blood bank courier was an invaluable resource during this multivictim trauma and allowed for the delivery of 119 blood products to four patients within 3 hours. Recognizing the value of a dedicated blood bank courier in such situations, hospital administration has agreed to mobilize hospital escort services to provide additional blood transport personnel during a disaster.

CONCLUSIONS

Optimal care for trauma patients cannot be accomplished without the reliable and timely provision of blood products. Our trauma transfusion program has successfully achieved this by utilizing standardized transfusion protocols based on the severity of the patient's injury and by addressing logistical issues such as patient ID,

communication, and blood product transport. We encourage other health systems to examine and consider the approaches we have described in this report. It is also our hope that discussions in this area can be generated and other transfusion services will share their expertise and experiences in this setting, particularly during larger-scale traumas involving multiple severely injured patients.

CONFLICT OF INTEREST

None.

REFERENCES

1. Krug EG, Sharma GK, Lozano R. The global burden of injuries. Am J Public Health 2000;90:523-6.
2. The 2007 national blood collection and utilization survey. Bethesda (MD): AABB; 2009. [cited February 19, 2009.] Available from: http://www.aabb.org/Documents/Programs_and_Services/Data_Center/07nbcusrpt.pdf
3. Hess JR. Blood and coagulation support in trauma care. Hematol Am Soc Hematol Educ Prog 2007;2007:187-91.
4. Sauaia A, Moore FA, Moore EE, Moser KS, Brennan R, Read RA, Pons PT. Epidemiology of trauma deaths: a reassessment. J Trauma 1995;38:185-93.
5. Como JJ, Dutton RP, Scalea TM, Edelman BB, Hess JR. Blood transfusion rates in the care of acute trauma. Transfusion 2004;44:809-13.
6. Figueroa PI, Ziman A, Wheeler C, Gornbein J, Monson M, Calhoun L. Nearly two decades using the check-type to prevent ABO incompatible transfusions: one institution's experience. Am J Clin Pathol 2006;126:422-6.
7. Mohammed M, Richard R, Uhl L. Guidelines for pneumatic tube delivery systems: validation and use to transport blood components. Bethesda (MD): AABB; 2004.
8. Verdaasdonk EG, Stassen LP, Widhiasmara PP, Dankelman J. Requirements for the design and implementation of checklists for surgical processes. Surg Endosc 2008 Jul 18. [Epub ahead of print].
9. March MG, Crowley JJ. An evaluation of anesthesiologists' present checkout methods and the validity of the FDA checklist. Anesthesiology 1991;75:724-9.
10. DuBose JJ, Inaba K, Shiflett A, Trankiem C, Teixeira PG, Salim A, Rhee P, Demetriades D, Belzberg H. Measurable outcomes of quality improvement in the trauma intensive care unit: the impact of a daily quality rounding checklist. J Trauma 2008;64:22-7.