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Red Blood Cell Transfusion: Experience in a Rural Aeromedical Transport Service

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Abbreviations:
AMTS: Aeromedical Transport Service
LOM: LifeFlight of Maine
QI: Quality Improvement
QIC: Quality Improvement Committee

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Abstract

Introduction: The administration of blood products to critically ill patients can be life-saving, but is not without risk. During helicopter transport, confined work space, communication challenges, distractions of multi-tasking, and patient clinical challenges increase the potential for error. This paper describes the in-flight red blood cell transfusion practice of a rural aeromedical transport service (AMTS) with respect to whether (1) transfusion following an established protocol can be safely and effectively performed, and (2) patients who receive transfusions demonstrate evidence of improvement in condition.

Methods: A two-year retrospective review of the in-flight transfusion experience of a single-system AMTS servicing a rural state was conducted. Data elements recorded contemporaneously for each transfusion were analyzed, and included hematocrit and hemodynamic status before and after transfusion. Compliance with an established transfusion protocol was determined through structured review by a multidisciplinary quality review committee.

Results: During the study, 2,566 missions were flown with 45 subjects (1.7%) receiving in-flight transfusion. Seventeen (38%) of these transports were scene-to-facility and 28 (62%) were inter-facility. Mean bedside and in-flight times were 22 minutes (range 3-109 minutes) and 24 minutes (range 8-76 minutes), respectively. The most common conditions requiring transfusion were trauma (71%), cardiovascular (13%) and gastrointestinal (11%). An average of 2.4 liters (L) of crystalloid was administered pre-transfusion. The mean transfusion was 1.4 units of packed red blood cells. The percentages of subjects with pre- and post-transfusion systolic blood pressures of <90 mmHg were 71% and 29%, respectively. The pre- and post-transfusion mean arterial pressures were 62 mmHg and 82 mmHg, respectively. The pre- and post- transfusion mean hematocrit levels were 17.8% and 30.4%, respectively. At the receiving institution, 9% of subjects died in the Emergency Department, 18% received additional transfusion within 30 minutes of arrival, 36% went directly to the operating room, and 36% were directly admitted to intensive care. Thirty-one percent of subjects died prior to hospital discharge. There were no protocol violations or reported high-risk provider blood exposure incidents or transfusion complications. All transfusions were categorized as appropriate.

Conclusions: In this rural AMTS, transfusion was an infrequent, likely life-saving, and potentially high-risk emergent therapy. Strict compliance with an established transfusion protocol resulted in appropriate and effective decisions, and transfusion proved to be a safe in-flight procedure for both patients and providers.

Higgins GL 3rd, Baumann MR, Kendall KM, Watts MA, Strout TD. Red blood cell transfusion: experience in a rural aero-medical transport service. ***Prehosp Disaster Med.*** **2012;27(3):1-4.**

Q1

Introduction

The emergent administration of blood products to critically ill patients can be life-saving, but is not without the risk of causing unintended and serious adverse outcomes. Therefore, strict protocols have been developed and implemented to minimize the chance of error and maximize the safety for both patients and clinical providers when emergency transfusions are initiated. In spite of this, systematic and human error cannot be completely eliminated.

The potential for transfusion error might be greatest during emergency inter-facility or scene-to-facility medical helicopter transports, given the combination of the limited

number of direct care providers, the confined work space, communication challenges resulting from the ambient noise environment, the distractions of multi-tasking, and the predictability of clinical patient instability. The purpose of this study was to describe the in-flight red blood cell transfusion experience of a single, rural aeromedical transport service (AMTS), with specific focus on protocol compliance, provider safety, patient outcomes and transfusion complications. It is hypothesized that adherence to an evidence-based emergency in-flight blood transfusion protocol would result in consistently appropriate transfusion decision-making, and eliminate transfusion complications for patients and providers.

Methods

This study was a retrospective review of the LifeFlight of Maine (LOM) quality improvement database for the calendar years 2007 and 2008. The study was exempted by the Maine Medical Center Institutional Review board and the requirement for written informed consent was waived. Approval to conduct the study also was obtained from LOM.

LOM is a not-for-profit critical care medical helicopter service serving the state of Maine. LOM's two helicopters, housed in Lewiston and Bangor, currently cover all of Maine, a largely rural state. Licensed as a scene response air ambulance, LOM provides both inter-hospital transfers and on-scene support for ground Emergency Medical Services (EMS) providers. During the study period, the service conducted 2,566 flights.

Flight clinical providers (both Paramedics and Registered Nurses) document patient encounters on a standardized data collection sheet. Data elements include information regarding patient demographics, injury or illness type, clinical interventions, medication interventions, clinician assessments, and patient disposition. Data elements from the data collection forms are entered into a Microsoft Excel spreadsheet (Version 7.0.2.5, Microsoft Corp., Redmond, Washington USA) by LOM's Quality Improvement (QI) Coordinator. During data entry, the QI Coordinator, who is an active clinician of the flight team, will confirm any data elements that are in question with the team who cared for the patient. Data for all patients receiving in-flight blood transfusion during the study period were included in this study.

The LOM blood administration protocol (Appendix) evaluated in this study incorporated the following components:

- Two units of type O packed red blood cells were available on-board for administration to patients while being transported, with Rh-negative blood being the preferred type. When the en-route transfusion requirement was anticipated to exceed two units of packed red blood cells, additional O negative units were obtained from the referring hospital;
- Transfusion-eligible patients were identified as having obvious or suspected acute blood loss;
- Adult patients qualified for transfusion if they demonstrated evidence of persistent hemorrhagic shock after the administration of 2 L of 0.9% normal saline. Persistent shock was defined as a systolic blood pressure of less than 90 mmHg and/or clinical signs of shock such as altered mental status, tachycardia, pallor, or delayed capillary refill;
- Pediatric patients qualified for transfusion if they demonstrated evidence of persistent hemorrhagic shock after the administration of 40 milliliter per kilogram (mL/kg) of 0.9% normal saline bolus, administered in 20 mL/kg increments. Persistent shock in the pediatric population was defined as clinical signs of shock, such as altered mental status, tachycardia, pallor, or delayed capillary refill. For pediatric patients, blood was transfused in 10 mL/kg increments, to a maximum of 40 mL/kg.

As an essential component of the service's on-going operations, detailed data are collected on various quality indicators, including blood product utilization. Every case of transfusion during flight is fully reviewed by the Quality Improvement Committee (QIC); committee membership includes Emergency Medicine Physicians, Critical Care Medicine Physicians, and Trauma Surgeons. Multiple data elements are reviewed including patient demographics, pre- and post-transfusion vital signs, pre- and post-transfusion hematocrit levels, total blood and crystalloid volume infused, transfusion-related complications, receiving hospital disposition, and ultimate patient outcome. Specific in-patient data for these patients were not collected or analyzed. Adverse reactions and any other complications for patients or providers are also reviewed.

In each case, the decision to initiate in-flight blood transfusion is assigned to one of the following categories described by the QIC:

- Appropriate—all elements surrounding the decisions made and care provided were evaluated by the committee and no issues or problems were identified.
- Acceptable—although there was no potential for harm to the patient, after review of the elements surrounding the decisions made and care provided, there are recommendations made by the QIC that can lead to modifications or improvements of the existing system.
- Suboptimal—after review of the elements surrounding the decisions made and care provided, there are concerns that there was potential for harm to the patient.
- Substandard—after review of the elements surrounding the decisions made and care provided, there are concerns that there was actual harm done to the patient.

Aeromedical flight crews are trained to recognize the early signs and symptoms of transfusion reactions. In addition to reviewing the details of each case as noted above, the QIC is expected to classify any potential transfusion reaction into one of the following categories: acute hemolytic, febrile non-hemolytic, allergic, anaphylactic, septic, graft versus host, or delayed hemolytic.

Outcomes for the study included the rate of blood product utilization, the appropriateness of transfusion as evaluated by the QIC, adherence to the LOM transfusion protocol, the rate of transfusion complications, evidence for clinical improvement following transfusion, patient outcome, bedside time, and flight time.

Total transport times recorded were divided into two components. Bedside time was defined as the interval between arriving at the patient's side (bedside or scene) and returning to the helicopter. Flight time was defined as the interval between lift-off from the sending facility or scene and touch-down at the receiving facility. All data were provided to the study investigators in a de-identified manner.

Data were entered into a Microsoft Excel spreadsheet (version 7.0.25, Microsoft Corporation., Redmond, Washington USA) and analyzed using SPSS statistical software (version 11.0, SPSS, Inc., Chicago, Illinois USA). Descriptive statistics were obtained

for all variables. Results for continuous variables were expressed as mean (standard deviation, 95% confidence interval). Categorical variables were expressed as number (percentage). Pre-post comparisons were made using χ^2 analysis or the *t*-test for paired samples.

Results

During the two-year study period, 2,566 patient transports were flown. A total of 45 (1.7%) of these patients received in-flight blood transfusion. Of the patients transfused, 17 (38%) were scene-to-facility transfers and 28 (62%) were inter-facility transfers. The average bedside time for all patients was 22 minutes (range 3-109 minutes) and the average flight time was 24 minutes (range 8-76 minutes). A single outlier was excluded from the time analysis as this patient developed active labor and complications of delivery requiring mobilization of the neonatal intensive care transport team to the sending hospital to complete the patient transfer.

Overall, trauma victims received 71% of the blood transfusions, with trauma encompassing all 17 scene transfers and 15 of 28 inter-facility transfers receiving blood transfusion. Non-traumatic conditions requiring transfusion were all inter-facility transfers and can be divided as follows: cardiovascular, n = 6 (13% of total); gastrointestinal/urologic, n = 5 (11%); respiratory, n = 1 (2%); and obstetrical/gynecologic, n = 1 (2%).

The average volume of crystalloid intravenous fluid infused prior to transfusion was 2.4 L (SD = 0.58, 95% CI: 1.45-3.31 L). The average number of packed red blood cell units transfused was 1.4 (SD = 0.23, 95% CI: 1.00-1.73 units). The percentages of study subjects experiencing trauma with pre- and post-transfusion systolic blood pressures of less than 90 mmHg were 71% and 29%, respectively, an improvement that was noted to be statistically significant ($\chi^2 = 9.29$, df = 1, $P = .002$). Pre- and post-transfusion mean arterial pressures also improved significantly at 62 mmHg and 82 mmHg, respectively ($t = -11.090$, df = 3, $P = .002$). The pre- and post-transfusion mean hematocrit levels were 17.8% and 30.4%, respectively, an improvement that was both statistically significant and clinically important ($t = -3.188$, df = 3, $P = .007$).

At receiving institutions, 9% of study subjects died in the emergency department, 18% received additional blood transfusion within 30 minutes of arrival, 36% went directly to the operating room, and 36% were admitted directly to the critical care unit. Thirty-one percent of study subjects did not survive to hospital discharge.

Comparison of interventions received by patients and the LOM blood transfusion protocol revealed no transfusion protocol violations, with complete adherence to the protocol in 100% of cases. Review of findings from the QIC evaluation of each transfusion case indicated that all 45 cases of red blood cell transfusion were categorized as "appropriate." Evaluation of the study safety outcomes included assessment of the rate of high-risk provider blood exposure incidents, transfusion reactions, and transfusion complications. No instances of exposure, reaction, or other transfusion-related complication were identified.

Discussion

There have been a few published reports relating to in-flight aeromedical red blood cell transfusion practices. Review of these reports, combined with the results of this study, allows for several general observations.[1–5]

Blood transfusion appears to be a low volume intervention during aeromedical patient transport. Reported average annual transfusion rates range from 13 to 31 patients, with services representing a wide range of geographic population densities. It is interesting to note that studies conducted in rural aeromedical programs with large coverage areas report the largest number of transfusions.[2] This is similar to that reported for this study, with a service region including all of Maine and parts of bordering New Hampshire, averaging 23 annual transfusions. One possible explanation for this observation might be the predictably longer flight times from remote areas to receiving institutions.

Transfusions in this study were more frequently associated with inter-facility, rather than scene, transports. Sixty-two percent of patient transports were inter-facility; while Berns and colleagues report a 91% inter-facility rate.[2] In-flight transfusions are often a continuation of transfusions initiated at the sending institution. Not surprisingly, frank or impending traumatic hemorrhagic shock is the most common condition requiring transfusion. Gastrointestinal (acute gastrointestinal hemorrhage) and cardiovascular (such as ruptured abdominal aortic aneurysm) conditions resulting in acute blood loss appear to represent a minority of this patient population.

Typically, two to four units of type 0-negative blood are carried by aeromedical services. This appears to meet in-flight transfusion needs with the average transfused volume in most studies reported as between one and two units of packed red blood cells. When measured, hematocrit levels increase and hemodynamic parameters improve following transfusion. This was evident in this study, with hematocrit levels increasing from approximately 18% to 30%, the percentage of patients with systolic blood pressures of less than 90 mmHg decreasing from 71% to 29%, and mean arterial pressures improving from 62 mmHg to 82 mmHg.

Transfusion appears to be a safe procedure when providers comply with established, evidence-based in-flight transfusion protocols. All transfusions were determined to be appropriate, and no adverse patient or provider events were reported in this aeromedical service during the two-year study period. A retrospective review of this same service for the seven years immediately preceding the study period also failed to identify any adverse events relating to transfusion. Published reports regarding in-flight transfusion reveal a similar experience, with only a single minor complication described. Dalton reported a six-year experience of a helicopter emergency medical service based in Portland, Oregon USA.[3] Of the 112 patients receiving transfusion, the only adverse reaction directly related to transfusion was a transient episode of self-resolving shortness of breath in a single patient.

Not unexpectedly, patients requiring blood transfusion have high acuity illnesses or injuries, and receiving blood products appears to be a marker for mortality. Eighty-four percent of our study subjects either died in the receiving institution's Emergency Department or were immediately transferred to an operating theater or critical care unit, with an overall in-hospital mortality rate of 31%. This finding is similar to mortality rates reported in other prehospital transfusion studies.[4]

Conclusion

In this rural aeromedical transport system, blood transfusion was an infrequent, likely life-saving, and potentially high-risk

emergent therapy. Strict compliance with an established blood transfusion protocol resulted in appropriate and effective transfusion decisions, and proved to be a safe in-flight procedure for both patients and providers.

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Appendix: Protocol

Version 13.7 2011
7.1a BLOOD PRODUCT ADMINISTRATION

Indications
Adult patients eligible for blood administration are those who have a history of obvious or suspected acute blood loss, who have had crystalloid fluid resuscitation with 2 L of NS, and who demonstrate:

1. SBP less than 90 mmHg and/or clinical signs of shock (alt. mental status, tachycardia, pallor, delayed capillary refill etc.)
2. Pediatric patients eligible for blood administration are those that have had crystalloid fluid resuscitation of 2 boluses of 20 ml/kg with a history of obvious or suspected acute blood loss, and/or who demonstrate persistent signs of clinical shock (alt. mental status, tachycardia, pallor, delayed capillary refill etc.)
3. Pediatric patients should receive blood transfusions of 10 ml/kg, incrementally, as needed; a maximum of 40 ml/kg should be transfused in this situation.

Procedure

1. If available, two units of 0 negative blood will be properly packed in a travel pack with ice for all LOM flights. A temperature indicator attached to the blood should be visible inside the cooler. Blood must stay in travel pack with ice. If removed and not transfused, blood will have to be discarded.
2. Remove the blood from the cooler and check the temperature indicator. Use only if proper temperature of 4-6o C is maintained. Record temperature status, blood unit # and the time the transfusion is initiated. Document unit number in patient care record.
3. Initiate transfusion as per EMMC PCD 11.008 and CMMC "Administration of Blood Components".
4. For instances of massive hemorrhage, administer Tranexamic Acid (TXA)

   Less than 60 kg: 1.5 g TXA in 50 ml of NS over 20 minutes

   60 kg and greater: 2 g TXA in 50 ml NS over 20 minutes
5. Return the completed transfusion documentation to the blood bank. Unused blood must be returned to the LOM blood bank refrigerator upon return to the base hospital.
6. If a transfusion reaction is suspected, stop transfusion immediately and present suspect blood unit and tubing to receiving facility for testing. Refer to other appropriate protocols such as: anaphylaxis, pulmonary edema, shock.
7. If a suspected transfusion reaction has occurred, notify base hospital blood bank as soon as possible upon completion of transport, and complete transfusion reaction (Blue) form for respective hospital.