Prehospital Use of Blood and Plasma in Pediatric Trauma Patients

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Abstract

Objective: Our rural trauma center uses packed red blood cells (PRBCs) and plasma onboard our helicopter to offset the delay of transport. We summarize our initial experience with prehospital blood use in pediatric trauma patients.

Methods: Our air ambulance service began carrying PRBCs in 1987 and plasma in 2009. We performed a 9-year retrospective review including patients (< 18 years) who received blood during helicopter transports. Only patients transported to our level 1 trauma center were included to ensure complete follow-up.

Results: Sixteen patients (6 females) were identified with a mean age of 13 years. The mean transport time was 30 minutes with 75% transferred in from a referring center. Injuries were blunt in 9 patients and penetrating in 2 patients. The mean Injury Severity Score was 30. Fifteen patients received an average of 1.5 units of PRBCs during flight. Indications for PRBCs were severe anemia (6), known blood loss (5), and nonresponder to intravenous fluids (4). Average hemoglobin improved from 9.4 to 11.4 mg/dL at our center. Base deficit improved from −7 to −5.7 at arrival. Five patients received a mean of 1.4 units of plasma. The arrival international normalized ratio was 1.4. The average length of stay was 9.3 days. Four patients died. Trauma Related Injury Severity Score showed 3 patients were unexpected survivors (0.24, 0.24, and 0.38).

Conclusion: Prehospital use of blood in injured children is rare. However, when indicated, this initial review of our protocol showed increased hemoglobin, decreased acidosis, and unexpected survivors with our program. Because of the rarity of prehospital blood use in children, administration triggers require continued review and refinement.

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Trauma is the leading cause of death in children and young adults.[1] Brain injury remains the leading etiology in this age group; however, hemorrhage contributes to death in up to 30%[2,3] of the most severely injured children. Damage control resuscitation with the delivery of packed red blood cells (PRBCs) and plasma has improved outcomes in exsanguinating trauma patients on the battlefield and in the civilian arena.[4,5] Equal transfusion ratios of PRBCs, plasma, and platelets have improved survival in the massively hemorrhaging victim,[6-10] and studies investigating timing and location for these transfusions have suggested that earlier initiation of damage control resuscitation also impacts outcomes.[11] Pediatric trauma providers have learned a great deal from our adult counterparts in regard to the trauma triad of death and damage control resuscitation; thus, experience with trauma-induced coagulopathy and massive transfusion in injured children is growing.[12-17] Yet, the use of prehospital blood and plasma by flight crews and paramedics in adults or children is rare.

The combination of damage control resuscitation with emphasis on early blood delivery and the rural location of our level 1 adult and pediatric trauma center led to the development of our air ambulance transfusion protocol. We have previously reported the effects of prehospital plasma in the injured adult population.[18] Several injured children have benefited from this program and have received PRBCs and thawed plasma during helicopter transport. The goal of this report is to describe our initial experience with prehospital PRBC and plasma transfusion in pediatric trauma patients.

Methods

After institutional review board approval, we searched our trauma database and flight registry for all patients less than 18 years of age who were transported by our rotary wing aircraft because of traumatic injuries from January 1, 2003, to December 31, 2012. From this group, only patients who were transfused PRBCs or plasma during the helicopter transport were included. Sixteen patients met these inclusion criteria and make up the cohort for this retrospective descriptive case series.

The prehospital transfusion protocol was developed in collaboration with the Division of Transfusion Medicine; Mayo Clinic Medical Transport; and the Division of Trauma, Critical Care and General Surgery at the Mayo Clinic in Rochester. Our air ambulance began carrying O− PRBCs in 1987 and routinely carried 4 units of fresh (< 14 days old) O− PRBCs on flights predicted to need blood transfusion. Blood products are now carried on every flight. Since 2009, these helicopters also carry 2 units of thawed

Table 1. Demographics and Packed Red Blood Cell Consumption

Patient	Sex/ Age	Scene Transport	Transport Time (min)	Mechanism of Injury	ISS	Indication for PRBCs	Units of PRBCs Transfused Prior/En Route/1st 24 Hours of Arrival	Arrival Hemoglobin mg/dL (Change)	Status
1	M/18	−	41	MVC	50	Nonresponder	0/1/3	13.9 (+0.9)	A
2	F/15	−	29	MVC	29	Nonresponder	0/1/2	12.8 (+1.8)	A
3	F/10	+	17	MVC	50	Blood loss	0/1/9	10 (+2.0)	D
4	M/9	−	35	MVC	41	Anemia	7/3/8	16.8 (+7.7)	D
5	M/16	−	14	GSW	10	Blood loss	2/2/2	14.1 (NA)	A
6	M/16	−	39	MVC	50	Anemia	2/1/2	13 (+6.7)	A
7	M/11	−	40	Auto vs. Ped	27	Nonresponder	0/1/0	10.2 (−0.7)	A
8	M/5	−	33	ATV	22	Nonresponder	0/1/2	11.2 (−0.1)	A
9	M/16	−	41	MVC	41	Anemia	0/3/2	11.4 (+1.3)	A
10	F/18	+	5	GSW	16	Blood loss	0/1/4	11.7 (NA)	A
11	M/16	+	32	MVC	66	Blood loss	0/0/0	NA	D
12	M/8	−	36	Run over	34	Anemia	2/1/9	11.6 (+6.0)	A
13	F/18	+	18	MVC	22	Blood loss	0/2/13	11.4 (NA)	D
14	F/18	−	35	MVC	22	Anemia	0/2/1	12.2 (+3.0)	A
15	M/7	−	31	Bull attack	21	Anemia	1/1/1	9.6 (+1.1)	A
16	F/10	−	29	Pushed	9	Nonresponder	0/1/0	11.9 (+1.0)	A

Auto = automobile; F = female; GSW = gunshot wound; M = male; MVC = motor vehicle crash; NA = not applicable; Ped = pedestrian; PRBCs = packed red blood cells.

A+/A− plasma in a self-contained cooler on each flight. Beginning in December 2012, the number of blood products carried was changed to 3 units of PRBCs and 3 units of thawed plasma. Over the study period, our rotary wing service has transported a total of 17,892 patients and 1,176 pediatric patients. During that time, 1,362 units of PRBCs and 525 units of plasma were transfused. To date, only 3 units of plasma have been "wasted" because of storage at an inappropriate temperature on a single flight. Indications for PRBCs in a pediatric trauma patient include age-appropriate tachycardia or hypotension despite 2 to 20 mL/kg crystalloid fluid boluses, nonresponder to initial 20-mL/kg crystalloid fluid bolus, patient already receiving blood or blood products at an outside institution, or known use of anticoagulants. Since 2009, 10 mL/kg plasma transfusion is given first followed by PRBCs once transfusion indication has been met. Continuous hemodynamic monitoring and serial point-of-care testing of lactate and hemoglobin with i-STAT (Abbott Point of Care, Princeton, NJ) is routine for all patients receiving blood and blood products in our helicopters.

All variables were recorded into an Excel workbook (Microsoft, Seattle, WA). Descriptive statistics were calculated using Excel. Predicted survival was based on Trauma Related Injury Severity Score (TRISS) methodology, taking into account the Injury Severity Score, age, systolic blood pressure, respiratory rate, and mechanism of injury.

Results

Of the 16 patients in the study cohort, 6 (38%) were female. The mean age for all patients was 13 years with a range of 5 to 18 years. Patient demographics are summarized in Table 1. The mechanism of injury was blunt in 14 patients (9 motor vehicle crashes, 1 automobile vs. pedestrian, 1 all-terrain vehicle crash, 1 ran over by a tractor, 1 mauled by a bull, and 1 pushed into a door). Both penetrating injuries were gunshot wounds. The mean transport time was 30 minutes with a range of 5 to 41 minutes. Three patients (25%) were transported directly from the scene. The mean Injury Severity Score was 30 (range, 9-66).

Fifteen patients received 22 units of blood during transport. The majority of patients (10) received 1 unit of PRBCs; however, 2 patients received 3 units, and 3 patients received 2 units en route on the helicopter. The mean volume of transfused PRBCs was 255 mL (8 mL/kg). The most common indication for transfusion was known anemia with signs of hemorrhagic shock in 6 patients, known significant blood loss with hemorrhagic shock in 5 patients, and 4 patients were transient or nonresponders to weight-based crystalloid resuscitation. On average, patients received 1,406 mL crystalloid fluids (40 mL/kg) at the referring facility and 832 mL (13 mL/kg) during transport. Nine patients had serum hemoglobin levels drawn at the referring facility, 7 patients had point-of-care hemoglobin levels measured by i-STAT during transport, and 15 patients had serum hemoglobin measurements obtained upon arrival in our emergency department. The 1 patient without laboratory studies at our facility was receiving cardiopulmonary resuscitation during transport and was pronounced dead minutes after arriving to our center. The mean hemoglobin from the referring center was 9.4 mg/dL; this increased to 10.1 mg/dL in the helicopter and was 11.4 mg/dL upon arrival. When comparing patients with multiple