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Massive transfusion in paediatric and adolescent trauma patients: Incidence, patient profile, and outcomes prior to a massive transfusion protocol

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ABSTRACT

Objectives: The purpose of this study was to quantify the incidence, patient profile, and outcomes associated with massive transfusion in paediatric trauma patients prior to establishing a massive transfusion protocol.

Methods: We performed a retrospective review of paediatric trauma patients treated at London Heath Sciences Centre between January 1, 2006, and December 31, 2011. Inclusion criteria were Injury Severity Score (ISS) greater than 12 and age less than 18 years.

Results: 435 patients met the inclusion criteria. Three hundred and fifty-six (82%) did not receive packed red blood cells in the first 24 h, 66 (15%) received a non-massive transfusion (<40 mL/kg), and 13 (3%) received a massive transfusion (>40 mL/kg). Coagulopathy of any kind was more common in massive transfusion (11/13; 85%) than non-massive (32/66; 49%) ($p = 0.037$). Hyperkalemia (18% versus 23%; $p = 0.98$) and hypocalcemia (41% versus 46%; $p = 1.00$) were similar in both groups. Of the 13 massively transfused patients, 9 had multisystem injuries due to a motor vehicle collision, 3 had non-accidental head injuries requiring surgical evacuation, and 1 had multiple stab wounds. In the absence of a massive transfusion protocol, only 8 of the 13 patients received both fresh frozen plasma and platelets in the first 24 h. Massive transfusion occurred in patients from across the age spectrum and was associated with severe injuries (mean ISS = 33), a higher incidence of severe head injuries (92%), longer hospital stay (mean = 36 days), and increased mortality (38%).

Conclusions: This study is the first to describe the incidence, complications, and outcomes associated with massive transfusion in paediatric trauma patients prior to a massive transfusion protocol. Massive transfusion occurred in 3% of patients and was associated with coagulopathy and poor outcomes. Protocols are needed to ensure that resuscitation occurs in a coordinated fashion and that patients are given appropriate amounts of fresh frozen plasma, platelets, and cryoprecipitate.

Introduction

Massive transfusion in adults is defined as the transfusion of 10 or more units of packed red blood cells (pRBC) in a 24-h period [1]. Some definitions include the transfusion of 5 or more units of pRBC in a 3-h period or ongoing bleeding of 150 mL/h. The definition of massive transfusion in children, however, is less clear. Some studies have used a cut-off of 70 mL/kg of body weight for all blood products transfused in a 24-h period [2–4]. It is argued that 70 mL/kg equates to the total blood volume of a typical child greater than three months of age. Others have used a cut-off of 40 mL/kg of pRBC transfused in a 24-h period [5,6].

The complications of massive transfusion have been well described [7]. These include coagulopathy, electrolyte abnormalities, acid–base disturbances, volume overload, and hypothermia. In addition to these metabolic and haemostatic derangements, transfusions are associated with an increased risk of sepsis, multi-organ failure, and death [8]. In trauma patients, coagulopathy is a

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frequent clinical problem and is associated with adverse outcomes. Early correction of coagulopathy is essential to improve outcomes in these patients.

Traditionally, clinicians thought that coagulopathy in trauma patients was due to the dilutional effect of massive transfusions of crystalloid and pRBC [9]. There is now a growing appreciation that coagulopathy is multifactorial and may be induced by the inflammatory response to traumatic injuries, independent of fluid resuscitation and transfusion [10]. In the adult population, this has led to the development of massive transfusion protocols, which are meant to guide resuscitation, facilitate communication and logistical support, and prevent coagulopathy before it occurs. A variety of protocols have been reported such as a 1:1:1 ratio for pRBC, fresh frozen plasma (FFP), and platelets [11]. In adults, these protocols have been shown to result in faster delivery of blood products, decreased rates of multi-organ failure, and improved 30-day survival [12–15]. Despite this, there is still a significant amount of controversy regarding which ratio is the most effective and research in this area is ongoing.

Unfortunately, the development of massive transfusion protocols for paediatric patients has lagged behind the adult population [16]. In many centres, decisions regarding blood component replacement are based on clinical judgements regarding estimation of blood loss, further expectation of blood loss, and clinical signs and symptoms. Laboratory results may not be immediately available and coagulopathic states can change rapidly. Furthermore, most centres do not commonly encounter paediatric trauma patients who require massive transfusion and so there is a great amount of uncertainty regarding transfusion management [6].

The purpose of this study is to describe our experience with massive transfusion in paediatric trauma patients with severe injuries in the absence of a massive transfusion protocol. London Health Sciences Centre is a Level 1 adult and paediatric trauma centre that treats approximately 70–80 paediatric trauma patients with severe injuries per year (Injury Severity Score greater than or equal to 12). There is a massive transfusion protocol in place for adult trauma patients but not for children. We want to determine the incidence of massive transfusion in this population and describe which types of paediatric trauma patients are massively transfused. We will also assess the incidence of complications of massive transfusion, including the rates of coagulopathy and severe electrolyte abnormalities. Finally, we will examine the association between massive and important clinical outcomes, including length of hospital stay and in-hospital mortality.

Patients and methods

This study received approval from the Research Ethics Board at the University of Western Ontario. All patients who were treated at the London Health Sciences Centre between January 1, 2006, and December 31, 2011, were identified through the hospital's trauma database. We included all patients 18 years and younger who had an Injury Severity Score (ISS) of 12 or greater. Data related to demographics (such as age, gender, and weight) and injuries (such as mechanism of injury, injury severity score, types of injuries, and mortality) were retrieved from the trauma database. For the purposes of this study, a severe head injury was defined as an Abbreviated Injury Score of 3 or more.

We used the Bloodbank at London Health Sciences Centre to collect data on blood products released for all patients included in the study. These products included pRBC, FFP, platelets, cryoprecipitate, recombinant factor VIIa, albumin, and pentaspan. The Blood Bank provided the following information for each product: type of product, volume, date, time, and patient identification. We used these data to calculate the total volume of pRBC (mL) transfused in the first 24 h following presentation to our centre. The total volume was divided by the patients recorded weight to determine the size of the transfusion (mL/kg). Patients were classified into three groups: (1) no transfusion of pRBC in the first 24 h; (2) non-massive transfusion (<40 mL/kg), and; (3) massive transfusion (>40 mL/kg). Only blood products released in the first 24 h following presentation to our centre were included in the analysis.

Data related to complications of massive transfusion were collected by manually searching the patient's electronic medical record. Our assessment of coagulopathy consisted of the presence of any of the following in the first 72 h: International Normalised Ratio (INR) >1.3, partial thromboplastin time (PTT) >35 s, platelets <100 (10^9 L^{-1}), or fibrinogen <1.00 g/L. Hyperkalemia was defined as serum potassium >5.5 mmol/L in the first 72 h. Hypocalcemia was defined as either serum calcium <2.15 mmol/L(corrected with serum albumin values whenever possible) or serum ionised calcium <0.9 mmol/L.

All data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 20. Descriptive statistics included mean, range, and frequency. Patient characteristics and clinical outcomes were compared between the patients who had massive transfusion, non-massive, and no transfusion. The frequency of complications from pRBC transfusions were compared for patients who underwent massive and non-massive transfusions only. Analytical statistics included analysis of variance for continuous data and chi-square tests for categorical data. Yates' correction was

Table 1
Summary of patient characteristics.

	No transfusion	Non-massive transfusion (<40 mL/kg)	Massive transfusion (>40 mL/kg)	Total	*p*
Number	356 (82%)	66 (15%)	13 (3%)	435	–
Age (years)	10.7	10.1	6.9	10.5	0.08
Range	1 day–17.9 yr	3 wks–17.8 yr	1 mo–17.8 yr	1 day–17.9 yr	
Male	253 (71%)	44 (67%)	6 (46%)	305 (70%)	0.14
Female	103 (29%)	22 (33%)	7 (55%)	130 (30%)	
Blunt	345 (97%)	65 (98%)	12 (93%)	422 (97%)	0.23
Penetrating	4 (1%)	1 (2%)	1 (7%)	6 (1.4%)	
Burns	7 (2%)	0 (0%)	0 (0%)	7 (1.6%)	
Direct presentation	117 (33%)	23 (35%)	6 (46%)	144 (33%)	0.57
Outside referral	239 (67%)	43 (65%)	7 (54%)	291 (67%)	
Mean ISS[a]	21	29	33	23	<0.001
Range	(12–50)	(13–75)	(16–50)	(12–75)	
Severe head injury[b]	42%	70%	92%	61%	0.005
Frequency (*n*)	(149/356)	(46/66)	(12/13)	(265/435)	

[a] Injury Severity Score.
[b] Defined as the presence of a head injury with Abbreviated Injury Score of 3 or more.