Fixed rate of blood component improves the survival rate of patients in massive transfusion

WEN-TING WANG[1*], YONG-HUA ZHAN[2*], XING-BIN HU[1], SHI-JIE MU[1], QUN-XING AN[1], ZHI-XIN LIU[1] and XIAN-QING ZHANG[1]

[1]Department of Blood Transfusion, Xijing Hospital, Fourth Military Medical University, Xi'an, Shaanxi 710032; [2]School of Life Sciences and Technology, Xidian University, Xi'an, Shaanxi 710071, P.R. China

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Abstract. The aim of this study was to examine the manner in which varying proportions of serum and red blood cells (RBC) in massive blood transfusion affect the survival rates of patients with severe blood loss. Massive transfusion (MT) was determined as receiving ≥10 units of red blood cells in 24 h. The electronic medical records and blood transfusion information for the period January, 2002 to December, 2011 of patients with MT were examined. Moreover, we calculated the ratio of blood components and examined their correlation with survival. In total, 1,658 patients underwent MT during the period 2002-2011, with an overall of 28,030 units RBC, accounting for 2.8% of the total blood transfusion. In conclusion, fixing blood-component ratios has the potential to help improve survival rate in MT.

Introduction

Severe trauma, hemorrhoea and major operation usually need massive blood transfusion or massive transfusion (MT), including blood exchange transfusion. MT is the replacement of large amount of blood, for example transfusion that is equal to a complete blood volume replacement over 24 h (1). MT has classically been defined as the administration of >10 units of red blood cells (RBC) in a 24-h period (2).

MT occurs in 1-3% of civilian trauma admissions (3,4) and this specific subset of patients suffers a high mortality (5,6). MT occurs in 10-15% of the most severely injured patients (7,8). In most institutions, the most common reason for MT is trauma (9). MT is also frequently required as treatment for severe hemorrhage in patients with gastrointestinal (GI) bleeding (10-12) and those undergoing surgery.

Several retrospective studies have demonstrated a survival benefit for bleeding trauma patients when transfused with an early high RBC:fresh frozen plasma (FFP) 1:1 ratio, in civilian as well as military settings (13-16). To promote the clinical treatment of MT, the present study aimed to explore the effective blood component transfusion ratio through a retrospective study of MT.

Correspondence to: Dr Xian-Qing Zhang, Department of Blood Transfusion, Xijing Hospital, Fourth Military Medical University, Xi'an, Shaanxi 710032, P.R. China
E-mail: zhangxq@fmmu.edu.cn

[*]Contributed equally

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Materials and methods

Patient data. During the time period examined in the present study, i.e., 2002-2011, 1,658 patients received a MT. The patients comprised 902 men and 756 women, with a mean age of 52 years. The 7-day hospital mortality for patients who received a MT was 27.3% MT was determined as receiving ≥10 units of RBC in this study. A total of 28,030 units of RBC were received. The medical records and blood transfusion information for the period January 2002 to December 2011 of patients with MT were examined using a computer information management system and the electronic medical records of the hospital. The study was approved by the Ethics Review Board of the Fourth Military Medical University, Xi'an, Shaanxi, China. Prior written and informed consent was obtained from each patient.

Methods. The blood component ratio in MT was calculated and its correlation with survival rate was examined. Variables including age, gender, admission diagnosis and cause of MT, such as intra-abdominal and GI bleeding, surgery, trauma, cardiac surgery, as well as obstetrics and gynecology bleeding, as well as its correlation with the number of patients were calculated to establish a stepwise logistic regression model using the SPSS 13.0 software for analysis.

Statistical analysis. Data were presented as the mean ± SD. $P<0.05$ was considered statistically significant.

Results

During the time period examined in the present study, 2002-2011, 1,658 patients received a MT. The study comprised

Table I. Comparison of the transfused blood products in patients with massive or various types of blood transfusion between 2002 and 2011.

	Number of infusion (units)	
Blood products	Patients with massive transfusion No. (%)	Patients with various types of blood transfusion
Red blood cells	28,030 (2.8)	1,001,071
Freshly frozen plasma	17,040 (4.2)	405,714
Platelet	15,020 (0.7)	2,145,714
Cryoprecipitate	1,110 (13.1)	8,473
Total	61,200 (1.7)	3,560,972

Table II. Demographic data of patients with massive transfusion.

	Total		Non-survival group		Survival group		
Characteristics	No.	%	No.	%	No.	%	P-value
Total	1,658	100	410	27.7	1,248	72.3	
Age (mean, years)	52						
Gender							0.069
Male	902	54.4	290	70.7	675	54.1	
Female	756	45.6	120	29.3	573	45.9	
Admission type							0.001
Emergency	776	46.8	220	53.7	510	40.9	
Non-emergency	882	53.2	190	46.3	738	59.1	
Diagnosis of type							
Gastrointestinal bleeding	253	15.3	25	6.1	167	13.4	0.090
Intra-abdominal bleeding	295	17.8	145	35.4	167	13.4	<0.001
Major vascular injury	227	13.7	65	15.9	170	13.6	0.597
Trauma	223	13.4	65	15.9	171	13.7	0.597
Heart disease	275	16.6	60	14.6	228	18.3	0.408
Liver disease	105	6.3	30	7.3	85	6.8	0.801
Obstetric hemorrhage	100	6.0	10	2.4	90	7.2	0.092
Plastic surgery	45	2.7	0	0	45	3.6	0.067
Skin/soft tissue injury	15	0.9	0	0	15	1.2	0.293
Other	120	7.3	10	2.4	110	8.8	0.029

902 men and 756 women, with a mean age of 52 years. The 7-day hospital mortality for patients who received a MT was 27.3%. In our study, 28,030 units of RBC were received, accounting for 2.8% of the total blood transfusion during the observation period. Moreover, patients were also administered 4.2% of FFP, 0.7% of blood platelets (PLT) and 13.1% of the entire cryoprecipitate usage in MT (Table I).

Baseline demographic data comparing survivors and non-survivors in the MT group are presented in Table II. In all diseases, patients receiving MT showed a higher survival rate compared with patients succumbing to various diseases. Additionally, a higher survival rate was detected in male compared to female patients. The ratio and amount of various blood components used in the survivors and non-survivors are shown in Table III. The median of FFP and RBC was 0.63, and 0.73 and 0.58 in the non-survivors and survivors, respectively. Similarly, the median of PLT and RBC was 0.64 in the non-survivors, and 0.57 in the survivors. To explore the correlation between the survival rate and blood component, FFP:RBC were divided into three levels: >1.2 was the high

Table III. Blood products used in patients with massive transfusion.

Blood products	Non-survival group		Survival group		
	Mean	Range	Mean	Range	P-value
RBC	22.4	10-64	15.3	10-75	<0.001
FFP	15.7	0-91	9.2	0-34	<0.001
PLT	13.0	0-17	8.4	0-45	0.003
Cry	0.7	0-8	0.9	0-18	0.573
Ratio					
FFP:RBC	0.73	0-2.9	0.58	0-2.4	0.034
PLT:RBC	0.64	0-2.4	0.57	0-2.5	0.421
Cry:RBC	0.05	0-0.8	0.05	0-0.9	0.943

RBC, red blood cells; FFP, fresh frozen plasma; PLT, platelets; Cry, cryoprecipitate.

Table IV. Comparison between the ratio of blood products used in patients with massive transfusion.

Blood products	Total		Non-survival group		Survival group	
	No.	%	No.	%	No.	%
FFP:RBC ratio						
High (>1.2)	278	16.8	100	24.4	133	10.7
Equal (0.8-1.2)	200	12.1	50	12.2	195	15.6
Low (<0.8)	1,180	71.1	260	63.4	920	73.7
PLT:RBC ratio						
High (>1.2)	203	12.2	50	12.2	105	8.4
Equal (0.8-1.2)	195	11.8	45	11.0	63	5.0
Low (<0.8)	1,260	76.0	315	76.8	1,080	86.6
Total	1,658	100.0	410	100.0	1,248	100.0

FFP, fresh frozen plasma; RBC, red blood cells; PLT, platelets.

value group; 0.8-1.2 was the equal group and <0.8 was the low group (Table IV).

Discussion

Timely and adequate blood transfusion to patients with blood loss is extremely significant. However, due to the coagulation disorders, hypothermia, acidosis and additional complications associated with blood transfusion, the clinical mortality rate remains high. MT in trauma patients affects a small percentage of civilian and military trauma patients, a great number of whom is expected to succumb to the disease early in their course from hemorrhage and to consume a great deal of trauma center resources (13,17-24).

In their study, Riskin *et al* (25) suggested that implementation of a MT protocol and fixed blood component ratio are associated with reduced mortality. Trauma is a public health problem that draws worldwide attention and ranks third, following heart and cancer disease as the leading cause of mortality. In trauma patients, traumatic blood loss accounted for 40% of deaths, followed by traumatic brain injury (26). For patients with large blood loss, MT is one of the main treatment options. However, large importation of red blood cell suspension would dilute the clotting factors, which leads to coagulation disorders and further trauma-induced aggravated acidosis and hypothermia (27). Traumatic coagulopathy markedly affects patient survival rate. The 24-h mortality rate in patients with trauma coagulopathy was demonstrated to be eight times more compared to other patients (28), while the overall mortality rate was four times more. Wafaisade *et al* (29) found that the survival rate improves significantly in patients with a FFP:RBC ratio of >1:1. However, Sperry *et al* (16) found that the infusion of FFP and RBC improved the survival rate at a ratio of 1:1.5.

The most appropriate transfusion amount of plasma, platelet and cryoprecipitation and volume of other coagulation factors and RBC remain unknown, but the ratio of RBC:FFP:PLT has recently been identified as 1:1:1. While previous studies suggest that the FFP:RBC ratio is a significant variable, its importance has yet to be fully elucidated. Additional studies used a computer model to assess the outcome of blood transfusion management, indicating that the optimal ratio of FFP:RBC and PLT:RBC are 2:3 and 8:10, respectively (30).

We recommend a fixed ratio of RBC:FFP:PLT at 1:1:1. In his study, Johansson (31) concluded that the optimal transfusion by proper monitoring improved the survival of massively bleeding patients. At present, MT delivers blood products at a certain ratio, as well as order and time intervals. Recent studies have found that early detection of coagulation, early and active intervention of blood component proportion is extremely significant in patients with severe trauma. MT of almost whole blood markedly reduces mortality (32). Therefore, fixed blood component ratios improve the use of blood components and reduce mortality.

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