Impact of Blood Transfusion During Definitive Stabilization Surgeries on Pelvic Fracture Patient Clinical Outcomes

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Research article

Abstract

Background: Orthopaedic definitive stabilization surgeries are conducted when pelvic fracture patients are stabilized and blood transfusion is usually inevitable for patients undergo major surgeries and few studies provide insight into the influence of the intraoperative transfusion of packed red blood cells (PRBCs) on the outcomes of pelvic patients . As it presents a risk to the recipient by inducing uncertain morbidity and mortality, this study was aiming at the influence of PRBCs during such surgeries on clinical outcomes of pelvic fracture patients.

Methods: 300 patients were collected and 103 patients were analyzed after exclusion. According to the units of intraoperative transfused PRBCs, 52 patients were in the <3U PRBCs group, 39 patients were in the 3-6U group and 12 patients were in the >6U group. Their characteristics, blood tests, details during surgeries, and outcomes were evaluated.

Results: Patients in the>6U PRBCs group were more likely admitted with hemorrhagic shock, lower blood platelet count (BPC) and higher Abbreviated Injury Scale (AIS) (all $p<0.05$). Blood tests of them at admission revealed higher levels of serum creatinine (Scr), prothrombin time (PT) and thromboplastin time (APTT), lower level of total serum protein (TSP), serum albumin (SA), and serum globulin (SG) (all $p<0.05$). They underwent more subsequent surgeries and intensive care unit (ICU) stays (all $p<0.001$). No significant differences between complications and clinical outcomes were observed among three groups. Increased intraoperative transfusion of PRBCs was an independent factor for increased numbers of subsequent surgeries after orthopaedic surgeries, and prolonged ICU days.

Conclusions: More intraoperative transfusion during orthopedic fixation surgeries indicated patients with more possibilities of hemorrhagic shock, severe pelvic injury, renal injury, and coagulopathy at admission. Increased intraoperative blood transfusion was associated with more ICU days and increased re-operations, whereas it wouldn't increase the risk of more complications or worsen clinical outcomes.

Background

With the progress of the society and development of the modern industry, the incidence of orthopaedic injuries worldwide is increasing with the increasing numbers of traffic accidents and industrial accidents. Among the most complex orthopaedic injuries are pelvic and acetabular fractures [1], pelvic fracture patients are frequently observed with severe trauma and can be critically ill, especially with the presence of organ injuries, abdominal injuries, and even hemorrhagic shock. As for emergency treatment, Damage Control Orthopaedics (DCO) is mainly applied [2], which firstly treats the lesions that cause major bleeding and pathological inflammatory response with a temporary fracture stabilization to avoid the traumatic effect of surgery in patient who is already traumatized, finally, definitive fracture fixation surgery will be conducted when the patient is stabilized and suitable for surgery. Nationwide epidemiological studies in countries conformed that the surgical treatment of pelvic fracture was rapidly rising with the incidence of pelvic fracture [3,4].

To address acute haemorrhage from trauma and surgery, blood transfusion is needed for pelvic fracture patients. Although the blood transfusion plays an indispensable role in saving lives, there is an altercation on the use of blood transfusion. Some researchers reported the improvement of patient outcome on the use of blood transfusion while others suggested that the blood transfusion could result in more complications and prolong the hospital stays [5,6], not to mention the shortage of safe blood is a worldwide acknowledged problem.

Studies on the intraoperative transfusion strategies during orthopaedic fixation surgeries were mostly about autologous blood transfusion and its outcome [7,8], the impact of the intraoperative allogeneic blood transfusion on definitive stabilization surgeries of pelvic fracture patients has not been discussed and still remains unclear. Multiple factors can affect the intraoperative blood transfusion, such as the coagulation function, the estimated blood loss, the type of surgery, and the traumatic condition. This multicenter cohort study investigated the tendency of intraoperative PRBCs transfusion in definitive stabilization surgeries and its effect on the patient clinical outcomes. Our hypothesis was that more intraoperative transfusion of PRBCs would increase the risk of complications, and result in worse outcomes of patients.

Methods

We retrospectively collected the data of pelvic fracture patient from the electronic information systems of five different hospitals, and the study protocol was granted with the local institutional review board approval. All available clinical, laboratory and radiography image results were obtained and recorded from May 2018 to April 2019. The inclusion criteria were (1) pelvic fracture, (2) underwent definitive fixation surgery, (3) received blood transfusion. The exclusion criteria were (1) a pelvic fracture had occurred within 3 months before, (2) pelvic fracture triggered by malignant tumors, (3) co-existing diseases like chronic anemia and/or coagulation disorders, (4) open pelvic fracture.

The demographics and clinical features of patients including age, gender, co-existing diseases, injury mechanisms, Tile classification, fracture sites, associated injuries, AIS, American Society of Anesthesiologists (ASA) score, time from injury to surgery, preoperative hemoglobin (Hb), defined as the latest Hb level recorded before the surgery, were collected.

The blood test for biochemical and coagulation functions on admission, all defined as the first test after hospital admission, parameters were sorted out and displayed as routine blood test, serum liver function test, serum kidney function test, and conventional coagulation test.

The preoperative, intraoperative, and postoperative PRBCs of patients who received different intaoperative PRBCs were analysed. The intraoperative transfusion of PRBCs, intraoperative fluid intake (crystalloid, colloid and blood) and intraoperative fluid loss (the blood loss and the urine output) were demonstrated on Fig. 1. Complications of patients were shown in Fig. 2.

The types of definitive fixation surgeries, curative effects including Matta scoring system, clinical outcomes, subsequent surgeries, hospitalization days, and ICU days were evaluated.

Parameters were displayed on Microsoft Excel and imported into the IBM SPSS Statistics 23.0 for further statistical analysis. All data were identified as quantitative variables and qualitative variables. Quantitative variables were tested by Shapiro-Wilk test to identify whether they were normally distributed, if they were, presented them as mean ± standard deviation (SD), if they were not, presented them as median with lower and upper inter quartile range (IQR). Differences of quantitative variables were evaluated by one-way multiple analysis of variance test or Jonckheere-Terpstra test. Qualitative variables were presented as number (percentage) and their differences were compared by Chi-Square test or Fisher's exact test. We generated an ordinal regression model to analyse the tendency of intraoperative transfusion where factors that were significantly different in univariate analyses were included. Besides, to find out the effect of intraoperative transfusion on numbers of subsequent surgeries and ICU days, multivariate analyses were respectively established. A variance inflation factor ⬜10 confirmed the absence of multicollinearity between the independent variables. A two-tailed p value ⬜0.05 indicated a significant difference.

Results

In this research, data of 300 pelvic fracture patients were obtained from multi-center electronic information systems. After exclusion, 103 patients were divided into three groups according to their transfusion of PRBCs during their definitive stabilization surgeries. 52 (48.1%) patients received 1−3 units PRBCs, 39 (37.9%) patients received 3−6 units PRBCs, and 12 (11.7%) patients received⬜ 6 units PRBCs.

As demonstrated in Table 1, the median age of the patients was 49 years (IQR 32−59) and 57 (55.3%) patients were male. Mechanisms of injury were mainly traffic accidents (58.3%), followed by falls from height (25.2%), crushes (8.7%), falls on the ground (5.8%), and others (1.9%). Tile classifications of fracture types were identified by an experienced orthopaedic surgeon. Patients in three groups did not differ in age, gender, co-existing diseases, injury mechanisms, fracture types, or fracture sites. 4 (33.3%) of 12 patients who were diagnosed with hemorrhagic shock at admission were in the⬜6U PRBCs group (p = 0.039). Patients in the ⬜6U PRBCs group had higher AIS (p = 0.013). The median time from injury to surgery was 7 hours (IQR 2−12) and the preoperative Hb was 98.7 ± 18.6 g/L. No significant differences in respect to ASA, the time from injury to surgery and the preoperative Hb were found among three groups.

The routine blood test, serum liver function test, serum kidney function test and coagulation test on admission were summarized in Table 2. No significant difference on the routine blood test was found among three groups except the blood platelet count (BPC). The BPC was lower in the ⬜6U PRBCs group (p = 0.011). Parameters of the blood chemistry test for the kidney function didn't differ among three groups except Scr, which was significant higher in the ⬜6U PRBCs group (p = 0.007). From the results of the blood chemistry test for the liver function, we could see that total serum protein (TSP), serum albumin (SA), and

serum globulin (SG) were significant lower in the ≥6U PRBCs group (all $p<0.01$). In regard to conventional coagulation test, PT and APTT prolonged in the ≥6U PRBCs group (all $p<0.05$).

As shown in Table 3, there were no differences between three groups about the preoperative and postoperative transfusions of PRBCs (all $p>0.05$). The median intraoperative transfusion of PRBCs was 1.5 units (IQR 0−2) in the ≤3U group, 4 units (IQR 3.6−4) in the 3−6U PRBCs group and 9.75 units (IQR 8.3−10) in the ≥6U PRBCs group ($p<0.01$). Intraoperative fluid intake and output were exhibited in Fig. 1, compared with 2500 mL (IQR 1500−3200) in the ≤3U group, the median intraoperative fluid intake was significantly higher with 3975 mL (IQR 3025−5687.5) in the 3−6U group and 5475 mL (IQR 3812.5−7462.5) in the ≥6U group (all $p<0.01$). Compared with 600 mL (IQR 300−1050) in the ≤3U group, the median fluid output was significant higher with 1585 mL (IQR 1000−2390) in the 3−6U group and 2375 mL (IQR 1225−3900) in the ≥6U group (all $p<0.01$). Seen from Table 4, there were no differences among three groups on types of procedures regarding the fracture sites performed in definitive orthopaedic stabilization surgeries (all $p>0.05$). The fracture quality reduction based on the plain film was assessed by an experienced orthopaedic surgeon, using a Matta scoring system [9], which is based on the maximum displacement on the radiograph of the anteroposterior and oblique. "Excellent" represents the hip joint normal, "good" represents mild changes (<1mm), "fair" represents intermediate changes (2~3mm) and "poor" represents major changes (≥3mm). No significant differences of complications, Mata scores and clinical outcomes were observed among three groups. Patients in the ≥6U PRBCs group underwent more subsequent surgeries after the orthopaedic surgeries and were associated with longer length of ICU stays (all $p<0.01$). No significant differences among three groups on complications were observed in Fig. 2. Six patients developed complications, which included pneumonia, anaphylaxis, infection, fever, deep venous thrombosis, and pressure ulcer.

Multivariate analyses were respectively established to discover the effects of intraoperative transfusion of PRBCs, presence of hemorrhagic shock, AIS, BPC, Scr, SA, SG, PT, APTT, and intraoperative fluid output on overall transfusions and clinical outcomes. TSP was with significant difference in univariate analyses but was eliminated in multivariate analyses, and multicollinearity diagnostics confirmed no multicollinearities existed among other factors. The results were concluded in Table 5. The increased intraoperative transfusion of PRBCs was an independent factor which was associated with increased transfusions of PRBCs ($p<0.01$) and FFP (p = 0.027), numbers of subsequent surgeries after orthopaedic fixation surgeries (p = 0.002), and prolonged ICU days ($p<0.01$).

Discussion

Orthopaedic trauma patients, especially pelvis fractures, are mostly associated with blood transfusion for their surgical interventions [10]. PRBCs are prepared to prevent and address hemorrhage during definitive fixation surgery. With the awareness of potential risks and further study proving that the intraoperative transfusion can present a risk to the recipient by inducing transfusion-related immunomodulation and systemic inflammatory response syndrome, the intraoperative transfusion is also known for close relation with the postoperative infection [11]. To make it clear, the impact of intraoperative transfusion of PRBCs

during definitive stabilization surgeries on the clinical outcomes of the pelvic patients was explored in this study.

In consistency with prior studies [12,13], our research also found that the main mechanism of pelvic fracture injuries was the traffic accident. Our study discovered that patients in the ≥6U PRBCs group had higher AIS. AIS is an internationally recognized injury severity grading method based on anatomical injury and Injury severity scale (ISS) is derived from AIS. Andrea et al.reported in a retrospective study that the patients who had higher ISS score were more likely to transfuse PRBCs [6]. A previous study conducted by Joathan et al. found that pelvic fracture patients with hemorrhagic shock caused by the retroperitoneal hematoma would increase the possibility of initial transfusion of PRBCs beyond 5 units [14], and other study confirmed it that the presence of hemorrhagic shock was correlated with numbers of transfused blood units [15], in our study, patients who were transfused with more PRBCs in definitive fixation surgeries were more likely admitted with hemorrhagic shock.

We excluded patients with open pelvic fractures because they usually require immediate emergency surgeries after admission. We also excluded patients with anemia or coagulation dysfunction, as pre-existing anemia and bleeding disorders can exacerbate the hemorrhage under the stress of trauma and surgeries [16,17]. Stabilization surgeries, such as open reduction internal fixation, invasive plate osteosynthesis, percutaneous insertion of sacroiliac screws [18], are aimed at recreating stability of the pelvic. Due to the concomitant injuries and limited surgical conditions, definitive fixation surgeries are usually not available immediately. Elective surgeries were performed when the trauma had been controlled. A previous study has discussed the orthopaedic fixation surgery about its optimal time for treatment [19,20], along with its outcome on patients [21,22]. No significant difference on time to surgery was found among the three groups in our study, the median time was 7 days and it was within the recommended 5−8 days after accident [23].

Studies have proven that the thrombocytopenia was responsible for the bleeding complication [24], and low level of blood platelet and coagulation factors resulting from consumption were associated with coagulopathy [25]. Blood loss from trauma can lead to observed hemostatic abnormalities, such as coagulation disturbance and platelet dysfunction [26]. The conventional coagulation tests were an efficient diagnostic means to identify acute traumatic coagulopathy [27]. The appropriate hematological testing was performed after admission to see the blood flow state and coagulation function of patients. Our finding reveled that patients in the 6U PRBCs group had a lower BPC value, which indicated a hemorrhagic tendency. The result of PT and APTT, which prolonged in the ≥6U PRBCs group indicated the consumption of coagulation factors and a tendency of coagulopathy. Research has shown that kidney and liver tend to be the most vulnerable organs to blunt trauma [28]. The higher Scr in the ≥6U PRBCs group might reflect the renal injury. SA reflects the function of liver protein synthesis and the elimination half-life of SA is 17−18 days. The quick decrease of SA in a short period of time is mainly caused by large blood loss, therefore the decreased SA in the ≥6U PRBCs group was due to the massive blood loss and so were the cases with the observed lower SG and TSP of patients in the ≥6U PRBCs. No differences of complications, quality of fracture reduction, and clinical outcomes among the pelvic fracture patients

were found in our study. The intraoperative PRBCs wouldn't increase the risk of complications or worsen patient clinical outcomes. However, we found in regression analyses that increased intraoperative transfusion was independently associated with more numbers of subsequent surgeries, and prolonged ICU days.

The unplanned subsequent surgeries are relatively common and are for postoperative infection management and fixation failure. A former study pointed open fractures, combined pelvic ring and acetabular injuries, abdominal visceral injuries, and increasing pelvic fracture grade as four independent factors for re-operations [29]. The increased intraoperative PRBCs was identified as an independent factor to the subsequent surgeries in our study. The presence of hemorrhagic shock and prolonged APTT in the ⩾6U group suggested a tendency of coagulopathy and an increase of transfusion may exacerbate it by hemodilution and blood overloads [26,30,31], thereupon, increased transfusion might increase subsequent surgeries by aggravating the risk of transfusion complication. Further studies are required on what types of followed surgeries are increased after the orthopaedic stabilization surgeries. It made sense that the patients in the in the ⩾6U group had longer ICU days, because the prolonged ICU and hospital stays were closely connected with transfusion [32,33], especially with the existence of coagulopathy, for a further study detected that an early correction of coagulation function could effectively reduce consumption of blood product and length of stay [31–34].

The use of a retrospective review method was subject to the inherently present information bias, but the data from 5 centers increased the external validity. Studies with a larger population might be required to confirm the results. We didn't consider the emergency interventions, such as pelvic binders, angio-embolization and extraperitoneal pelvic packing, which may affect the transfusion requirements and mortality of patients [35–37]. Other limitations of our study included not taking into account of confounding factors, such as perioperative anemia.

Conclusions

The research provided insight into the association of PRBCs transfused in definitive stabilization orthopaedic surgeries with the clinical results in pelvic fracture patients. The increased intraoperative transfusion of PRBCs did not increase the risk of complications or worsen the clinical outcomes but was associated with more overall transfusions of PRBCs and frozen fresh plasma(FFP), subsequent surgeries and ICU stays.

Abbreviations

(PRBCs): Packed red blood cells; (BPC): Blood platelet count; (AIS): Abbreviated Injury Scale; (Scr): Serum creatinine; (PT): Prothrombin time; (APTT): Thromboplastin time; (TSP): Total serum protein; (SA): Serum albumin (SG): serum globulin; (ICU): Intensive care unit; (DCO): Damage Control Orthopaedics; (ASA): American Society of Anesthesiologist; (Hb): Hemoglobin; (SD): Standard deviation; (IQR): Inter quartile range; (FFP): Frozen fresh plasma; (ISS): Injury severity scale; (RBC): Red 1blood cell count; (HCT):

Hematocrit; (WBC): White blood cell count; (ANC): Absolute neutrophil count; (ALC): Absolute lymphocyte count; (BUN): Serum urea nitrogen; (SUA): Serum uric acid; (TSP): Total serum protein; (ALT): Alanine aminotransferase; (AST): Aspartate aminotransferase; (STB): Serum total bilirubin; (SDB): Serum direct bilirubin; (TT): Thrombin time; (INR): International Normalized Ratio; (FIB): Fibrinogen

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Authors' contributions

Xiuqiao Xie、Jie Wang, Yuanshuai Huang did the review and designed the study . Rong gui helped organizing technicians in five hospitals to collect data. Xiuqiao Xie analyzed the data with the help of Xue Yuanhuang. Xiuqiao Xie interpreted the data and wrote the manuscript. All authors revised and approved the final manuscript.

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Tables

Table 1

Demographics and Clinical Characteristics of Patients Who Received Different Intraoperative Packed Red Blood Cells

	⩽5U PRBCs (n=52)	5-10U PRBCs (n=39)	⩾10U PRBCs (n=12)	Total (n=103)	p
Age (years), median (IQR)	52 (40.5-65.5)	52 (40-60)	50.5 (42-65.5)	52 (41.5-63)	0.279
Male gender, n (%)	79(59.4)	28 (48.3)	8 (36.4)	115 (54)	0.164
Co-existing diseases, n (%)					
Total no. diseases	75	37	11	123	0.909
Healthy	62 (46.6)	32 (55.2)	10 (45.5)	104 (48.8)	0.536
Hypertension	3 (7.7)	6 (11.5)	1 (8.3)	10 (9.1)	0.891
Diabetes	0 (0)	4 (7.7)	0 (0)	4 (3.6)	0.23
Cardiopathy	2 (5.1)	3 (5.8)	0 (0)	5 (4.5)	1
Others	5 (12.8)	11 (21.2)	2 (16.7)	18 (16.4)	0.574
Injury mechanisms, n (%)					
Traffic accident	24 (61.5)	31 (59.6)	5 (41.7)	60 (58.3)	0.515
Fall from height	5 (12.8)	17 (32.7)	4 (33.3)	26 (25.2)	0.071
Fall on the ground	3 (7.7)	2 (3.8)	1 (8.3)	6 (5.8)	0.581
Crush	5 (12.8)	2 (3.8)	2 (16.7)	9 (8.7)	0.127
Others	2 (5.1)	0 (0)	0 (0)	2 (1.9)	0.362
Tile classifications, n (%)					
A	13 (33.3)	15 (28.8)	3 (25)	31 (30.1)	0.826
B	15 (38.5)	18 (34.6)	3 (25.5)	36(35.1)	0.702
C	11 (28.2)	19 (36.5)	6 (50)	36(35.1)	0.376
Fracture sites, n (%)					
Total no. fractures	52	80	17	149	0.593
Spine	6 (15.4)	5 (9.6)	1 (8.3)	12 (8.1)	0.749
Femur	0 (0)	4 (7.7)	1 (8.3)	5 (3.4)	0.148
Pelvis	33 (84.6)	46 (88.5)	12 (100)	91 (61.1)	0.461

Acetabulum	7 (17.9)	15 (28.8)	3 (25)	25 (16.8)	0.516
Upper limbs	3 (7.7)	2 (3.8)	0 (0)	5 (3.4)	0.813
lower limbs	3 (7.7)	8 (15.4)	0 (0)	11 (7.4)	0.342
Associated injuries, n (%)					
Total no. injuries	61	99	24	184	0.452
None	29 (74.4)	42 (80.8)	9 (75)	80 (43.5)	0.746
Head trauma	1 (2.6)	4 (7.7)	0	5 (2.7)	0.54
Organ injury	26 (66.7)	38 (73.1)	8 (66.7)	72 (39.1)	0.785
Nerve injury	1 (2.6)	3 (5.8)	0 (0)	4 (2.2)	0.778
Retroperitoneal hematoma	1 (2.6)	4 (7.7)	1 (8.3)	6 (3.3)	0.479
Hemorrhagic shock	2 (5.1)	7 (13.5)	4 (33.3)	13 (12.6)	0.039
Others	1 (2.6)	1 (1.9)	2 (16.7)	4 (3.9)	0.109
AIS, median (IQR)	2 (2-2)	2 (2-3)	2.5 (2-3)	2 (2-3)	0.013
ASA, median (IQR)	2 (1-3)	2 (1-2)	1 (1-1.75)	2 (1-2)	0.07
Time from injury to surgery (days), median (IQR)	7 (3-12)	8 (4-12)	1.5 (0.43-4.75)	7 (2-12)	0.405
Preoperative Hb (g/L), mean ± SD	101.5 ± 19.5	98.4 ± 17.4	91.4 ± 20.2	98.7 ± 18.6	0.26

PRBCs Packed red blood cells, *AIS* Abbreviated Injury Scale, *IQR* Interquartile Range, *ASA* American Society of Anesthesiologists, *Hb* Hemoglobin, *SD* standard deviation

Table 2

Blood Tests of Patients Who Received Different Intraoperative Packed Red Blood Cells on Admission

n (%)	≤3U PRBCs	3-6U PRBCs	≥6U PRBCs	Total	p
	52 (48.1)	39 (37.9)	12 (11.7)	103 (100)	
Blood routine test					
RBC (X10^{12}/L), mean ± SD	3.1 ± 0.6	3.1 ± 0.6	2.8 ± 0.6	3.1 ± 0.6	0.202
HCT (%), mean ± SD	28.4 ± 6.7	27.5 ± 5.4	25.7 ± 7	27.6 ± 6.1	0.423
WBC (X10^9/L), median (IQR)	10.2 (8.0-12.1)	10.2 (8.2-13.5)	8.2 (5.8-12)	10 (7.9-13.2)	0.461
Hb (g/L), mean ± SD	93.2 ± 19.1	92.3 ± 17.5	86.8 ± 15.9	92 ± 17.9	0.559
BPC (X10^9/L), median (IQR)	168 (125-254)	136 (100.5-215)	98 (48-171.8)	140 (103-243)	0.011
ANC (X10^9/L), median (IQR)	8.5 (6.5-10.6)	8.2 (6.7-11.9)	6.3 (4.1-10.4)	8.2 (6.4-11.4)	0.402
ALC (X10^9/L), median (IQR)	1 (0.7-1.3)	1.1 (0.6-1.5)	1.1 (0.7-2)	1 (0.7-1.5)	0.356
Serum liver function test					
Scr (umol/L), median (IQR)	59 (44-81)	66 (56.3-91.3)	85 (67.3-103.5)	66 (52-92)	0.007
BUN (mmol/L), median (IQR)	5.6 (3.4-8.2)	5.9 (4.2-7.6)	7.6 (5-8.6)	5.9 (4.3-8.2)	0.156
SUA (umol/L), median (IQR)	244 (142-303)	233.5 (163-343.8)	252 (113.3-305.3)	240.2 (163-308.1)	0.855
Serum liver function test					
TSP (g/L), mean ± SD	57.2 ± 8.6	53.6 ± 8.3	44.9 ± 11	54 ± 9.4	0
SA (g/L), mean ± SD	33.2 ± 5.1	32.6 ± 4.7	27.2 ± 5.5	32.2 ± 5.2	0.001
SG (g/L),	23.3 (19.4-27.3)	20.8 (16.1-25.6)	19.2 (11.7-22.5)	21.4 (17.4-26.2)	0.003

median (IQR)					
ALT (U/L), median (IQR)	44 (23-73)	40.5 (28.1-76.5)	42 (32-168.8)	42 (27-81)	0.433
AST (U/L), median (IQR)	45 (31-106)	49.5 (28.8-109.3)	70 (54-187.5)	51 (31-109)	0.175
STB (umol/L), median (IQR)	14.6 (12-17.8)	18.5 (11.2-23.9)	15.2 (11.3-22.7)	15.9 (11.6-23.2)	0.651
SDB (umol/L), median (IQR)	5 (3.8-8.4)	5.9 (4-9.7)	6.3 (4.4-9.1)	5.7 (3.9-9.3)	0.204
Conventional coagulation test					
PT (s), median (IQR)	11.9 (11.1-12.8)	12 (11.2-13.6)	14 (11.7-17.4)	12 (11.3-13.4)	0.028
APTT (s), median (IQR)	29.3 (25.4-34)	29.6 (27-35)	38.5 (29.1-64.8)	30 (26.7-35.1)	0.013
TT(s), median(IQR)	15.6 (14.5-17)	16.1 (14.8-17.3)	15.3 (14.7-17.7)	15.8 (14.7-17.1)	0.495
INR, median (IQR)	1 (1-1.1)	1 (1-1.2)	1.2 (1-1.5)	1 (1-1.2)	0.138
FIB (g/L), median (IQR)	3.4 (2.1-4.5)	3.1 (2-4.9)	5 (1.6-6.6)	3.3 (2.1-5)	0.757

PRBCs Packed red blood cells, *RBC* Red blood cell count, *SD* standard deviation, *HCT* Hematocrit, *WBC*

White blood cell count, *BPC* Blood platelet count, *IQR* Interquartile Range, *ANC* Absolute neutrophil count, *ALC* Absolute lymphocyte count, *Scr* Serum creatinine, *BUN* Serum urea nitrogen, *SUA* Serum uric acid, *TSP* Total serum protein, *SA* Serum albumin, *SG* Serum globulin, *ALT* Alanine aminotransferase, *AST* Aspartate aminotransferase, *STB* Serum total bilirubin, *SDB* Serum direct bilirubin, *PT* Prothrombin time, *APTT* Activated partial thromboplastin time, *TT* Thrombin time, *INR* International Normalized Ratio,*FIB* Fibrinogen

Table 3

Preoperative, Intraoperative and Postoperative Packed Red Blood Cells of Patients Who Received Different Intaoperative Packed Red Blood Cells

n (%)	⩽3U PRBCs	3-6U PRBCs	⩾6U PRBCs	Total	*p*
	52 (48.1)	39 (37.9)	12 (11.7)	103 (100)	
Preoperative PRBCs (units), IQR	2 (0-4)	2 (0-4)	1 (0-4.38)	3.5 (2-4)	0.703
Intraoperative PRBCs (units), IQR	1.5 (0-2)	4 (3.6-4)	9.75 (8.3-10)	2 (0-4)	0
Postoperative PRBCs (units), IQR	0 (0-0)	0 (0-1.88)	1 (0-6.5)	0 (0-2)	0.075
PRBCs Packed red blood cells, *IQR* Interquartile Range					

Table 4

Definitive Fixation Surgery Types and Curative Effects of Patients Who Received Different Intraoperative Packed Red Blood Cells

n (%)	≤3U PRBCs	3-6U PRBCs	≥6U PRBCs	Total	p
	52 (48.1)	39 (37.9)	12 (11.7)	103 (100)	
Definitive Fixation Surgery types, n (%)					
Total no. surgeries	51	62	15	128	0.713
Spine fixation	6 (15.4)	4 (7.7)	1 (8.3)	11 (8.1)	0.489
Pelvic fixation	19 (48.7)	23 (44.2)	3 (25)	45 (33.3)	0.372
Acetabulum fixation	4 (10.3)	3 (5.8)	2 (16.7)	9 (6.7)	0.31
Femur fixation	4 (10.3)	10 (19.2)	3 (25)	17 (12.6)	0.382
Upper limbs fixation	7 (17.9)	6 (11.5)	2 (16.7)	15 (11.1)	0.664
Lower limbs fixation	7 (17.9)	13 (25)	2 (16.7)	22 (16.3)	0.697
Craniotomy	1 (2.6)	1 (1.9)	0 (0)	2 (1.5)	1
Laparotomy	3 (7.7)	2 (3.8)	2 (16.7)	7 (5.2)	0.26
Matta scores, n (%)					
Excellent	7 (17.9)	6 (11.5)	1 (8.3)	14 (13.6)	0.87
Good	7 (17.9)	11 (21.2)	4 (33.3)	22 (21.4)	0.875
Fair	14 (35.9)	18 (34.6)	3 (25)	35 (34)	0.494
Poor	11 (28.2)	17 (32.7)	4 (33.3)	32 (31.1)	0.651
Clinical outcomes, n (%)					
Cured	17 (43.6)	26 (50)	7 (58.3)	50 (48.5)	0.641
Improved	21 (53.8)	22 (42.3)	4 (33.3)	47 (45.6)	0.388
Abandoned therapy	0 (0)	2 (3.8)	0 (0)	2 (1.9)	0.614
Death	1 (2.6)	2 (3.8)	1 (8.3)	4 (3.9)	0.583
Numbers of subsequent Surgeries, median (IQR)	0 (0-1)	0 (0-2)	2 (2-2.75)	0 (0-2)	0.005
Hospital days, median (IQR)	23 (16-26)	21 (14.3-30)	23.5 (14.3-40.3)	23 (15-28)	0.676
ICU days,	0 (0-1)	4 (3-6)	6 (3.3-8.8)	3 (0-6)	0

median (IQR)
PRBCs Packed red blood cells, *IQR* Interquartile Range, *ICU* Intensive care units

Table 5

Multiple Regression Analyses on the Effect of Intraoperative Transfusion of Packed Red Blood Cells on Clinical Outcomes

Dependent Variable	Independent Variable	Unstandar-dized Beta	Standar-dized Beta	Significance	VIF
Overall PRBCs					
	The 3-6 U PRBCs group	3.043	0.252	0.004	1.669
	The ⬛6 U PRBCs group	9.877	0.526	0	2.258
	Intraoperative FFP	-0.005	-0.223	0.057	3.005
	Intraoperative blood loss	0.002	0.249	0.077	4.38
	Intraoperative urine output	0.001	0.068	0.46	1.913
	Intraoperative infusion	0	-0.073	0.652	5.829
	BPC	-0.004	-0.086	0.32	1.645
	Scr	0.038	0.25	0.001	1.257
	SA	-0.089	-0.077	0.331	1.404
	SG	0.046	0.047	0.616	1.987
	PT	-0.027	-0.031	0.704	1.453
	APTT	0.006	0.012	0.903	2.106
	Hemorragic shock	5.055	0.278	0.002	1.682
	AIS	0.398	0.043	0.576	1.33
	ASA	-0.299	-0.042	0.556	1.151
Overall FFP					
	The 3-6 U PRBCs group	-42.786	-0.03	0.759	1.669
	The ⬛6 U PRBCs group	567.832	0.255	0.027	2.258
	Intraoperative FFP	0.463	0.177	0.178	3.005
	Intraoperative blood loss	0.165	0.202	0.202	4.38
	Intraoperative urine output	0.106	0.106	0.311	1.913
	Intraoperative infusion	-0.055	-0.159	0.383	5.829
	BPC	0.3	0.057	0.555	1.645

	Scr	-1.006	-0.056	0.511	1.257
	SA	23.159	0.169	0.062	1.404
	SG	-20.949	-0.182	0.09	1.987
	PT	-7.406	-0.071	0.437	1.453
	APTT	18.894	0.336	0.003	2.106
	Hemorragic shock	313.082	0.145	0.14	1.682
	AIS	-38.027	-0.035	0.689	1.33
	ASA	15.659	0.019	0.818	1.151
Numbers of subsequent surgeries					
	The 3-6 U PRBCs group	-0.194	-0.077	0.47	1.669
	The ⩾6 U PRBCs group	1.061	0.27	0.031	2.258
	Intraoperative FFP	0	0.087	0.542	3.005
	Intraoperative blood loss	0	-0.136	0.43	4.38
	Intraoperative urine output	0	-0.095	0.406	1.913
	Intraoperative infusion	0	0.177	0.374	5.829
	BPC	0	-0.004	0.968	1.645
	Scr	-0.002	-0.074	0.425	1.257
	SA	0.004	0.017	0.861	1.404
	SG	-0.007	-0.034	0.767	1.987
	PT	-0.031	-0.167	0.094	1.453
	APTT	-0.009	-0.09	0.45	2.106
	Hemorragic shock	1.551	0.408	0	1.682
	AIS	0.45	0.233	0.015	1.33
	ASA	-0.003	-0.002	0.98	1.151
ICU days					
	The 3-6 U PRBCs group	3.555	0.461	0	1.669
	The ⩾6 U PRBCs group	4.548	0.378	0.001	2.258
	Intraoperative FFP	-0.001	-0.099	0.455	3.005
	Intraoperative blood loss	-0.001	-0.198	0.218	4.38

Intraoperative urine output	0	0.002	0.986	1.913
Intraoperative infusion	0	0.132	0.475	5.829
BPC	0.001	0.02	0.835	1.645
Scr	-0.013	-0.132	0.127	1.257
SA	0.122	0.165	0.071	1.404
SG	-0.056	-0.091	0.4	1.987
PT	0.028	0.049	0.593	1.453
APTT	0.084	0.276	0.014	2.106
Hemorragic shock	4.517	0.389	0	1.682
AIS	-0.023	-0.004	0.964	1.33
ASA	0.11	0.024	0.766	1.151

VIF Variance inflation factor, *PRBCs* Packed red blood cells, *FFP* Frozen fresh plasma, *BPC* Blood platelet count, *Scr* serum creatinine, *SA* Serum albumin, *SG* Serum globulin, *PT* prothrombin Time, *APTT* Activated partial thromboplastin time, *AIS* Abbreviated Injury Scale, *ASA* American Society of Anesthesiologists
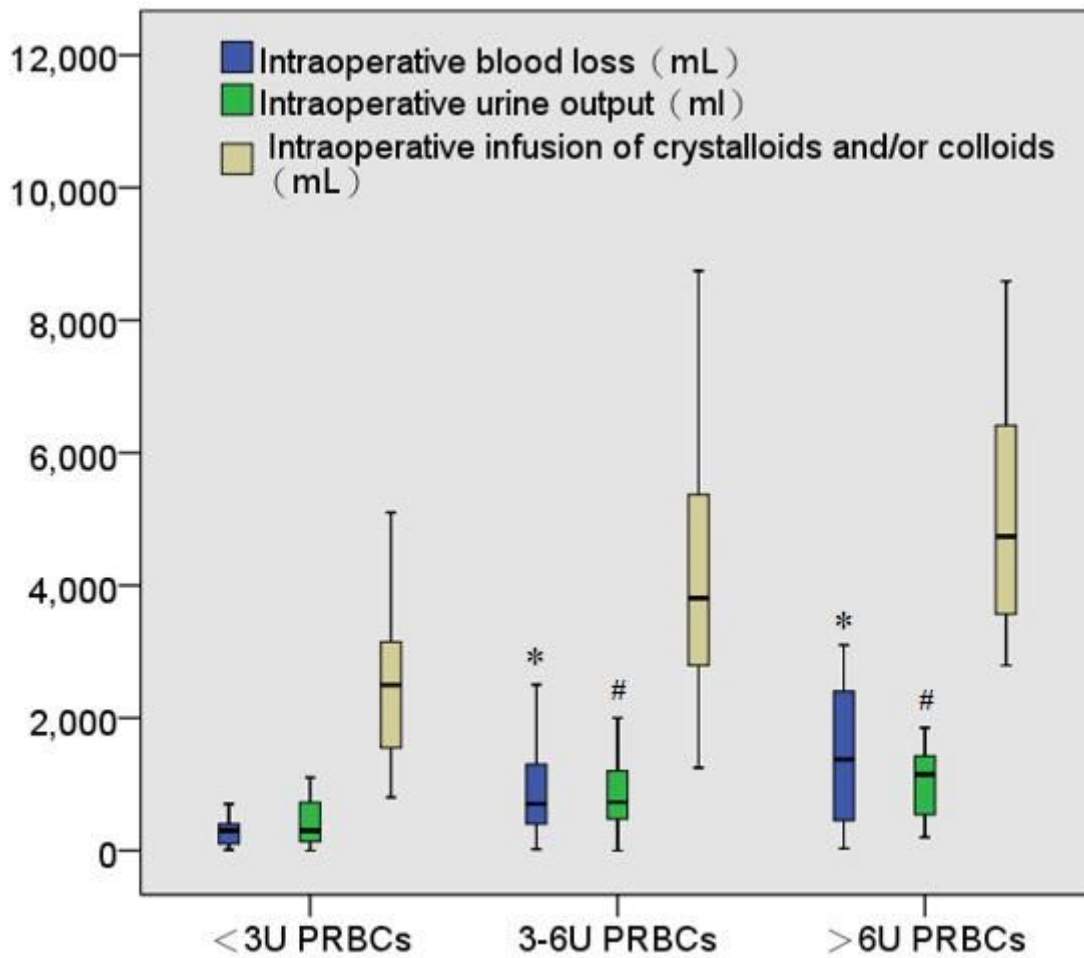
Figures

Figure 1

The intraoperative blood loss, urine output, and infusion of crystalloids and/or colloids of patients who received different packed red blood cells during definitive stabilization surgeries (*P⊠0.01, compared to the ⊠3U group in intraopertive blood loss; #P⊠0.01, compared to the ⊠3U group in intraopertive urine output.) .

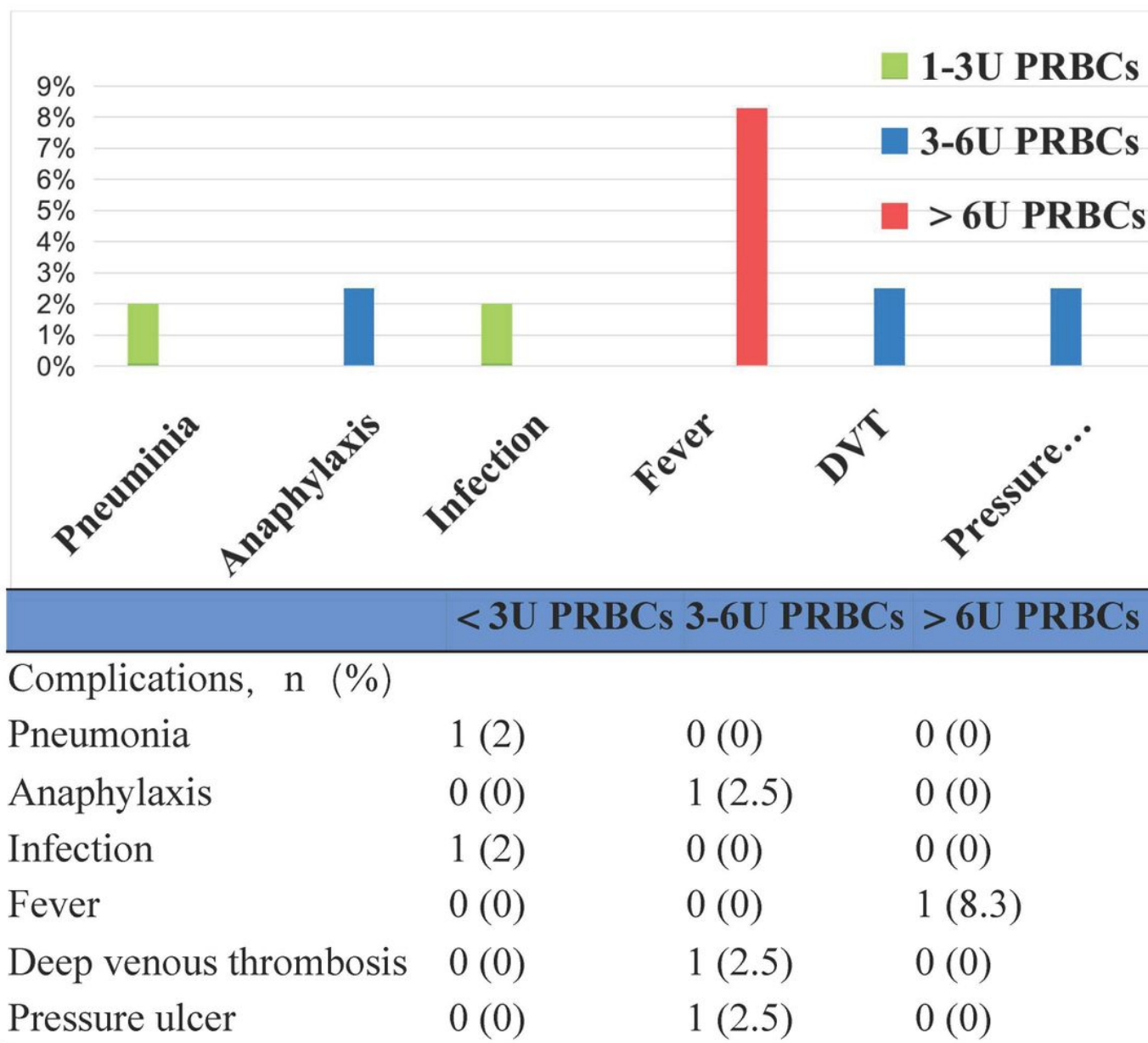|	< 3U PRBCs	3-6U PRBCs	> 6U PRBCs
Complications, n (%)			
Pneumonia	1 (2)	0 (0)	0 (0)
Anaphylaxis	0 (0)	1 (2.5)	0 (0)
Infection	1 (2)	0 (0)	0 (0)
Fever	0 (0)	0 (0)	1 (8.3)
Deep venous thrombosis	0 (0)	1 (2.5)	0 (0)
Pressure ulcer	0 (0)	1 (2.5)	0 (0)

Figure 2

Complications of patients who recieved different packed red blood cells during definitive stabilization surgeries (all P⬚0.05).