Randomized Controlled Study on Safety and Feasibility of Transfusion Trigger Score of Emergency Operations

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Abstract

Background: Due to the floating of the guideline, there is no evidence-based evaluation index on when to start the blood transfusion for patients with hemoglobin (Hb) level between 7 and 10 g/dl. As a result, the trigger point of blood transfusion may be different in the emergency use of the existing transfusion guidelines. The present study was designed to evaluate whether the scheme can be safely and effectively used for emergency patients, so as to be supported by multicenter and large sample data in the future.

Methods: From June 2013 to June 2014, patients were randomly divided into the experimental group (Peri-operative Transfusion Trigger Score of Emergency [POTTS-E] group) and the control group (control group). The between-group differences in the patients' demography and baseline information, mortality and blood transfusion-related complications, heart rate, resting arterial pressure, body temperature, and Hb values were compared. The consistency of red blood cell (RBC) transfusion standards of the two groups of patients with the current blood transfusion guideline, namely the compliance of the guidelines, utilization rate, and per-capita consumption of autologous RBC were analyzed.

Results: During the study period, a total of 72 patients were recorded, and 65 of them met the inclusion criteria, which included 33 males and 32 females with a mean age of (34.8 ± 14.6) years. 50 underwent abdomen surgery, 4 underwent chest surgery, 11 underwent arms and legs surgery. There was no statistical difference between the two groups for demography and baseline information. There was also no statistical differences between the two groups in anesthesia time, intraoperative rehydration, staying time in postanesthetic care unit, emergency hospitalization, postoperative 72 h Acute Physiologic Assessment and Chronic Health Evaluation II scores, blood transfusion-related complications and mortality. Only the POTTS-E group on the 1st postoperative day Hb was lower than group control, $P < 0.05$. POTTS-E group was totally (100%) conformed to the requirements of the transfusion guideline to RBC infusion, which was higher than that of the control group (81.25%), $P < 0.01$.There were no statistical differences in utilization rates of autologous blood of the two groups; the utilization rates of allogeneic RBC, total allogeneic RBC and total RBC were 48.48%, 51.5%, and 75.7% in POTTS-E group, which were lower than those of the control group (84.3%, 84.3%, and 96.8%) $P < 0.05$ or $P < 0.01$. Per capita consumption of intraoperative allogeneic RBC, total allogeneic RBC and total RBC were 0 (0, 3.0), 2.0 (0, 4.0), and 3.1 (0.81, 6.0) in POTTS-E groups were all lower than those of control group (4.0 [2.0, 4.0], 4.0 [2.0, 6.0] and 5.8 [2.7, 8.2]), $P < 0.05$ or $P < 0.001$.

Conclusions: Peri-operative Transfusion Trigger Score-E evaluation scheme is used to guide the application of RBC. There are no differences in the recent prognosis of patients with the traditional transfusion guidelines. This scheme is safe; Compared with doctor experience-based subjective assessment, the scoring scheme was closer to patient physiological needs for transfusion and more reasonable; Utilization rate and the per capita consumption of RBC are obviously declined, which has clinical significance and is feasible. Based on the abovementioned three points, POTTS-E scores scheme is safe, reasonable, and practicable and has the value for carrying out multicenter and large sample clinical researches.

Key words: Emergency Operations; Transfusion Guideline; Transfusion Trigger Score; Red Blood Cell

Introduction

Clinical transfusion of red blood cell (RBC) can be implemented through relatively standardized guidelines, namely blood transfusion guidelines. However, now, there exists no emergency versions of blood transfusion guidelines according to patients' instant hospitalization state, that is to say, current blood transfusion in emergency still need to be operated based on the ordinary blood transfusion guidelines. Because the above transfusion guidelines are mostly used for critically ill patients or patients with elective surgical procedures, it has not been determined whether the emergency patients should be transfused according to the minimum restrictive blood transfusion (6 or 7 g/dl). As the

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use of blood and blood components in China can be largely by the supply or shortage of blood, due to the floating of the guideline, there is no bevidence-based evaluation index on when to start the blood transfusion for patients with hemoglobin (Hb) between 7 and 10 g/dl.

Patients of elective operation have preoperative preparation for a certain period of time. Except the primary diseases, the patients are close to healthy people, vital signs, and physiological status; Second, surgical process is destructive, namely there are the possibilities of blood loss during the whole operation process until the end of surgery. Compared with elective surgery, damage exists prior to most of the emergency operation, even shock and internal environment disorder caused by preoperative blood loss.[1,2] The patients' operation is a process of repairing, controlling damage, and saving lives. But patients of emergency surgery are most healthy in advance without previous medical history, so along with the advancement of surgery, the patients' bleeding is reduced until the end of the surgery.[3]

As a result, the trigger point of blood transfusion may be different in the emergency use of the existing transfusion guidelines, for the same patient facing different doctors or different patients facing the same doctor. With marking scheme to guide the RBC transfusion at the right time and right amount, this study was designed to evaluate whether the scheme can be safely and effectively used for emergency patients, so as to be supported by multicenter and large sample data in the future.

Methods

Patient selection

This study has been registered in Chinese Clinical Trial Register, and the Registration No. was ChiCTR-TRC-14004135. This study was approved by the ethics committee of Affiliated Hospital of Zunyi Medical College (20121115.001). The subjects and their relatives were informed, and informed consent was signed. All patients were randomly divided into the experimental group (Peri-operative Transfusion Trigger Score of Emergency [POTTS-E] group) and the control group (control group) after screening by inclusion and exclusion criteria.

Inclusion criteria

(1) Preoperative Hb <10 g/dl, or intraoperative Hb may be less than 10 g/dl; (2) Age ≥44 years old and ≤55 years old; (3) Permanent resistant area was <2500 m; (4) American Society of Anesthesiologists (ASA) classification: I–IV level; (5) Emergency surgery.

Exclusion criteria

(1) History of blood system diseases; (2) Multiple tumors and/or tumor metastasis; (3) Clear history of coronary heart disease preoperatively; (4) Nerve surgery and obstetrics patients; (5) Patients must be given hypervolemic hemodilution; (6) Patients had other test drugs within 3 months before the selected research or participated in other clinical trials.

Elimination criteria

(1) Intraoperative uncontrollable and life-threatening bleeding, which needs a large number of blood transfusion; (2) Re-emergency operation is needed during hospitalization after an emergency operation.

Treatment

Intraoperative monitoring was implemented on electrocardiogram, blood pressure (BP), SpO_2, temperature, invasive BP (art), and central venous pressure; preoperative and intraoperative medications were executed according to the current standard daily work in clinical; endotracheal intubation anesthesia was selected and the researchers do not interfere in selection and medication of compound anesthesia.

Blood transfusion for Peri-operative Transfusion Trigger Score of emergency group

Through POTTS-E marking scheme, transfusion requirement of the patients and the amount of RBC transfusion were evaluated based on the current transfusion guidelines issued by the China's Ministry of Health. Patients with Hb of 7–10 g/dl were especially refined for scoring and were guided for blood transfusion. Circulation condition, blood oxygenation situations, oxygen consumption, and compensatory state were respectively evaluated by whether the patients needed adrenaline to maintain normal BP, whether higher oxygen concentration was needed to maintain the oxygenation, whether there was high metabolism as a result of high body temperature, and whether there was high shock index. The scheme referred to the POTTS of Western China Hospital of Sichuan University. The scheme had passed the authorization, and there was no conflict of interest [Table 1].

For all the patients of the POTTS-E group, the baseline point was 7, POTTS-E was 0–8 points, and blood transfusion indications were 7 + POTTS-E scores. If the total score was still higher than 7.5, however, RBC infusion was still needed to be continued until the Hb value was equal to or greater than the immediate total score. When the total score was more than 10 and Hb >10 g/dl, RBC infusion was no longer needed.

Blood transfusion for the control group

According to the transfusion guidelines (2000) issued by the China's Ministry of Health, when Hb >10 g/dl, RBC transfusion was not needed; while when Hb <7 g/dl, transfusion should be considered; when Hb between 1–9 g/dl, the RBC transfusion should be considered according to patients' cardiopulmonary compensatory function, body

Table 1: Peri-operative transfusion trigger score of emergency

Score	Epinephrine ($\mu g\ kg^{-1}\ min^{-1}$)[a]	FiO_2 (%)[b]	Temperature (°C)[c]	[d]Shock index
0	0	≤35	<38	<1.5
1	0–0.05	36–49	38–40	1.5–2
2	≥0.06	≥50	>40	>2

[a]The amount of Epinephrine for maintain normal blood pressure; [b]Fraction of inspiration O_2 to sustain the SpO_2 95% or higher; [c]Nasopharyngeal temperature.

metabolism, and oxygen consumption. Doctor in charge should judge the time and amount of RBC infusion according to the guideline of blood transfusion subjectively.

Calculation method of autologous blood: The volume of autologous blood was recorded, and autologous hematocrit (HCT) was examined. The volume that was equivalent to 45% HCT was calculated. And each 200 ml of autologous blood with 45% HCT was recorded as 1 U.

Postoperative follow-up

With the end of the surgery as the starting point, the patients were followed-up in the hospital at 24 h, 72 h after the operation and during emergency hospitalization (discharge, transfer or second selective surgery). The patients were recorded for their mortality, blood transfusion-related complications, and vital signs. POTTS-E group was rated for the requirement of postoperative RBC transfusion. And CON group was based on the doctors' experience to decide whether to give RBC transfusion. Postoperative Hb review results and RBC application of the two groups of patients were recorded; the patients were followed up outside the hospital every 4 weeks in the 3 months postoperatively to record blood transfusion-related complications.

Measurements

The patients were collected for their age, gender, and body mass index; American Society of Anesthesia (ASA) score, operation area, Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) scores and vital signs (temperature, heart rate, breathing, BP and SpO_2); operation time, intraoperative rehydration, staying time in postanesthetic care unit (PACU) and postoperative emergency hospitalization; mortality and blood transfusion-related complications; heart rate, resting arterial pressure, body temperature, and Hb values during hospital follow-up; the consistency of RBC transfusion standards of the two groups of patients with the current blood transfusion guideline, namely the compliance of the guidelines; utilization rate and per-capita consumption of autologous RBC, intraoperative allogeneic RBC, postoperative allogeneic RBC, perioperative (intraoperative and postoperative) allogeneic RBC, and overall RBC (perioperative allogeneic RBC + autologous blood).

Statistical analysis

Statistical analysis was performed with SPSS 17.0 software package (SPSS Inc., Chicago, IL, USA). In normal distribution, measurement data were represented as mean ± standard deviation (± s), and *t*-test of independent sample was used in comparison between the two groups; In nonnormal distribution, the data were represented as M (P25, P75), and Wilcoxon test was used in comparison between the two groups; categorical data were represented as rate and constituent ratio, and Chi-square test or Fisher's exact test were used in comparison between groups, and pearmen linear correlation analysis was adopted for data analysis. $P \leq 0.05$ referred as the statistically significant difference.

Results

A total of 72 cases were included from June 2013 to June 2014 with 7 cases excluded. The excluded cases include 2 cases whose postoperative RBC infusion was not according to the experiment scheme; 2 cases who were given large amount of blood transfusion due to intraoperative vascular rupture; 3 cases were lost to postoperative follow-up because of transferred to other hospitals immediately after surgery. A total of 65 patients completed the data, where 33 cases were in the POTTS-E group of 33 cases, and 32 cases were in the control group, and no mortality occurred in two groups.

Baseline information

Peri-operative Transfusion Trigger Score of Emergency group and control group were compared in age, gender, body mass index, ASA score, and operation area; Heart rate, mean arterial pressure, SpO_2, body temperature, and shock index when entering into the operation room; there was no statistical difference between the two groups for Hb values and APACHE II scores after entering into the operation room [Table 2].

Treatment and prognosis of the patients

There were no statistical differences between the two groups in anesthesia time, intraoperative rehydration, staying time in PACU, emergency hospitalization, postoperative 72 h APACHE II scores, blood transfusion-related complications and mortality [Table 3].

There were no statistical differences in the comparison of vital signs at the 1st and 3rd postoperative day and at the end of the emergency hospitalization. There were no statistical differences in the comparison of Hb values at the time when entering into the operation room, at the 3rd postoperative day and at the end of the emergency hospitalization. Hb values of the two groups were both higher than the time when entering into the operation room at the 1st and 3rd postoperative day and at discharge [Table 4].

Compliance of blood transfusion guidelines

There were no patients of POTTS-E group that were not transfused with Hb <7 g/dl or were transfused with Hb >10 g/dl; 5 patients of CON group were not transfused with Hb <7 g/dl and 1 case was still transfused with Hb >10 g/dl; POTTS-E group was totally (100%) conformed to the requirements of the transfusion guideline to RBC infusion, which was higher than that of CON group (81.25%) [Table 5].

Analysis on correlation of intraoperative total amount of red blood cells with patient serum iron, Acute Physiologic Assessment and Chronic Health Evaluation II scores and hemoglobin results when entering the operation room

In the POTTS-E group, the intraoperative total amount of RBCs showed a linear positive correlation with serum iron (SI) at the time of entering the operation room, with

Table 2: Demography and baseline information

Variables	POTTS-E (n = 33)	Control (n = 32)	χ^2/t	P
Age (years)	35.00 ± 16.80	34.59 ± 12.29	0.111	0.912
Sex (male, n)	19	14	0.746	0.388
BMI (kg/m^2)	21.46 ± 2.32	21.71 ± 3.47	−0.330	0.743
ASA (n)				
II	9	10	0.124	0.724
III	20	19	0.010	0.919
IV	4	3	0.128	0.721
Surgery area (n)				
Abdomen	27	23	0.905	0.341
Chest	2	2	0	1.000
Arms and legs	4	7	1.099	0.294
Vital signs (entering the operation room)				
Temperature (°C)	36.51 ± 0.60	36.31 ± 0.63	1.304	0.197
HR (/min)	110.93 ± 23.26	110.68 ± 21.93	0.045	0.964
RR (/min)	25.18 ± 5.45	24.59 ± 4.81	0.647	0.460
MAP (mmHg)	69.94 ± 16.13	73.92 ± 21.18	−0.853	0.397
SpO_2 (%)	96.48 ± 1.17	96.15 ± 10.5	1.187	0.240
Shock index	1.16 ± 0.12	1.17 ± 0.62	−0.076	0.939
Hb (g/dl)	7.87 ± 2.22	7.69 ± 1.98	0.603	0.736
APACHE II	8.69 ± 4.28	8.09 ± 4.65	0.544	0.588

POTTS-E: Peri-operative transfusion trigger score of emergency; BMI: Body mass index; ASA: American society of anesthesiologists; HR: Heart rate; MBP: Mean blood pressure; RR: Relative risk; SpO_2: Oxygen saturation; Hb: Hemoglobin; APACHE II: Acute physiology and chronic health evaluation II.

Table 3: Operation information and prognosis

Variables	POTTS-E (n = 33)	Control (n = 32)	t	P
Operation time (min)	143.81 ± 91.50	166.21 ± 105.81	−0.914	0.364
Intraoperative rehydration (ml)	2275.75 ± 756.73	2763.1250 ± 1324.19	−1.814	0.072
PACU stays (min)	85.09 ± 51.16	90.12 ± 51.25	−0.368	0.714
Emergency hospital stays (days)	10.57 ± 6.68	9.81 ± 6.25	0.475	0.636
Postoperation 72 h APACHE	2.78 ± 2.26	2.96 ± 4.06	−0.222	0.825
Complications (%)	1 (3.03)	1 (3.12)	0	0.982

POTTS-E: Peri-operative transfusion trigger score of emergency; PACU: Postanesthetic care unit; APACHE: Acute physiology and chronic health evaluation.

Table 4: The two groups of patients are compared in vital signs and Hb (mean ± SD)

Vital signs	HR (/min)			MAP (mmHg)			Temperature		
	1-day	3 days	End of hospitalization	1-day	3 days	End of hospitalization	1-day	3 days	End of hospitalization
POTTS-E (n = 33)	91.78 ± 19.11	88.06 ± 11.92	85.51 ± 12.62	80.23 ± 14.00	81.16 ± 10.68	83.19 ± 7.18	37.22 ± 0.85	36.82 ± 0.53	36.62 ± 0.32
Control (n = 32)	89.53 ± 17.36	88.93 ± 17.35	83.46 ± 10.63	81.66 ± 10.12	82.17 ± 11.45	84.05 ± 11.16	37.02 ± 0.71	36.69 ± 0.57	36.65 ± 0.56

Hb values	Entering into the operation room (g/dl)	1-day (g/dl)	3-day (g/dl)	End of hospitalization (g/dl)
POTTS-E (n = 33)	7.87 ± 2.22*	9.13 ± 1.25†	9.30 ± 2.30	9.54 ± 1.29
Control (n = 32)	7.69 ± 1.98*	9.89 ± 1.68	9.67 ± 2.36	9.82 ± 1.55

*Compared with the same group, 1-day, 3 days and end of hospitalization P<0.05; †Compared with postoperative day P<0.05. Hb: Hemoglobin; SD: Standard deviation; MAP: Mean arterial pressure; HR: Heart rate.

a correlation coefficient of r = 0.609 (P < 0.05); in the control group, the intraoperative total amount of RBCs showed a linear positive correlation with SI at the time of entering the operation room, with a correlation coefficient of r = 0.509 (P < 0.05).

In the POTTS-E group, the intraoperative total amount of RBCs showed a linear positive correlation with APACHE II scores at the time of entering the operation room, with a correlation coefficient of r = 0.670 (P < 0.05); in the control group, the intraoperative total amount of RBCs showed a

linear positive correlation with APACHE II scores at the time of entering the operation room, with a correlation coefficient of $r = 0.523$ ($P < 0.05$).

In the POTTS-E group, the intraoperative total amount of RBCs showed a linear negative correlation with Hb value at the time of entering the operation room, with a correlation coefficient of $r = -0.360$ ($P < 0.05$); in the control group, the intraoperative total amount of RBCs showed a linear negative correlation with Hb value at the time of entering the operation room, with a correlation coefficient of $r = -0.604$ ($P < 0.05$) [Table 6].

Differences of red blood cell application

Utilization rate of RBC: There were no statistical differences in utilization rates of autologous blood of the two groups; the utilization rates of allogeneic RBC, total allogeneic RBC and total RBC were 48.48%, 51.5%, and 75.7% in POTTS-E group, which were lower than those of the CON group (84.3%, 84.3%, and 96.8%) [Table 7].

Amount of red blood cell: Per capita consumption of autologous blood, intraoperative allogeneic RBC, total allogeneic RBC and total RBC in POTTS-E groups were all lower than those of CON group [Table 8].

Discussion

Over years, researchers have tried to find an alternative for allogeneic blood, in order to eliminate the negative impacts of blood transfusion and the tensions of blood application. But there is not a drug or product that can completely replace the human red blood cells based on the current study results and application conclusion.[4,5] Failure to be replaced does not mean that it is perfect. Modern medical research has shown that allogeneic blood transfusion has a risk.[6-9] At the same time, the growing contradiction between supply and demand of blood products has affected the normal medical order.[10] As policy makers of medical action, judging the time and amount of infusion in the face of anemia patients who need RBC infusion is a question needed to be carefully considered.[11]

Different blood transfusion guidelines are introduced in various parts of the world, to specific transfusion of Hb for patients with different levels. Perioperative blood transfusion and adjuvant treatment guidelines in 2006 of ASA suggest that: Patients with Hb <6 g/dl should be given RBC infusion, and should not be transfused with Hb >10 g/dl; if the patients' Hb lies in the range of 6–10 g/dl, the RBC transfusion should be determined according to the speed and levels of ischemia, and the risks such as the subsequent complications due to insufficient blood oxygenation capacity, low cardiopulmonary reserves and high oxygen consumption, etc.;[12] British Society of Hematology defines that blood transfusion starts at Hb <8 g/dl;[13] Scottish perioperative blood transfusion guidelines was defined at Hb <7 g/dl;[14] and Spanish Society of blood transfusion defines that blood transfusion starts at Hb <7 g/dl and at Hb <5 g/dl in patients with chronic anemia.[15] Though there are differences in the concrete values in the above blood transfusions guidelines, the general direction is roughly the same-the restrictive transfusion strategy. This is because that the most important reference for such guidelines is a comparative research on open blood transfusion and restrictive blood transfusion (Hébert *et al*., 1999). The results showed that the critically ill patients whose blood transfusion was started at Hb <7 g/dl with Hb was maintained in 7–9 g/dl had obviously fewer amount of blood transfusion and lower incidence of related complications; And the most important thing was that mortality within 30 days of hospitalization was declined.[16] In a follow-up study, Carson *et al*. also supported that restrictive blood transfusion can decrease the amount of transfusion but not increase the incidence of complications and mortality of the patients with experiment results.[17,18]

Determination on the requirement of RBC transfusion needs the quick analysis results of patients' pulmonary function, oxygen partial pressure, oxygenation index, oxygen uptake rate;[19,20] Heart rate, cardiac output and vascular resistance;[21] Mixed venous oxygen saturation, arterial lactic acid concentration, base defect, pH (pHi) and CO_2 partial pressure in gastric mucosa;[22-24] capacity state, etc. Under the emergency state, the above evaluation indexes would deviate from the normal physiological condition because of the stress response, and body compensatory changes. In clinical work, in the face of emergency patients, it is very difficult to require all medical institutions to judge whether patients need RBC infusion according to the evaluation on patients' cardiopulmonary compensatory ability, metabolism, and oxygen consumption.[25]

In this study, we referenced to the "POTTS" which was put forward by Professor Liu Jin (Anesthesia Department, Western China Hospital of Sichuan University), to

Table 5: The two groups of patients are compared in compliance of blood transfusion guidelines (%)

Variables	POTTS-E ($n = 33$)	Control ($n = 32$)	χ^2	*P*
<7 g/dl no transfusion	0 (0)	5 (15.62)	7.517	0.006
>10 g/dl still transfusion	0 (0)	1 (3.12)	1.433	0.231
Compliance rate	100 (100)	26 (81.25)	9.135	0.003

POTTS-E: Peri-operative transfusion trigger score of emergency.

Table 6: Correlation of intraoperative total amount of RBCs with SI, APACHE II and Hb

Variables	RBC of group POTTS-E		RBC of group control	
	Correlation coefficient	*P*	Correlation coefficient	*P*
Serum iron	0.609	0.000	0.509	0.003
APACHE II	0.670	0.000	0.523	0.002
Hb	−0.360	0.040	−0.604	0.000

APACHE II: Acute physiology and chronic health evaluation II; Hb: Hemoglobin; RBCs: Red blood cells; POTTS-E: Peri-operative transfusion trigger score of emergency.

Table 7: The two groups of patients are compared in utilization rate of RBC (%)

Variables	Autologous RBC	Operation allogeneic RBC	Postoperation allogeneic RBC	Total allogeneic RBC	Total RBC
POTTS-E (n = 33)	14 (42.4)	16 (48.4)	4 (12.1)	17 (51.5)	25 (75.7)
CON (n = 32)	16 (50.0)	27 (84.3)	7 (21.8)	27 (84.3)	31 (96.8)
χ^2	0.375	9.346	1.099	8.021	5.143
P	0.54	0.002	0.294	0.005	0.023

POTTS-E: Peri-operative transfusion trigger score of emergency; RBC: Red blood cell.

Table 8: The two groups of patients are compared in per capita consumption of RBC (M (P25, P75))

Variables	Autologous RBC	Operation allogeneic RBC	Postoperation allogeneic RBC	Total allogeneic RBC	Total RBC
POTTS-E (n = 33)	0 (0, 2.6)	0 (0, 3.0)	0 (0, 0)	2.0 (0, 4.0)	3.1 (0.81, 6.0)
CON (n = 32)	0 (0, 2.7)	4.0 (2.0, 4.0)	0 (0, 0)	4.0 (2, 6.0)	5.8 (2.7, 8.2)
Z	−4.506	−2.236	−4.619	−2.499	−4.864
P	0.012	0.025	0.000	0.000	0.000

POTTS-E: Peri-operative transfusion trigger score of emergency; RBC: Red blood cell.

replace the required subjective judgment in the original blood transfusion indications when patients' Hb in 7 ~ 10 g/dl. The evaluation scheme is composed of four parts: Circulation condition, blood oxygenation situations, oxygen consumption, and compensatory state namely whether the patients need adrenaline to maintain normal BP, whether higher oxygen concentration is needed to maintain the oxygenation, whether there is high metabolism with high body temperature and whether there is high shock index.

The two groups of actually included patients are consistent at preoperative baseline, and the data are comparable. In the hospital follow-up, surgical operation time, staying time of PACU, and emergency hospitalization time of POTTS-E group did not increase; And there are no differences between the two groups in intraoperative rehydration, APACHE II scores on the 3rd days after operation, and postoperative vital signs; except the 1st day after operation, there are no differences between the POTTS-E group and the control group in Hb on the 3rd day after operation and at the end of emergency hospitalization. Compared with posthospitalization follow-up, there are no differences between the two groups in mortality and blood transfusion-related complications till 6 months after the operation.

Due to the own reason of the research center, this study does not involve nerve surgery and obstetrics patients; affected by the local medical policy, the hospitalization condition of ICU is not counted. Since it is the first time to introduce marking scheme into the blood transfusion research of emergency patients; risk control is carried out on the included patients, and some critically ill patients are excluded to ensure safety.[26-30] The lower limit is 7 points, and the upper limit is 10 points, which are consistent with the currently executed blood transfusion guidelines in China. This study does not appear deaths; due to the differences of the case range, the results do not tally with the study of Heeney *et al*.[31] But the results still hint that according to the blood transfusion scheme guided by POTTS-E, complications and death risk are not increased, and there are no significant differences in the postoperative vital signs, suggesting the safety of POTTS-E scheme. But limited by the number of cases and the research time, this study fails to complete the comparison in the postoperative quality of life and longer follow-up.

In the comparison of transfusion in all included patients, we found that the traditional doctor experience-based transfusion strategy subject to blood transfusion guidelines appeared to be not completely consistent with the requirements of "guidelines" in the perioperative RBC transfusion. The results of the study showed that in the control group, 5 patients did not undergo intraoperative RBC transfusion when the Hb value was less than 7 g/dl, while one patient still underwent allogeneic RBC transfusion when the Hb value was higher than 10 g/dl. Only 81.25% of the patients met the requirements of "guidelines," and this ratio was lower than the 100% in the ETS scoring group. According to the reason analysis, as the experimental group was in strict accordance with the experiment plan and the scoring rules of the experimental group were established within the framework of blood transfusion guidelines, the patients had to undergo transfusion when the Hb value was less than 7 g/dl. Throughout the experiment stages, the number of patients with extra points in the ETS group was small, and no patient achieved 3 points regarding ETS scores, that is, no patient was reported to undergo blood transfusion with an Hb value up to 10 g/dl. Meanwhile, the experiment in the ETS group required its patients to undergo transfusion when Hb value was less than 7 g/dl. As a result, the Hb values of all patients in the ETS group were maintained between 7 and 10 g/dl in the operation stage. In contrast, in the control group, the blood transfusion guidelines allowed doctors to decide the maintained Hb value range only when they had evaluated patient conditions including cardiopulmonary compensatory ability, body metabolism, and oxygen consumption. Although the recommended maintained range of the guidelines was also 7–10 g/dl, the subjective assessment of doctors may be insufficient considering the emergency conditions, resulting in insufficient transfusion for patients with such need while excessive transfusion for patients without such need. Consequently, 6 patients in the

control group were out of the requirements of "guidelines". At the same time, we speculated that the rest patients in the control group, whose Hb values ranged from 7 to 10 g/dl might still have these shortcomings above.

In the results of this group, we conducted an analysis on the linear correlation of the patient intraoperative total amount of RBCs with shock index, APACHE II scoring, and Hb value when entering the operation room. The results suggested that there was a linear correlation between the blood amount of patients in two groups and above three indicators. However, in the POTTS-E group, the correlation coefficient of blood amount with shock index and APACHE II scores was higher than that in the control group; the correlation coefficient with Hb values in the control group was higher than that in the POTTS-E group. According to the reason analysis, the transfusion need of emergency patients could be estimated preoperatively via their signs, inspection, and testing results, but theoretically, the more objective indicators included by an assessment standard, the greater its correlation with body hypoxia. Therefore, for the transfusion assessment of emergency patients especially patients with hemorrhagic shock, the accuracy of APACHE II scores would be higher than shock index, which appeared to be higher than Hb values. It can be seen that the control group was most closely related to Hb values at the time of entering into the operation room, suggesting that the assessment mixed with experience was easy to be misled by some key indicators, while the POTTS-E group was more closely associated with shock index and APACHE II, suggesting that POTTS-E scheme was closer to patient physiological status and more consistent with their transfusion need. Consequently, it is more reasonable to guide blood transfusion using the POTTS-E scores-based transfusion strategy.

Compared with the POTTS-E group, more RBC is infused in the control group; thus, Hb of the POTTS-E group is lower in the control group on the follow-up of the 1st postoperative day. But the mean value is not greater than 1 g/dl. At the same time, as the patients' recovery, there are no differences of Hb on the third postoperative day and at the end of hospitalization. Reason analysis: The control group was given RBC transfusion not completely according to the regulation of blood transfusion guidelines. Some patients needing RBC transfusion fail to strictly perform certain rule. And the average level of Hb after blood transfusion is pulled down. We have reason to believe that, if the control group can complete reference to the guideline, the difference of Hb at follow-up point should be even greater or may be affected for a longer time.

Only a minority of patients with POTTS-E >0 during the entire study period, namely most of the patients are given allogeneic RBC transfusion according to the lower limit of Hb <7 g/dl in most of the scoring, so it is not difficult to understand the intraoperative and perioperative utilization rate and per capita consumption of allogeneic RBC in POTTS-E group are lower than those of the control group; autologous blood utilization rate in POTTS-E group is the same as the control group, but the per capita consumption is lower than the control group, and the difference is from the small sample size. But there is reason to believe that if the sample size is enlarged, but the utilization rates of autologous blood in the two groups are not changed, per capita consumption of autologous blood in the control group is the same as the POTTS-E group, and more allogeneic RBC infusion is needed in the control group. Therefore, the intraoperative and perioperative utilization rate and the per capita consumption of total RBC in POTTS-E group should be lower than those of the control group. The results suggest that with the evidence-based method of classification to guide transfusion for emergency patients, utilization rate and the per capita consumption of RBC can effectively be reduced.

In summary, POTTS-E scores scheme is safe, reasonable, and practicable and has the value for carrying out multicenter and large sample clinical researches.

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