Application value of thromboelastography in perioperative clinical blood transfusion and its effect on the outcome of patient

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Abstract. Application value of thromboelastography (TEG) in perioperative clinical blood transfusion and its effect on the outcome of patient were investigated. Seventy-four patients, admitted to The Surgical Department of the First Hospital of Zibo from March 2015 to March 2018, were selected for this study. Among them, 34 patients took only the traditional coagulation function testing method as the blood transfusion guide during the perioperative period and they were regarded as the control group. The other 40 patients used TEG as the blood transfusion guide during the perioperative period, and they were regarded as the TEG group. The coagulation function indicators in 2 h before the operation and in 24 h after the operation, the transfusion amount and blood loss during the operation, the condition of the blood transfusion during the perioperative period, the occurrence rate of the postoperative rebleeding, the length of hospital stay and mortality of the patients in the two groups were compared. The coagulation function indicators of the patients in the two groups in 2 h before the operation and in 24 h after the operation showed that there was no significant difference between the two groups ($P>0.050$). However, APTT and Pt of the patients in the two groups both increased when compared with those before the treatment ($P<0.050$) and Hb, Hct, Plt and Fib all decreased ($P<0.050$). The suspended erythrocytes, Plt, fibrinogen and plasma in the TEG group were both significantly lower than those in the control group ($P<0.001$). Compared with the traditional coagulation function test, TEG was more accurate for estimating the coagulation function of patient and was more suitable for estimating the condition of blood transfusion of patient in the perioperative period; also, it could shorten the recovery period of patient and it is worthwhile to promote it in the clinic.

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Introduction

During the process of surgery, perioperative massive hemorrhage is also a major problem needed to be solved first in the clinic (1). Most patients will cause a disorder of coagulation function due to the traumatic invasive surgery (2). Moreover, the patient is extremely prone to have massive hemorrhage, which endangers the patient's life and health (3). In clinic, a patient who is in the perioperative period is required to provide timely blood products to supplement the normal blood circulation in the patient (4). When facing the problem how to choose the most appropriate opportunity of blood transfusion, the most traditional method in clinic is to estimate whether the patient's coagulation function and erythrocyte function are abnormal or not (5). However, at present, with the continuous increase of difficult diseases, the defects of traditional detection methods are becoming more and more obvious. For example, the timeliness and effectiveness of the detection are poor, and real-time blood function detection cannot be achieved (6). When facing the situation of sudden massive hemorrhage, an effective prejudgment cannot be made, which may lead to excessive blood loss and threaten patient's life (7). Therefore, research on how to detect the coagulation function of the patient in real-time in clinic is urgent and a major breakthrough is required.

With the continuous development of modern medical technology, thromboelastography (TEG) was developed. TEG can draw changeable images according to the dynamic changes of patient's coagulation function and can accurately and integrally estimate the general situation of coagulation function and the formation of thrombus of patient, and the monitoring is convenient and fast (8,9). Since 2015, the surgical department of our hospital have widely used TEG as the judgment indicator for the perioperative blood transfusion of patients, and now enough research cases have been accumulated. The value of TEG in perioperative clinical blood transfusion is researched through retrospective analysis, and the purpose is to provide effective reference and guidance when choosing

Table I. Comparison of the clinical data of the patients in the two groups [n (%)].

Data	TEG group (n=40)	Control group (n=34)	χ^2 or t value	P-value
Age (years)	48.14±9.16	49.07±9.86	0.420	0.676
Weight (kg)	62.18±15.67	63.14±14.89	0.269	0.789
BMI (kg/m^2)	21.24±6.24	21.54±6.17	0.207	0.837
Preoperative WBC (x10^9/l)	3.16±2.54	3.08±2.49	0.136	0.892
Preoperative RBC (x10^{12}/l)	4.07±1.14	4.15±1.08	0.308	0.759
Preoperative PLT (x10^9/l)	167.24±50.14	172.33±42.86	0.465	0.644
Operation time (min)	138.14±34.86	142.27±38.12	0.487	0.628
Sex			0.128	0.721
Male	24 (60.00)	19 (55.88)		
Female	16 (40.00)	15 (44.12)		
Living environment			0.003	0.956
City	28 (70.00)	24 (70.59)		
Countryside	12 (30.00)	10 (29.41)		
ASA			0.085	0.771
I grade	19 (47.50)	15 (44.12)		
II grade	21 (52.50)	19 (55.88)		
Type of operation			0.171	0.918
Orthopedic operation	17 (42.50)	14 (41.18)		
Surgical operation	16 (40.00)	15 (44.12)		
Other operation	7 (17.50)	5 (14.71)		

the opportunity of blood transfusion of patient in clinic in the future.

Patients and methods

General data. Seventy-four patients, who were admitted by the surgical department in the First Hospital of Zibo (Zibo, China) from March 2015 to March 2018, were selected for the study and were retrospectively analysed. There were 43 males and 31 females, aged from 29 to 67 years, and the average age was 48.94±10.54 years. Inclusion criteria: All patients had surgery in the hospital; patient condition assessment before anesthesia was in the grade from I to II according to ASA (10); intraoperative blood loss >1,000 ml; patients had complete case data; patients were willing to cooperate with the hospital for the investigation work. Exclusion criteria: Patients had severe organ failure; patients had blood diseases that may affect coagulation function; patients took anticoagulant or antiplatelet drugs in recent 2 months; patients had emergency operations; patients had liver dysfunction; patients were transferred to other hospitals; patients had mental illness.

This study was approved by the Ethics Committee of the First Hospital of Zibo (Zibo, China). Patients who participated in this research had complete clinical data. The signed informed consents were obtained from the patients or the guardians.

Grouping methods. Of the 74 patients, only 34 patients took the traditional coagulation function testing method as the blood transfusion guide during the perioperative period and they were regarded as the control group. The other 40 patients used TEG as the blood transfusion guide during the perioperative period and they were regarded as the TEG group.

Operation methods. The anesthesia induction, intraoperative anesthesia maintenance and operation of the patients in the two groups were completed by the senior clinicians in the hospital, and the operation methods of the same kind of diseases were consistent.

Blood transfusion methods. The control group: Blood gas analysis, the test of coagulation function and blood routine function were carried out respectively before and after the operation (the interval was 1 h), when Hb <70 g/l and Hct <25%, 2 units of the suspended erythrocytes was added; when PLT <50x10^9 U/l, 1 unit of platelets was added; 2 g of fibrinogen was added when fibrinogen was <1.2 mg/dl. The TEG group: TGE detector (purchased from American Haemoscope company, TEG5000 thromboelastograph) was used for real-time monitoring based on the monitoring of the control group; when R value was >10 min, it indicated that the clotting factor was reduced, and the frozen plasma (15 ml/kg) was added; when MA value was >70 min, 1 unit of platelets was added; when Angle value was >72 degrees, 2 g of fibrinogen was added.

Observation indicators. The coagulation function indicators of the patients in the two groups in 2 h before the operation and in 24 h after the operation were: Hb, APTT, Pt, Hct, Plt, Fib; intraoperative transfusion amount and intraoperative blood loss of the patients in the two groups; the condition of blood transfusion of the patients in the two groups during the perioperative

Table II. The comparison of coagulation function indicators before and after the operation.

Index	TEG group (n=40)	Control group (n=34)	t value	P-value
In 2 h before the operation				
Hb (g/l)	131.14±14.01	128.63±13.42	0.783	0.436
APTT(s)	31.07±3.15	31.24±2.95	0.238	0.812
Pt(s)	11.05±0.94	10.98±0.76	0.348	0.729
Hct (%)	35.68±5.14	37.21±5.06	1.285	0.203
Plt (g/l)	207.63±66.54	211.08±70.52	0.216	0.829
Fib (g/l)	3.98±0.26	3.93±0.29	0.782	0.437
In 24 h after the operation				
Hb (g/l)	96.14±7.05[a]	95.23±8.14[a]	0.515	0.608
APTT(s)	35.08±4.66[a]	33.87±5.24[a]	1.051	0.297
Pt(s)	16.23±2.51[a]	15.14±3.01[a]	1.700	0.094
Hct (%)	26.96±6.56[a]	27.08±7.12[a]	0.075	0.940
Plt (g/l)	142.37±69.52[a]	146.72±72.37[a]	0.263	0.793
Fib (g/l)	3.08±0.49[a]	2.96±0.55[a]	0.992	0.324

[a]P<0.050, compared with the preoperative indicators in the same group.

Table III. The comparison of the condition of the operation.

Index	TEG group (n=40)	Control group (n=34)	t value	P-value
Intraoperative blood loss (ml)	2,486.12±654.73	2,514.26±701.08	0.178	0.859
Intraoperative transfusion amount (ml)	1,577.63±364.62	2,574.46±514.63	9.717	<0.001

period: the suspended erythrocyte, fibrinogen, Plt, the condition of plasma use; the clinical results of the patients in the two groups: The occurrence rate of the postoperative rebleeding, the length of hospital stay and mortality.

Statistical methods. The data were analysed and processed by using SPSS 24.0 statistical software (IBM Corp., Armonk, NY, USA); the enumeration data were expressed in the form of a rate; the comparison between the groups was performed by using Chi-square test; the measurement data were expressed as the mean ± standard deviation and the comparison between the groups was performed by using t-test. P<0.05 was considered to indicate a statistically significant difference.

Results

Comparison of the general data. The age, weight, BMI, preoperative blood routine indicators, operation time, sex, ASA grade and the type of operation were compared between the two groups, and no significant difference (P>0.050) was found, indicating that the patients in the two groups were comparable (Table I).

Comparison of coagulation function before and after the operation. When comparing the coagulation function indicators of the patients in the two groups in 2 h before the operation and in 24 h after the operation, it was shown that there was no significant difference between the two groups (P>0.050). However, APTT and Pt of the patients in the two groups both increased when compared with those before the treatment (P<0.050) and Hb, Hct, Plt and Fib both decreased (P<0.050) (Table II).

Comparison of the condition of the operation. There was no significant difference when comparing the intraoperative blood loss of the patients in the two groups (P>0.050), while the intraoperative transfusion amount in the TEG group was 1,577.63±364.62 ml, which was significantly less than the intraoperative transfusion amount in the control group (2,574.46±514.63 ml), P<0.001 (Table III).

Comparison of the condition of the blood transfusion. In the TEG group, 4.24±1.24 units of the suspended erythrocytes was used during the perioperative period, which was significantly less than that in the control group (6.27±1.86 units, P<0.001); 1.94±0.75 units of Plt was used in the TEG group during the perioperative period, which was significantly less than that in the control group (3.42±1.24 units, P<0.001); 2.13±0.83 g of fibrinogen was used in the TEG group during the perioperative period, which was significantly less than that in the control group (3.24±1.22 g, P<0.001); 224.63±41.86 ml of plasma was used in the TEG group during the perioperative period, which was significantly less than that in the control group (427.86±35.14 ml, P<0.001) (Figs. 1-4).

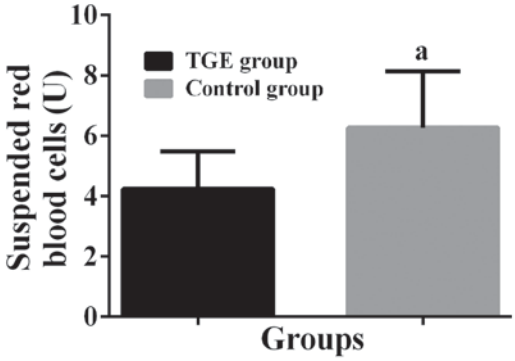

Figure 1. The comparison of the use of the suspended erythrocytes of the patients in the two groups. The amount of the suspended erythrocytes in the control group was significantly higher than that used in the TEG group; [a]P<0.050, compared with the amount of the suspended erythrocytes used in the TEG group.

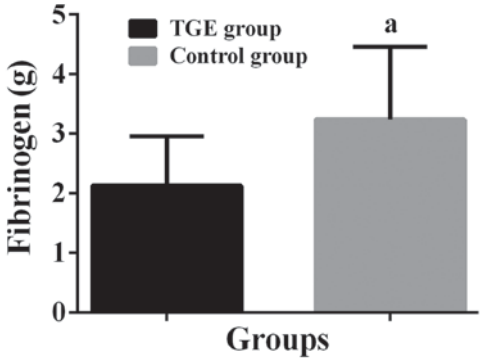

Figure 3. The comparison of the use of fibrinogen of the patients in the two groups. The amount of fibrinogen in the control group was significantly higher than that used in the TEG group; [a]P<0.050, compared with the amount of fibrinogen used in the TEG group.

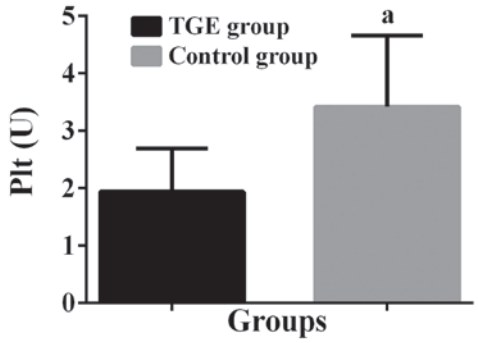

Figure 2. The comparison of the use of Plt of the patients in the two groups. The amount of Plt in the control group was significantly higher than that used in the TEG group; [a]P<0.050, compared with the amount of Plt use in the TEG group.

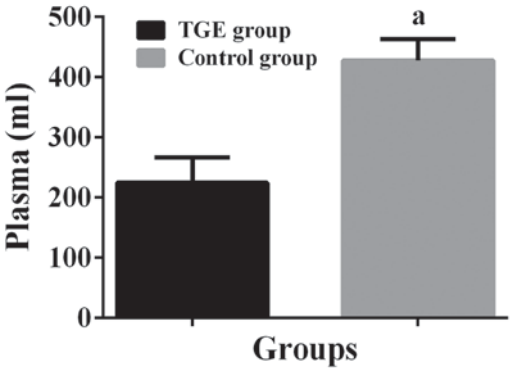

Figure 4. The comparison of the use of plasma of the patients in the two groups. The amount of plasma in the control group was significantly higher than that used in the TEG group; [a]P<0.050, compared with the amount of plasma used in the TEG group.

Comparison of the clinical results. The length of hospital stay of the patients in the TEG group was 16.24±2.16 days, which was significantly shorter than that in the control group (18.96±5.62 days), P=0.006; there was no significant difference when comparing the occurrence rate of the postoperative rebleeding and mortality of the two groups (P>0.050) (Table IV).

Discussion

Coagulation function is the key to determine the condition of perioperative bleeding of patient, and keeping patient's coagulation function in a stable state is the fundamental solution to reduce the occurrence of operating massive hemorrhage in patients (11). During the operation, traumatic invasive procedures, blood loss *in vitro*, oxidative reaction in the body and the various aspects of factors could cause coagulopathy in patient (12-14). The blood circulation is a necessary part of the rehabilitation of patient's body; slight damage of coagulation function causes the prolongation of the rehabilitation cycle, and the treatment effect is not good and serious damage of coagulation function endangers patient's life and health (15). In order to keep the patient's blood circulation operating normally, perioperative blood transfusion is necessary and an extremely important part (16). During the process of perioperative blood transfusion, patients may have some symptoms, such as low calcium, high potassium, and pH imbalance due to the massive loss of clotting factors and platelets and the infusion of erythrocyte suspension, and the anticoagulant infused into the blood may also cause coagulation function becoming abnormal again (17,18). Therefore, how to accurately assess the blood transfusion amount and blood transfusion type of patient during the perioperative period is a research hotspot in clinic. The traditional blood routine and coagulation function have a low detection mobility and their real-time monitoring ability is poor, thereby they cannot meet the clinical accurate judgment for the condition of patient's blood transfusion; TEG is the only effective method to continuously and dynamically monitor the process of blood coagulation when the blood transfusion amount is extremely low (19,20). Not only does it have a good monitoring effect on the changes in cells and plasma, but also have a clear judgment on the generation time of blood clots (21). At present, there are still only a few studies on TEG worldwide and few accurate references, which are on TEG and can be used as a guide in clinic. Therefore, this study aims to prove that the diagnostic value of TEG in the condition of blood transfusion of the patients who are in the perioperative period by comparing TEG and traditional blood coagulation monitoring applied in the condition of blood transfusion of the patients who are in the perioperative period.

Table IV. The comparison of the clinical results of the patients in the two groups [n (%)].

Index	TEG group (n=40)	Control group (n=34)	χ^2 or t value	P-value
Length of hospital stay (days)	16.24±2.16	18.96±5.62	2.828	0.006
Occurrence rate of the postoperative rebleeding	4 (10.00)	7 (20.59)	1.628	0.202
Mortality	1 (2.50)	1 (2.94)	0.014	0.907

The results of this study showed that there was no significant difference in the inspection results of coagulation function of the patients in the two groups in 2 h before the operation and in 24 h after the operation, suggesting that TEG would not affect the patient's coagulation function, such as the traditional detection method, which was also available for the patients who were in the perioperative period. When comparing the intraoperative blood transfusion amount and intraoperative blood loss in the two groups, it was shown that there was no significant difference in the intraoperative blood loss of the patients in the two groups, but the intraoperative blood transfusion amount in the TEG group was significantly less than that in the control group. Further comparison of the condition of the blood transfusion between the two groups showed that the use of each infusion solution of the patients in the TEG group was significantly lower than that in the control group, which was consistent with the results of Lawson *et al* (22). The length of hospital stay of the patients in the TEG group was significantly lower than that in the control group, and there was no significant difference when comparing the occurrence rate of the postoperative rebleeding and mortality in the TEG group with those in the control group, suggesting that TEG could make a more accurate judgment on the perioperative blood transfusion of patient. In terms of the reasons, it was considered that during the monitoring process of TEG, the generation time (R value) of the patient's blood clot was used as the infusion basis of plasma; the maximum amplitude (MA value) of the formation of thrombus was used as the infusion basis of Plt, and the intensity (K value) of fibrinogen was used as the infusion basis of fibrinogen (23,24), which more reasonably and accurately guided the patient's mathematical situation. Compared with the traditional coagulation function test, TEG can infuse the targeted blood products into the patients who are in the perioperative period, and accurately adjust the improved condition of blood coagulation in patient's body according to the quality of the blood transfusion to achieve the purpose of significantly improving the coagulation function of patient. TEG can comprehensively reflect the process, in which the blood clot forms and fiber dissolves in the sample blood, and reflect the interaction between clotting factors and platelets, which has a more accurate judgment for patient's overall coagulation condition (25). Moreover, the generation speed of TEG monitoring results are significantly faster than that of the traditional coagulation function test, which helps to instruct doctors to make timely decision and treatment for the blood transfusion. Since the transfusion condition of the patients in the TEG group was more accurate, it was speculated that this was one of the reasons why the recovery period of the TEG group was shorter than that of the control group. There was no statistical difference in the postoperative rebleeding rate between the two groups, and it was speculated that the reason for this was the experimental error, which was caused by the small sample size; in terms of the actual number of the patients, the patients in the TEG group were significantly less than those in the control group.

The results of this experiment showed that TEG was more suitable for estimating the blood transfusion of a patient who was in the perioperative period when compared with the traditional coagulation function test, but there were still some shortcomings. For example, TEG is a test *in vitro*, and detecting differences between patient and the internal environment in patient's body may cause errors in the results of coagulation function (e.g., the effects of patient's vascular endothelium and vascular nose, on coagulation function); and the patient usually is in anesthesia during the operation, also patient's body temperature is low, which may have an effect on the results. The test result of TEG for the general coagulation function of patient is better, but it has a weaker ability to distinguish the abnormality in certain coagulation process. Moreover, the number of cases included in this study was small, and the statistical analysis of large data could not be carried out.

In summary, compared with the traditional coagulation function test, TEG is more accurate for estimating the coagulation function of patient, and is more suitable for estimating the condition of blood transfusion of patient in the perioperative period; also, it can shorten the recovery period of patient and it is worthwhile to promote in the clinic.

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Availability of data and materials

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

Authors' contributions

HS and BS conceived the study and drafted the manuscript. JL and LW acquired the data. BS and GS analyzed the data. HS and JL revised the manuscript. All authors revised, read and approved the final manuscript.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the First Hospital of Zibo (Zibo, China). Patients who participated in this research had complete clinical data. The signed informed consents were obtained from the patients or the guardians.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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