International Journal of Clinical Medicine, 2019, 10, 70-77
http://www.scirp.org/journal/ijcm
ISSN Online: 2158-2882
ISSN Print: 2158-284X

Value of Thromboelastography in Judging Abnormal Coagulation Function in Patients with Early Hemorrhagic Shock

Yiwu Yan, Jinjun Li

The Medical College of Wuhan University of Science and Technology, Wuhan, China
Email: entry2003@126.com

How to cite this paper: Yan, Y.W. and Li, J.J. (2019) Value of Thromboelastography in Judging Abnormal Coagulation Function in Patients with Early Hemorrhagic Shock. *International Journal of Clinical Medicine*, **10**, 70-77.
https://doi.org/10.4236/ijcm.2019.102007

Received: January 18, 2019
Accepted: February 17, 2019
Published: February 20, 2019

Abstract

Objective: To detect the changes of coagulation function in patients with early hemorrhagic shock by thromboelastography (TEG). **Methods:** TEG was performed in 50 patients with early hemorrhagic shock and surgical indications. The TEG parameters were compared with 50 healthy people. The coagulation and fibrinolysis in patients with early hemorrhagic shock were observed. **Results:** In terms of coagulation parameters, the R value decreased, the α angle increased, and the K value and MA value did not change significantly in patients with early hemorrhagic shock. Fibrinolytic aspects: EPL, LY30 observations have no significant changes compared to normal values. **Conclusion:** The plasma coagulation factor activity is increased in patients with early hemorrhagic shock; the fibrin level is increased; the blood is in a hypercoagulable state; and the fibrinolysis function is not changed. The timely detection of TEG can be used for coagulation function monitoring and blood transfusion therapy in patients with surgical hemorrhagic shock. It provides an important basis for preventing the formation of deep vein thrombosis.

Keywords

Thromboelastography, Early Hemorrhagic Shock, Coagulation Function, Fibrinolytic System, Deep Venous Thrombosis

1. Introduction

Hemorrhagic shock and coagulopathy caused by various causes during surgical perioperative period are serious threats to patients' life safety. Hemorrhagic shock is a common emergency in surgery. When the effective blood volume of the body is drastically reduced, the coagulation function and blood state will change accordingly. Studies have shown that patients with traumatic dysfunction cause a mortality rate of 25% to 40% when admitted to hospital [1]. At present, clinically routine coagulation parameters such as prothrombin time (PT) and activated partial thrombin time (APTT) can only detect the activity and function of blood coagulation factors in the absence of platelets, reflecting a certain stage of the coagulation process or some kind of blood coagulation product [2]. The thromboelastograph is an analyzer that monitors the coagulation process from the entire dynamic process of platelet aggregation, coagulation, fibrinolysis, etc. It was invented by the German Harter in 1948. The principle is based on the final result of the blood coagulation process to form a blood clot, and the physical characteristics of the blood clot (blood clot strength and stability) determine whether it has normal coagulation function. The thromboelastogram (TEG) is a graphical display of the complete process of coagulation initiation to clot formation and fibrinolysis. Compared with conventional detection methods, TEG is faster and more accurate. In this paper, TEG detection is used to determine the perioperative coagulation function and fibrinolysis status in patients with early hemorrhagic shock, which provides an important basis for blood transfusion therapy and prevention of deep vein thrombosis in patients with hemorrhagic shock.

2. Subjects and Methods

2.1. Object and Grouping

Control group: 50 people with normal physical examination and normal coagulation function, 27 males and 23 females; experimental group: 50 patients with hemorrhagic shock treated in The Central Hospital of Xiaogan from December 2016 to November 2018, all undergoing surgical treatment (10 cases of chest trauma, 11 cases of abdominal trauma, 2 cases of chest and abdomen combined injury, 3 cases of open head injury, 5 cases of multiple body injuries, 19 cases of open fracture and pelvic fracture), including 34 males and 16 females. Sixteen patients, aged 6 to 74 years, with a median of 56 years, did not take antiplatelet drugs in all cases. Exclusion criteria: 1) history of primary thrombocytopenia; 2) history of blood; 3) less blood loss (less than 800 ml), less trauma, failure to meet early hemorrhagic shock criteria; 4) lungs Disease, hemolysis, and heart failure. The diagnostic criteria for early hemorrhagic shock are: 1) There is a cause of shock. 2) Pulse fine speed, more than 100 times/minute. 3) Systolic blood pressure is lower than 90 mmHg, or pulse pressure difference is less than 20 mmHg. 4) Within 6 hours after trauma. 5) Blood loss is not less than 800 ml. This research was approved by the Medical Ethics Committee of our hospital. All patients signed an informed consent form.

2.2. Test Methods

All patients considering early hemorrhagic shock were tested for TEG within 6 hours after trauma and within half an hour after admission, and 50 patients with healthy controls were tested for TEG.

2.2.1. Coagulation Function Parameter

1) R value: The time required for coagulation to form the first obvious thrombus, usually 4 to 9 minutes, mainly reflecting the interaction between all relevant coagulation factors involved in the coagulation process; application of anticoagulant or lack of coagulation factor. When the value of R is prolonged, the value of R is shortened when the blood is hypercoagulable [3]. 2) K value: The time from the first obvious thrombus formation to the time when the blood clot reaches a certain level (MA amplitude 20 mm), the reference range is 1 - 3 min, which mainly reflects the action of fibrinogen; 3) α angle: refers to from R The point is the maximum tangent of the arc and forms an angle with the horizontal line, reflecting the rate of blood clot formation from the thrombus, the normal range is 53˚ - 72˚; 4) MA value: the maximum intensity of thrombus, mainly reflecting platelets and fibrin The function, the normal range is 50 - 70 mm.

2.2.2. Fibrinolysis Function Parameter

1) EPL: predict the percentage of blood clots to be dissolved within 30 min after the MA value is determined, the normal range is 0% - 15%; 2) LY30: MA determines the degree of blood clot dissolution after 30 min, reflecting the fibrinolysis; the normal range is 0% - 8.0%.

2.3. Assess the Risk of Venous Thrombosis after Surgery

Evaluation sheet of risk factors for deep venous thrombosis of lower limbs was used to assess the risk of thrombogenesis after surgery. The higher the score, the greater the risk of thrombosis.

2.4. Statistical Methods

The control group and the experimental group were tested for TEG parameters. The measurement data were expressed as mean ± standard deviation. Two independent samples were performed using SPSS 17.0 statistical software package. $P < 0.05$ was considered statistically significant.

3. Results

1) In terms of coagulation parameters, the R value decreased and the α angle increased in patients with early hemorrhagic shock. The difference was statistically significant. There was no significant change in K value and MA value, indicating that the patient's plasma coagulation factor activity increased, fibrin level increased, and blood was in a hypercoagulable state (**Table 1**).

2) In terms of fibrinolysis, the EPL and LY30 observations in patients with early hemorrhagic shock did not change significantly compared with the normal values, indicating that there was no abnormality in fibrinolytic function in patients with early hemorrhagic shock (**Table 2**).

3) Since the high risk of thrombosis after surgery, we use the Autar Form to assess the risk. It was invented by Autar, which was proved useful.

Table 1. Coagulation function parameter change (n = 50, $\bar{x} \pm s$).

	R (min)	K (min)	αangle (˚)	MA (mm)
Normal	5.34 ± 0.80	1.83 ± 0.45	64.59 ± 4.65	58.51 ± 4.06
shock	4.06 ± 1.13*	1.78 ± 1.07	69.07 ± 8.07*	59.91 ± 10.04

Table 2. Fibrinolysis function parameter change (n = 50, $\bar{x} \pm s$).

	EPL (%)	LY30 (%)
Normal	1.63 ± 2.84	0.70 ± 1.43
shock	1.18 ± 2.57	0.72 ± 1.92

Remark: Compared with the normal group, *P < 0.05.

4. Discussion

4.1. Coagulation Mechanism in Patients with Early Hemorrhagic Shock

The normal coagulation system includes the exogenous coagulation system and the endogenous coagulation system. The main role of the coagulation process in the initiation of coagulation is the exogenous coagulation system. When the wound causes acute hemorrhage, tissue factor release, activation of coagulation factor VII initiates the exogenous coagulation process, and activates FXI, FVIII, and FV through a small amount of thrombin generated after activation, and activates the endogenous coagulation system to produce a high concentration. Thrombin promotes fibrin formation through a series of cascades.

4.2. TEG

TEG can monitor the whole process of blood coagulation, synthesizes plasma components and cellular components, and considers the effects of quantity and function on blood clot formation [4]. Due to the value of TEG in the monitoring of coagulation function, it has been widely used in the monitoring of coagulation status during surgical perioperative period, to assess the coagulation function of critically ill or surgical patients, guide treatment and provide reference indicators. The coagulation function of patients with surgical hemorrhagic shock changes significantly. Early monitoring of coagulation status in patients with hemorrhagic shock has important reference value for surgical treatment and prevention of postoperative complications in patients with hemorrhagic shock.

4.3. Coagulation

4.3.1. R Value

The R-value thromboelastogram reflects the activity of the clotting factor. This study showed that the R value of patients with early hemorrhagic shock was lower than the normal value (the difference was significant), indicating that the clotting factor activity increased in patients with hemorrhagic shock, and the infusion in shock. In the treatment, blood volume should be supplemented quickly. If blood transfusion is needed, the concentrated red blood cells should be infused. If the blood loss is large, infusion of plasma rich in blood coagulation factors should be considered. Studies have shown that if the R value is greater than 10 min, it indicates that the clotting factor is significantly reduced, and fresh frozen plasma (15 mL/kg) can be input [5].

4.3.2. K Value and Alpha Angle

K values were used to assess the rate at which the blood clot reached a certain intensity (20 mm amplitude), and the alpha angle was used to assess the rate of fibrin formation, and the two provided the same information, both affected by fibrinogen. The angle determines the rate at which blood clots form. This study showed that the angle of α in patients with early hemorrhagic shock was higher than the normal value (the difference was significant), and there was no significant difference in K value, indicating that fibrinogen increased and the formation rate of blood clot was accelerated in hemorrhagic shock, suggesting that suggesting that after relieving the cause of bleeding, low molecular weight heparin anticoagulant therapy can be applied.

4.3.3. MA

MA was used to assess the intensity of blood clots. Due to platelet count and function, MA value was associated with platelet action, and elevated MA value suggested that blood was hypercoagulable [6]. Studies have shown that the MA value and the probability of thrombosis have higher sensitivity and specificity, the MA value increases, and the probability of thrombosis increases significantly [7]. Another study found that trauma patients with MA > 65 mm, the chance of pulmonary embolism is 3.5 times that of other patients, can guide the prevention of anticoagulant therapy [8]. This study showed that the MA value of patients with early hemorrhagic shock increased slightly (the difference was not significant), reflecting that there was no significant difference in overall platelet function before and after early hemorrhagic shock, suggesting that patients with early hemorrhagic shock do not need to transfuse platelets.

4.4. Fibrinolytic Function

The regulation of the fibrinolytic system and the coagulation system does not result in the formation of effective hemostasis due to hyperfibrinolysis, and also avoids excessively low fibrinolysis, thereby forming excessive and excessive thrombus and causing unnecessary blood vessel embolism. This study showed that EPL in patients with early hemorrhagic shock was lower than normal, and LY30 was slightly higher than normal, indicating that patients with early hemorrhagic shock had mild hyperfibrino function, but the difference was not statistically significant.

4.5. Risk Factors for Deep Venous Thrombosis of Lower Extremities

The risk assessment form for deep vein thrombosis developed by Autar is applicable to all bedridden patients [9]. Most patients with surgical hemorrhagic shock were mainly bedridden in the early postoperative period. The risk factors for lower extremity deep venous thrombosis were scored in 50 patients with hemorrhagic shock. ≤10 points is divided into low-risk, 11 - 14 points is classified as medium-risk, and ≥15 points is classified as high-risk, including 4 low-risk patients, 5 intermediate-risk patients, and 41 high-risk patients. It indicates that patients with surgical hemorrhagic shock have high risk factors of deep venous thrombosis of lower extremity in the early postoperative period, and the risk of deep vein thrombosis is increased. On the one hand, due to limited mobility of patients after trauma, they are in bed for a long time, and the venous return flow is slow. In particular, patients with lower extremity surgery; on the other hand, through the changes in the R and α angles of the thromboelastogram, the blood is in a hypercoagulable state, the rate of formation of blood clots increases, and the risk of venous thrombosis increases. Studies have shown that the hypercoagulable state of TEG is associated with deep vein thrombosis in patients with trauma [10], so TEG provides a basis for early prevention of deep vein thrombosis in patients with surgical hemorrhagic shock.

In summary, patients with early hemorrhagic shock have a significant change in blood status and coagulation function compared with normal body due to the rapid loss of blood volume, activation of the coagulation system. In addition, the traumatic blood loss itself causes the loss of coagulation factors, coupled with the compensatory transfer of body fluids, and the subsequent active rehydration causes the dilution of coagulation factors, eventually leading to coagulation disorders [11]. The traditional coagulation function test index only reflects one aspect of coagulation function, cannot monitor the function of platelet and fibrinogen, evaluate the true state of coagulation, or clarify the real-time coagulation level to predict the potential bleeding and thrombosis risk [12]. TEG can reflect the whole process of blood clot formation to dissolution, namely the speed, final strength and stability of blood clot formation, and dynamically reflect the fibrinolysis process, which can help us visually and accurately determine the blood coagulation of patients with hemorrhagic shock. Fibrinolysis function changes [13]. TEG quickly adjusts the coagulation function, which in turn prompts the patient to inject blood component treatment, thus effectively adjusting the patient's coagulation function [14]. At the same time, it can accurately analyze the factors of coagulopathy in hospitalized patients, which is beneficial to reduce the use of clinical blood products and avoid blind blood transfusion [15]. Through the analysis of TEG, we can see that the R value of patients with early hemorrhage is lower than normal, and the angle of α is higher than normal, indicating that the activity of coagulation factor is increased, the fibrinogen is elevated, and the formation of blood clot is formed in patients with early hemorrhagic shock. The rate is accelerated, the blood is in a hypercoagulable state, and the blood volume should be actively supplemented, and the cause of shock should be relieved by surgery in time. For patients with shock who need blood transfusion, infusion of homologous red blood cells should be preferred because plasma is rich in clotting factors, and at this time, patients have higher clotting factor activity. Infusion of plasma will aggravate the patient's hypercoagulable state, and if necessary, infusion of plasma and Cold precipitation, etc. Due to increased clotting factor activity, increased fibrinogen, and hypercoagulable state in patients with hemorrhagic shock, the risk of deep venous thrombosis in the lower extremities increases. Especially for patients after orthopedic surgery, long-term bed rest also increases the risk of venous thrombosis. The thromboelastogram can be treated with different anticoagulant treatment according to the change of index, thus further reducing the probability of deep venous thrombosis after orthopedic surgery [16]. Clinical studies have shown that actively improving blood hypercoagulability after surgery can effectively prevent the occurrence of deep venous thrombosis of lower extremities, and the use of low molecular weight heparin anticoagulation has no clinical significance [17]. Therefore, after the operation to relieve the cause of hemorrhagic shock, preventive measures should be taken early in the postoperative period, and if necessary, anticoagulation with low molecular weight heparin should be used to reduce the risk of postoperative deep vein thrombosis. The thromboelastogram has its advantages in judging abnormal coagulation function in patients with hemorrhagic shock, but it also has limitations, and cannot completely replace the traditional coagulation function detection method. First of all, TEG is an in vitro testing program, so the detection environment is still different from the actual environment of the organism. Second, TEG detects the body's overall coagulation function, but sometimes it cannot be used to distinguish abnormalities in a certain coagulation process. Third, there is currently no standardized operation and evaluation guideline. The quality control of TEG is not ideal. So the combination of the two is more conducive to hemorrhagic shock and other critically ill patients.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] MacLeod, J.B., Winkler, A.M., Mccoy, C.C., *et al.* (2014) Expertly Induced Coagulopathy (ETIC): Prevalence across the Injury Spectrum. *Injury*, **45**, 910-915. https://doi.org/10.1016/j.injury.2013.11.004

[2] Hoffman, M. (2015) Coagulation in Liver Disease. *Seminars in Thrombosis and Hemostasis*, **41**, 447-454. https://doi.org/10.1055/s-0035-1550435

[3] Wei, K.K., Liao, Z.N. and Zhang, H.M. (2018) Advances in the Application of Thromboelastography in Cerebrovascular Diseases. *Journal of Clinical Neurology*, **31**, 71-72.

[4] Fan, R.J., Liu, B., Li, D.J. and Pu, W.H. (2016) The Application Value of Thrombus Elasticity Diagram in Guiding Perioperative Clinical Blood Transfusion. *Journal of Ningxia Medical University*, **38**, 1255.

[5] Lyu, X., Qiao, W., Li, D., *et al.* (2017) Impact of Perioperative Blood Transfusion on Clinical Outcomes in Patients with Colorectal Liver Metastasis after Hepatectomy: A Meta-Analysis. *Oncotarget*, **8**, 41740-41748.

https://doi.org/10.18632/oncotarget.16771

[6] Lawson, P.J. and Moore, H.B. (2018) Microfluidics Contrasted to Thrombelastography: Perplexities in Defining Hypercoagulability. *Journal of Surgical Research*, **231**, 54-61.

[7] Bai, J., Zheng, Q.W., Fu, S.H., *et al.* (2013) Association between Thromboelastography System and Thromb Oembolic and Bleeding Events in Chinese Aged People. *International Journal of Clinical and Experimental Medicine*, **6**, 310-319.

[8] Cotton, B.A., Minei, K.M., Radwan, Z.A., Matijevic, N., *et al.* (2012) Admission Rapid Throm-Belastography Predicts Development of Pulmonary Embolism in Trauma Patients. *Journal of Trauma and Acute Care Surgery*, **72**, 1470-1477. https://doi.org/10.1097/TA.0b013e31824d56ad

[9] Autar, R. (1996) Nursing Assessment of Clients at Risk of Deep Vein Thrombosis (DVT): The Autar DVT Scale. *Journal of Advanced Nursing*, **23**, 763-770. https://doi.org/10.1111/j.1365-2648.1996.tb00049.x

[10] Toukh, M., Siemens, D.R., Black, A., *et al.* (2014) Thromboelastography Identifies Hypercoagulablilty and Predicts Thromboembolic Complications in Patients with Prostate Cancer. *Thrombosis Research*, **133**, 88-95. https://doi.org/10.1016/j.thromres.2013.10.007

[11] Wang, J.J. and Zhou, J.Z. (2018) Study on the Effects of Different Fluid Resuscitation Strategies on Complications and Prognosis in Patients with Hemorrhagic Shock. *Chinese General Practice*, **16**, 1446-1448.

[12] Song, J.G., Jeong, S.M., Jun, I.G., *et al.* (2014) Five-Minute Parameter of Thromboelastometry Is Sufficient to Detect Thrombocytopenia and Hypofibrinogenaemia in Patients Undergoing Liver Transplantation. *British Journal of Anaesthesia*, **112**, 290-297. https://doi.org/10.1093/bja/aet325

[13] Huang, R.H., *et al.* (2012) Application of Thromboelastography in the Monitoring of Coagulation Function in Splenectomy and Resection. *Journal of Practical Medicine*, **28**, 3211-3212.

[14] Song, P. (2017) The Application Value of Thromboelastography and Conventional Coagulation Test in Plasma Infusion in Patients with Severe Infections. *Clinical Medicine*, **32**, 56-57.

[15] Xu, J.L. (2018) The Application of Thromboelastography in Clinical Rational Use of Blood in Hospitalized Patients with Severe. *Chinese and Foreign Medical*, **31**, 51-53.

[16] Zhang, X.C., Zheng, X., Li, C.Y., *et al.* (2017) Diagnostic Value of Thromboelastogram for Predicting Perioperative Thrombosis in Hip and Knee Joint Replacement. *Chinese Journal of Bone and Joint Surgery*, **10**, 386-389.

[17] Testroote, M.J. and Wittens, C.H. (2013) Prevention of Venous Thromboembolism in Patients Undergoing Surgical Treatment of Varicose Veins. *Phlebology*, **28**, 86-90. https://doi.org/10.1177/0268355512475121