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Perioperative Application of Point-of-Care Test for Blood Viscoelasticity

Jiazhen Dai and Lin Su*

Department of Anesthesiology, Tianjin Medical University General Hospital, Tianjin, China

Abstract

Point-of-Care Testing (POCT) of blood viscoelasticity provides accurate and timely insights into patients' coagulation status. It can monitor the effects of preoperative antithrombotic drugs on coagulation, aiding in the selection of optimal surgical timing. Additionally, POCT helps analyze intraoperative bleeding causes and guides blood product transfusions. It is also useful for assessing postoperative thromboembolism risk and determining the need for prophylactic anticoagulation. This article discusses the principles and clinical applications of commonly used POCTs for blood viscoelasticity.

Keywords: Blood viscoelasticity • Point-of-care testing • Individualized coagulation management • Prothrombin time • Thromboelastometry

Introduction

The perioperative management of coagulation function is crucial for patient prognosis. Timely and appropriate blood product transfusion strategies can significantly reduce mortality rates and hospitalization costs. Conventional Coagulation Tests (CCTs), including Prothrombin Time (PT), International Normalized Ratio (INR) for PT, Activated Partial Thromboplastin Time (APTT), fibrinogen levels, fibrin degradation products, and platelet count, are commonly used to assess coagulation status. However, CCTs have significant limitations; they do not indicate the stability of blood clots or the process of fibrinolysis in the hematologic system, with detection times ranging from 30 to 90 minutes. Additionally, while platelet count measures quantity, it does not reflect functional capacity. These limitations create challenges in reliable laboratory testing during emergency blood product transfusions. Given the complexity of coagulation disorders, targeting specific abnormalities through empirical transfusions is difficult.

Recently developed Point-of-Care Testing (POCT) methods can greatly reduce evaluation time for coagulation function, enabling rapid bedside diagnosis by physicians. Consequently, clinical application has gradually increased. Among POCT modalities used in perioperative management are Viscoelastic Hemostatic Assays (VHAs). These assays offer comprehensive insights into blood clot formation and dissolution while highlighting abnormal factors within the coagulation system; thus they hold significant clinical value. Currently, commonly used POCTs for assessing blood viscoelasticity include Coagulation and platelet function analyzers (CPA) such as Century clot and Sonoclot, Thromboelastography (TEG), and Rotational Thromboelastometry (ROTEM). This article outlines the basic principles, key parameters, and clinical usage recommendations based on recent research of these three methods.

Literature Review

The principle of CPA

A disposable probe is installed on the electromechanical sensor and oscillates perpendicularly in the blood sample. The sensor records the resistance to the movement in the sample continuously. At the initial stage when the blood is liquid, there is little resistance to the probe. As blood clotting progresses and more fibrin and platelets adhere to the probe, the resistance increases. Then, as the blood clots dissolve, the resistance gradually decreases. Coagulation and Platelet Function (PF) are calculated based on the speed and amplitude of changes in probe resistance from blood clotting to fibrinolysis.

***Address for Correspondence:** Lin Su, Department of Anesthesiology, Tianjin Medical University General Hospital, Tianjin, China; E-mail: sulin_sl@126.com*

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The principle of TEG

The whole-blood sample is put into the testing cup, and the lid attached with the pin suspends in the sample. When the blood sample is still liquid, the rotation of the testing cup does not cause the lid to turn. As the liquid sample becomes blood clots, the resistance of the testing cup to rotate gradually increases and makes the lid and pin rotate. The rotation of the pin cuts the magnetic field lines to generate electric currents, converting the resistance into electrical signals to form the TEG trace [1].

The principle of ROTEM

The principle of ROTEM is similar to that of TEG (Table 1). The main difference is that in ROTEM, the active oscillation of the pin initiates the detection instead of the rotation of the testing cup in TEG. Also, the resistance to movement in ROTEM is evaluated by the alteration of the light signal in the optical detection system rather than the electromechanical sensor on the pin in TEG [2].

	Sonoclot	TEG	ROTEM
Time to initial clot formation	ACT	R	CT
Rapidity of fibrin buildup	CR, TP	K	CFT
		α	α
Maximum clot strength	PA	MA	MCF
Platelet function	PF		
Clot breakdown		LY30/60	CLI30/60, ML
Coagulation kinetics at specified time point		A5/10	CA5/10
The function of residual platelet		MAADP	
The effect of antiplatelet drugs on platelet function		AA/ADP inhibitory rate	

Table 1. Parameters displayed on Sonoclot, TEG, and ROTEM.

Discussion

POCT holds the advantage of comprehensively assessing the coagulation system status of patients, rendering it highly valuable in clinical practice throughout various stages of the perioperative period [3]. We monitor the current coagulation status of patients by analyzing coagulation indicators in different instruments. Based on the variations in these parameters, we can dynamically manage the patient's condition. Blood viscoelastic POCT is capable of detecting the effects of preoperative antithrombotic drugs on the coagulation system, thereby facilitating personalized monitoring of coagulation function. Additionally, this is not only conducive for doctors to analyze the causes of intraoperative bleeding and carry out precise component transfusions, but also for predicting the risk of postoperative thrombosis.

Blood viscoelasticity testing, as a POCT method for blood management, has clear advantages over traditional coagulation tests in monitoring bleeding and guiding blood use. Its application in patients with significant changes in the coagulation system function, like those having cardiac surgery, experiencing trauma, in obstetrics, or with liver disease, has drawn more attention. In cardiac surgery, abnormal coagulation function is the main cause of increased postoperative bleeding and mortality. These whole blood viscoelasticity testing methods can assess the coagulation system function comprehensively, help predict surgical bleeding, show the cause of bleeding, and guide personalized blood transfusion treatment, reducing the chance of secondary surgery and improving the clinical outcomes of cardiac surgery. Trauma-Induced Coagulation Dysfunction (TIC) relates to abnormal coagulation processes caused by trauma. Blood viscoelasticity testing can quickly evaluate the coagulation status of trauma patients and is better at detecting coagulation problems than conventional coagulation tests [4]. In obstetric surgery, routine coagulation function and whole blood cell count can't provide comprehensive information to the parturient, but blood viscoelasticity testing can assess the overall coagulation status of the parturient, reflect the coagulation status promptly, and be widely used to detect the coagulation function of parturients with uterine atony, preeclampsia, acute fatty liver during pregnancy, reproductive tract trauma, as well as genetic and prenatally acquired coagulation diseases. Due to the lack of both procoagulant and anticoagulant factors in liver disease patients, these conventional indicators may not accurately show the status of the coagulation system in such patients [5]. Bedside blood viscoelasticity testing has advantages in perioperative coagulation monitoring, guiding component transfusion, and coagulation factor replacement therapy for liver disease patients.

Conclusion

As POCTs for managing coagulopathic patients perioperatively, TEG and rotational ROTEM offer timely insights into blood clot formation. They can identify coagulation abnormalities, predict bleeding events, and guide targeted transfusion strategies, thereby reducing perioperative blood loss and minimizing blood product use.

However, due to the complex causes of clinical bleeding, it is crucial to integrate VHA results with patient symptoms and findings from other diagnostic evaluations. This integrative approach enables a more thorough assessment and informs appropriate treatment decisions.

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