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Mini Review

The Role of Thromboelastography and Rotational Thromboelastometry in Deep Vein Thrombosis Diagnosis and Management

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Abstract

Deep Vein Thrombosis (DVT) is a serious condition that can lead to significant morbidity and mortality in hospitalized patients. Early identification and prevention of DVT-related coagulation abnormalities are crucial for patient outcomes. While Conventional Coagulation Assays (CCAs) provide limited information on the clotting of whole blood and are of limited value in the assessment of coagulation status of patients with DVT. Whole-blood viscoelastic coagulation tests like Thromboelastography (TEG) and Rotational Thromboelastometry (ROTEM) offer a more comprehensive assessment of coagulation status in patients with DVT. These tests have shown promise in identifying individuals at increased risk of DVT and detecting related hypercoagulability. TEG/ROTEM may also play a role in guiding anticoagulation therapy for these patients. We recommend incorporating TEG/ROTEM into the coagulation testing regimen to improve the accuracy of prophylaxis, diagnosis, and management of DVT.

Keywords: Deep vein thrombosis; Thromboelastography; Rotational Thromboelastometry; Hypercoagulability

Introduction

Deep Vein Thrombosis (DVT) is a prevalent and growing global health issue that frequently affects the lower limbs, often starting in the calf and spreading upward [1]. The incidence of DVT is estimated to be 1.6 cases per 1000 individuals annually [1,2], and is on the rise due to factors such as aging populations, increasing prevalence of comorbidities such as obesity, heart failure, and cancer, and improved diagnostic testing methods [3,4]. Symptoms of DVT can include pain, swelling, redness, and dilated superficial veins in the affected limb [3]. Compression ultrasonography and D-dimer testing are commonly used for initial diagnosis [5,6]. Standard treatment for DVT involves anticoagulation to prevent further clotting and embolization [7]. The coagulation status of patients is typically monitored through Conventional Coagulation Assays (CCAs) including Prothrombin Time (PT), activated Partial Thromboplastin Time (aPTT), Thrombin Time (TT), International Normalized Ratio (INR) and, Platelet Count (PLT), to guide the use of anticoagulants. However, challenging complications of DVT such as life-threatening hemorrhage and recurrence after discharge are frequently observed, indicating the poorly monitoring of patients' coagulation status by CCAs [3,5,7]. PT, aPTT, TT and INR end with the formation of the first fibrin strand and indicate deficiencies in clotting factors, while the PLT measures the number of platelets [8,9]. The coagulation process can be complex and snapshots of isolated parts of it may not provide sufficient information on the clotting of whole blood [10]. As a result, there has been an increase in interest in whole-blood viscoelastic coagulation tests, such as Thromboelastography (TEG) and Rotational Thromboelastometry (ROTEM), which can provide real-time information on the sufficiency of hemostasis and detect coagulation defects [11-13]. These tests are based on the changes in the viscosity of blood as it coagulates and take into account the fibrin and platelet-dependent cross-linking between whole blood [14]. This provides a more comprehensive view of the coagulation process than traditional plasma-based coagulation tests [11]. TEG/ROTEM tests, allowing faster identification of coagulation disorders than CCAs, have been shown to be superior to traditional tests in many clinical fields [15], including hemophilia, sepsis, coronary artery bypass, trauma, pregnancy and postpartum hemorrhage [11-13,16-20]. In this paper, we provide an overview of the application of TEG/ROTEM in the management of DVT.

TEG/ROTEM for the Prediction and Assessment of the Risk of DVT

The risk factors for developing DVT include trauma, injury, and surgery, which can lead to disruptions in coagulation and increase the risk of bleeding followed by a hypercoagulable state, making DVT more likely to occur [2-4]. To prevent this life-threatening complication, a comprehensive evaluation of coagulation abnormalities, early identification, and targeted prophylaxis is necessary. In recent decades, the utility of TEG in assessing DVT risk in patients has been demonstrated in multiple studies. A prospective cohort study by Brill, et al. [21] evaluated 938 trauma patients who were at high risk of developing DVT, using TEG in admission and ultrasound surveillance. The results showed that 85% of patients were hypercoagulable based on TEG results and that hypercoagulability was associated with a higher rate of lower-extremity DVT [21]. TEG was found to predict DVT with a high sensitivity of 91.9%, making it a useful metric for assessing DVT risk. Another study of over 1800 patients with severe extremity fractures found that TEG values ≥65 and ≥72 were independent predictors of DVT and pulmonary embolus [22]. This indicates that TEG can effectively identify patients at increased risk of in-hospital DVT and pulmonary embolus. Other studies have also shown the predictive role of TEG in DVT, including in patients undergoing neurosurgery and gastric cancer patients after surgery [23,24]. Overall, these results suggest that TEG has the capacity to assess the risk of DVT and predict its occurrence, making it a valuable tool in DVT risk assessment and prevention.

TEG/ROTEM for the Identification and Detection of Hypercoagulability related to DVT

Patients in a state of hypercoagulability are shown to be at a significantly higher risk for DVT. Timely detection and vigilant monitoring of hypercoagulability is crucial in reducing the occurrence of thromboembolic events in surgical or injured patients. The usefulness of TEG in detecting hypercoagulability is widely recognized recently [9,25-27]. Park, et al. [26] performed TEG on critically ill and nonbleeding patients with trauma and found TEG was more sensitive than CCAs in detection of hypercoagulable state in these patients. Spiezia, et al. [28] also reported that ROTEM was a useful tool to detect DVT-related hypercoagulability, particularly on maximum clot firmness and the area under curve values from ROTEM. A strong correlation was observed between the hypercoagulable state in the acute phase of DVT and the risk of DVT development. In addition, Mao [9] and her team observed that the TEG parameters of angle, MA, clot strength (G), and coagulation index (CI) were significantly elevated, while K was significantly reduced, in patients with DVT compared to healthy individuals, indicating a hypercoagulable tendency in DVT patients. However, no significant differences in aPTT, PT, or PLT were observed between the patients and controls. The team also found that TEG was the most effective method for identifying DVT when compared to conventional coagulation assays (CCAs), which further suggests the clinical implication of TEG in DVT identification [9]. Moreover, a systematic review and meta-analysis based on 8939 patients showed TEG/ROTEM possessed a great ability to identify hypercoagulability in trauma and operative patients [27]. Interestingly, the study revealed that among all the TEG parameters, MA was consistently used to diagnose hypercoagulability and predict venous thromboembolism after traumatic injury and surgical intervention. The results indicate that MA has satisfactory specificity and sensitivity in detecting DVT [27]. Taken together, the above studies suggest that TEG is effective in identifying DVT-related hypercoagulability and can serve as an indicator of DVT.

TEG/ROTEM for the Management of DVT

The main treatment for DVT is anticoagulation, which has the goal of reducing mortality, preventing the growth of blood clots, reducing the likelihood of recurrence, and reducing the risk of post-thrombotic syndrome. Anticoagulant options for DVT include low molecular weight heparin, dabigatran, rivaroxaban, and apixaban [5]. TEG has been found to be significantly more sensitive to the presence of heparin than other coagulation tests, such as aPTT, PT, or INR [10,29]. In a study of 205 patients receiving low molecular weight heparin anticoagulation therapy in a surgical intensive care unit, Wu et al. observed that the R value of TEG was associated with both the occurrence of DVT and the risk of hemorrhagic complications. These findings suggest that TEG may be useful in guiding low molecular weight heparin treatment for patients with DVT [30]. Solbeck [31] and colleagues found that the R value of TEG correlated strongly with the Hemoclot and Ecarin clotting time, which are current gold-standard tests for assessing dabigatran. This suggests that TEG may be a rapid and precise method for monitoring dabigatran treatment in whole blood. Although more research is needed to fully establish the effectiveness of TEG in guiding anticoagulation treatment for DVT, these findings provide promising insight into its potential use in managing patients with DVT.

Conclusion

TEG/ROTEM, in contrast to CCAs, evaluates the interactions between the cellular and plasma components of the coagulation process, providing a comprehensive assessment of whole-blood coagulation. Early research suggests that TEG/ROTEM may be useful in identifying individuals at risk for DVT, detecting hypercoagulability related to DVT, and diagnosing the condition itself. While further studies are necessary to fully understand the role of TEG/ROTEM in the management of DVT, we believe that they have the potential to become valuable tools in both clinical and research settings. It is our suggestion that TEG/ROTEM be used in conjunction with other coagulation tests to improve the accuracy of prophylaxis, diagnosis, and management of DVT.

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