Thrombelastography (TEG): A Graphic Profile for Analyzing Coagulation After Cardiopulmonary Bypass

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Abstract

Thrombelastography (TEG) was first introduced in 1948 by Hartert and is now used to examine coagulation in a wide range of clinical research settings. TEG measures the elastic properties of whole blood clots as they are formed. A graphic profile of the clot analysis is produced on a chart recorder. Manual evaluation of the graphic profile provides useful information regarding the status of coagulation. The basic theory and technology is demonstrated through this poster presentation.

Introduction

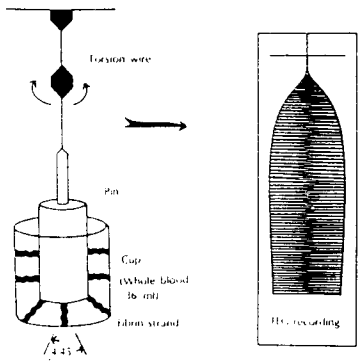
Coagulopathies immediately following cardiopulmonary bypass (CPB) are a contributing source of morbidity and mortality, and remain difficult to evaluate because of the acuity of the problem and the need for immediate therapy. Often, treatment is begun empirically without a specific hematologic diagnosis, using broad-spectrum therapy with protamine, platelet concentrate, and fresh frozen plasma. The increased awareness of the risks associated with homologous blood transfusions has led to a greater effort to obtain a rapid diagnosis of coagulopathy in the OR before rendering treatment.

Routine coagulation tests (RCT) represent separate but linked components or systems of the hemostatic process and end when the first fibrin strands are formed. Whereas TEG offers prompt intraop whole blood evaluation: from initiation of clotting to the final stages of clot lysis.

Materials

The basic principles of TEG (shown in Figure 1) are simple. Whole blood (0.36ml) is placed in a metal cup, and four drops of mineral oil are spread over the blood surface to prevent evaporation. A piston, suspended by a torsion wire, is lowered into the blood which is maintained at a temperature of 37°C. After the piston is placed in the blood, the cup is oscillated continuously. While the blood remains fluid, the oscillation of the cup does not influence the piston; however, as coagulation occurs, fibrin strands form from the walls of the cup to the piston and gradually strengthen their hold. This results in the coupling of the cup to the piston; the shear elasticity of the blood clot that is transmitted to the piston is recorded on thermal paper.[1]

Figure 1



THROMBELASTOGRAPHY (TEG)
A. Oscillating cup at 37°C with pin suspended by torsion wire
B. Recording of TEG on thermal paper

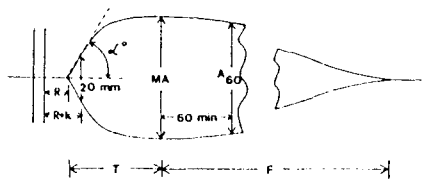
Methods

Profile

A typical thrombelastogram is shown in Figure 2, with the standard parameters of coagulation that can be measured on a TEG profile. The R value (reaction time) is measured from the time the blood is placed in the cup until an amplitude of 1 mm is reached. The R value correlates with the time necessary for initial fibrin formation. The K value is the time interval from the end of the R value until the amplitude of the TEG tracing reaches 20mm. The K value measures the rapidity of fibrin buildup and cross-linking. The R + K interval correlates with the whole blood clotting time. The MA (maximum amplitude) is a reflection of the absolute strength of the fibrin clot. It depends on platelet number and function and on fibrinogen level. The A_{60} is the amplitude 60 minutes after MA is reached. A_{60}/MAx100 represents the whole blood clot lysis index. F, is the time from MA to complete lysis and corresponds to the whole blood clot lysis time. The ~ (angle in degrees) value measures the slope of divergence of the tracing from the

point of the R value. The α value is a reflection of platelet function and fibrinogen level.[2,3]

Figure 2



Variables and normal values measured by TEG. **R** = reaction time, 8-12 minutes; **R + K** = clot formation time, 12-16 minutes; α = clot formation rate, >50°; **MA** = maximum amplitude, 50-70 minutes; A_{60}**/MAx100** = whole blood clot lysis index, >85%; and **F** = whole blood clot lysis time, >300 minutes.

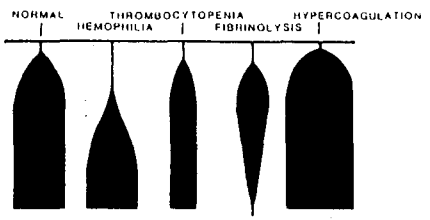
FIGURE 4

Pararmeter	Normal	Measures	Represents	Data	Interpretation	Treatment
R	8–12 min	Reaction time	Intrinsic pathway clotting factors Heparin	Prolonged	Heparinization Factor deficit	Protamine Fresh frozen plasma
R + K	12–16 min	Clot formation time	Platelet activity Fibrin buildup	Prolonged	Heparinization Factor deficit Platelet defect	Protamine Fresh frozen plasma
α	>50°	Clot formation rate	Rate & quality of developing fibrin & platelet aggregates	Decreased	Hypofibrino-genemia	Cryoprecipitate
MA	50–70 min	Maximum amplitude	Platelet number & function Fibronogen level	Decreased	Thrombocyto-penia Platelet dysfunction Hypofibrino-genemia	Platelets DDAVP Cryoprecipitate
A_{60}/MA	>85%	Whole blood clot lysis	Clot lysis index	Decreased	Lysis present	Epsilon-aminocaproic acid
F	>300 min	Whole blood clot lysis	Clot lysis time	Decreased	Lysis present	Epsilon-aminocaproic acid

Patterns

TEG has been shown to be clinically useful in evaluating and deciphering hemostatic problems. It can give faster and more information about qualitative defects in fibrin or platelets than RCT. TEG can mechanically record studies of red blood cell and platelet interactions, clot structure and stiffness, hypercoagulable states, and fibrinolysis as they occur.Results

Figure 3



TEG patterns characteristic of several hemostatic defects.

Correlation of post-CPB TEG data and those from RCT are poor because the TEG test is performed on whole blood, whereas RCT are performed on plasma. Therefore, RCT do not assess the altered interaction of the coagulation cascade and the platelet surface caused by CPB. TEG monitors the interaction of all the coagulation components, and using an algorithm (Figure 4), abnormal values can be further differentiated to identify the etiology of post-CPB coagulopathies.[3,4]

Summary

The ability to diagnose hemostatic abnormalities after CPB will help guide its specific therapy and decrease the risks of empiric treatment. The value of TEG is the capability to predict, rapidly and accurately, coagulopathies shortly after protamine reversal. By immediately treating post-CPB bleeding intraoperatively, morbidity and mortality can be reduced.

Although TEG is not a new monitoring technique, it is gaining acceptance because it is uniquely suited for monitoring coagulation function in the OR. Linkage with the computer software and hardware being developed will eliminate the manual evaluation of graphic profiles and allow for automatic measurement and analysis of TEG data.

References

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