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## **Thromboelastography<sup>®</sup>** *Past, Present, and Future*

THIS issue of ANESTHESIOLOGY contains an article by Camenzind *et al.*<sup>1</sup> regarding the influence of citrate storage on thromboelastography<sup>®</sup> (TEG<sup>®</sup> Haemascop Corp.). Although the TEG<sup>®</sup> is most commonly performed on a native (uncitrated) sample, the use of citrated blood permits longer delays after sample acquisition, thus facilitating ancillary or research laboratory analysis. Camenzind *et al.*<sup>1</sup> nicely outline some of the issues related to the impact of sample storage on the TEG<sup>®</sup>. Anesthesiology, as a specialty, has taken a leading role in evaluating the TEG<sup>®</sup> as a near-site monitor of hemostasis in several clinical settings. Many issues, however, remain unresolved about how to use the TEG<sup>®</sup> to guide clinical decision-making. The purpose of this Editorial View is to briefly review studies that have led to current applications of the TEG<sup>®</sup> and to outline future challenges that need to be addressed for its broader use.

### General

The use of the TEG<sup>®</sup> to monitor whole-blood coagulation was first described by Hartert in 1948.<sup>2</sup> The TEG<sup>®</sup>

This Editorial View accompanies the following article: Camenzind V, Bombeli T, Seifert B, Jamnicki M, Popovic D, Pasch T, Spahn DR: Citrate storage affects Thrombelastograph<sup>®</sup> analysis. ANESTHESIOLOGY 2000; 92:1242-9.

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**Key words:** Blood; coagulation; measurement techniques; transfusion.

Dr. Whitten is currently a clinical investigator for Bayer Corporation, New Haven, Connecticut, and Alliance Pharmaceutical, San Diego, California, and has performed published protocols using a thromboelastogram that was donated to his department from Haemascop Corporation, Skokie, Illinois.

Dr. Greulich is currently a clinical investigator for Bayer Corporation, New Haven, Connecticut, and Biopure Corporation, Cambridge, Massachusetts, and is the principal investigator of a study funded by grants (VISN17) from the Department of Veterans Affairs, Dallas, Texas, and the Society of Cardiovascular Anesthesiologists, Richmond, Virginia, which uses the Thromboelastograph as a bioassay.

Both Dr. Whitten and Dr. Greulich are currently participating in research protocols for which Haemascop Corporation has provided cups and pens for the TEG<sup>®</sup> machines at a discount rate.

measures shear elastic modulus (dynes per centimeters squared) during clot formation in whole or recalcified citrated blood.<sup>2,3</sup> The global nonspecific nature of the TEG<sup>®</sup> measurement may be both its greatest weakness and strength. Although specific coagulation assays rarely correlate with blood loss, they do provide specific diagnoses that respond to specific treatments. The TEG<sup>®</sup> maximum amplitude (MA) is a complex integrated measurement that has been associated with blood loss. The chief limitations of the TEG<sup>®</sup> include its: (1) inability to diagnose a specific hemostatic lesion; (2) weak correlation with specific assays (prothrombin and activated partial thromboplastin times); and (3) inability to consistently detect benefits of fractionated blood product therapy.

Since 1948, the technique has enjoyed periods of popularity but has never achieved widespread use in the United States. In the early 1980s, the TEG<sup>®</sup> was used routinely for coagulation monitoring during liver transplantation.<sup>5</sup> The TEG<sup>®</sup> has now found additional applications in a diverse group of clinical settings, including cardiovascular surgery, obstetric anesthesia, and trauma anesthesia (massive transfusion).

### Liver Transplantation

Each of the three phases of orthotopic hepatic transplantation has associated metabolic, hemorrhagic, and other derangements that complicate the preexisting coagulopathy present in these patients. Transfusion requirements are highly variable, but sudden massive blood loss occurs in conjunction with hyperfibrinolysis, coagulation factor and inhibitor deficiencies, and/or thrombocytopenia. Without prompt and effective treatment, these complicated clinical coagulopathies can result in dramatic hemorrhagic consequences. Kang *et al.*<sup>5</sup> demonstrated that the use of the TEG<sup>®</sup> for monitoring hemostasis during liver transplantation decreases blood transfusion requirements. However, a study of low-dose tranexamic acid showed that inhibition of fibrinolysis as measured by the TEG<sup>®</sup> during orthotopic hepatic transplantation had no influence on transfusion of blood products.<sup>6</sup>



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