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Admission rapid thrombelastography delivers real-time "actionable" data in pediatric trauma

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Abstract

Purpose: Admission rapid thrombelastography (rTEG) is a "real-time" clinical tool used to evaluate trauma-induced coagulopathy and direct hemostatic resuscitation. The relationship of rTEG to conventional coagulation tests (CCT) and early lifesaving interventions (LSI) in pediatric trauma is unknown.

Methods: Severely injured patients (age ≤ 14 years) with an rTEG were retrospectively reviewed (8/1/2009–8/31/2011). Demographic and clinical information was collected. Spearman's correlation and regression models were used to evaluate rTEG with respect to CCT, early transfusion, LSI, and mortality.

Results: Eighty-six patients were identified. The median age was 8 years, and the median injury severity score (ISS) was 21. Activated clotting time ($r = 0.68$), *k*-time ($r = 0.77$), and α-angle ($r = -0.75$) showed strong correlation to PTT, and maximum amplitude (MA) ($r = 0.46$) showed good correlation to platelet count (all $p < 0.001$). When controlling for age, gender, and ISS, regression analysis showed that ACT, *r*-value, *k*-time, α-angle, and MA predicted red blood cell and plasma transfusion within 6 h. MA (OR 0.82, 95% CI 0.70–0.96; $p = 0.018$) was predictive of LSI. All rTEG values, except for LY30, predicted mortality.

Conclusion: Admission rTEG correlates with CCT and predicts early transfusion, early LSI, and outcome in pediatric trauma. rTEG provides valuable data for goal-directed hemostatic resuscitation of critically injured children.

1. Purpose

Trauma is a leading cause of morbidity and mortality in children [1,2]. Acute coagulopathy of trauma is an ill-defined but well-described phenomenon of multifactorial etiology that is common in severely injured patients [3]. In children, this coagulopathy is strongly associated with increased morbidity and mortality [4,5]. Therefore, rapid identification and management of this coagulopathy is a critical component of the trauma resuscitation.

Conventional coagulations tests (CCT) such as the prothrombin time (PT), international normalized ratio (INR), and activated prothrombin time (aPTT) evaluate components of the traditional, "cascade" model of hemostasis characterized by the classic extrinsic and intrinsic pathways and are widely used in trauma patients. Originally designed for the management of certain disease states or to guide anticoagulation therapy, CCT incompletely characterize the

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coagulopathy associated with severe trauma [6–9]. Additionally, there is often a significant delay in obtaining results from even emergent CCT that is suboptimal in the management of critically ill trauma patients [3,10–12].

In contrast, thrombelastography (TEG) is a point-of-care measure of hemostasis that evaluates the global viscoelastic mechanical properties of whole blood [13]. TEG generates a graphical tracing and multiple data points that may more accurately reflect the in vivo interactions of all the components of coagulation and fibrinolysis [10,13]. TEG has been shown to reflect acute coagulopathy of trauma and predicts morbidity and mortality [11,14–16]. In adults, admission rapid TEG (rTEG—a TEG assay using kaolin and tissue factor as activating agents) has been shown to be quickly available (within minutes) and to correlate with CCT as well as predict early transfusion of red blood cells, plasma, and platelets [10]. In a large prospective series of adult trauma patients, rTEG was clinically superior to CCT for identifying patients at risk for acute coagulopathy of trauma [27]. These data can be used to guide hemostatic resuscitation of adult and pediatric patients [12,17,18,27].

The purpose of this study is to evaluate the use of admission rTEG in pediatric trauma patients for predicting the acute coagulopathy of trauma as well as the clinical trajectory as assessed by early blood product transfusion and early lifesaving interventions. We hypothesize that admission rTEG will correlate with CCT and predict outcome as well as the need for early blood product transfusion and early lifesaving interventions in children.

2. Methods

This research was approved by the IRB (HSC-MS-11-0403). The study center is an American College of Surgeons verified Level I pediatric trauma center. The trauma registry was retrospectively queried for consecutive pediatric patients (age less than 14 years) who were the institutions highest-level trauma activation from August 1, 2009 through August 31, 2011. Patients were excluded if they were discharged from the emergency center (EC) to home or were admitted to a non-intensive care setting. Demographic and clinical data were extracted from the registry database and medical record and included age, gender, weight, mechanism of injury, scene and EC vital signs, Glasgow coma score (GCS), abbreviated injury scale (AIS), injury severity score (ISS), initial laboratory data (rTEG, PT, PTT, INR, fibrinogen, hemoglobin, platelet, and base deficit), 6-h transfusion requirements (red blood cells, plasma, platelets and cryoprecipitate), lifesaving interventions (LSI) performed within 6 h, and 30-day mortality. An LSI was defined as emergent endotracheal intubation, emergent bedside surgical procedure (intracranial monitor placement, thoracostomy tube placement, emergent central venous access), or an emergent surgical procedure (craniotomy, thoracotomy, or laparotomy).

The means by which rTEG specimens are processed and the results are reported have been previously described in detail elsewhere [10]. Briefly, blood was collected in a citrated tube and transported to the laboratory where reversal with calcium chloride was performed. Standard tissue factor and kaolin-activated rTEG was performed according to manufacturer's instructions on a TEG thrombelastograph 5000 (Hemoscope Corporation, Niles, IL) in the EC Stat Lab that is in close proximity to the trauma resuscitation area. The rTEG tracing is displayed real time in the trauma resuscitation bay with well-defined components (Fig. 1). The *r*-value or ACT (activated clotting time) is defined as the time between the initiation of the test and fibrin formation and is representative of clotting factors (normal range, 0–118 s). The *k*-time is the time needed for the tracing to reach 20 mm from 2 mm and is increased with hypofibrinogenemia or platelet deficiency (normal range, 1–2 min). The α-angle is slope of the tracing that represents the rate of clot formation and decreases with hypofibrinogenemia or platelet deficiency (normal range, 66°–82°). The maximal amplitude (MA) is the greatest amplitude of the tracing and represents the platelet contribution to clot strength (normal range, 54–72 mm). Finally, LY30 is the percent amplitude reduction at 30 min after achievement of MA and represents fibrinolysis (normal range, 0.0%-7.5%). The rTEG tracing and parameters (including normal ranges) are automatically generated and are displayed on monitors in the trauma bay. A computer record in the electronic medical record was also available for review. The rTEG was interpreted by the treating trauma team.

Continuous data are presented as medians with the 25th and 75th interquartile range (IQR) with comparisons between groups performed using the Wilcoxon rank-sum test or Mann–Whitney *U* test. Categorical data are reported

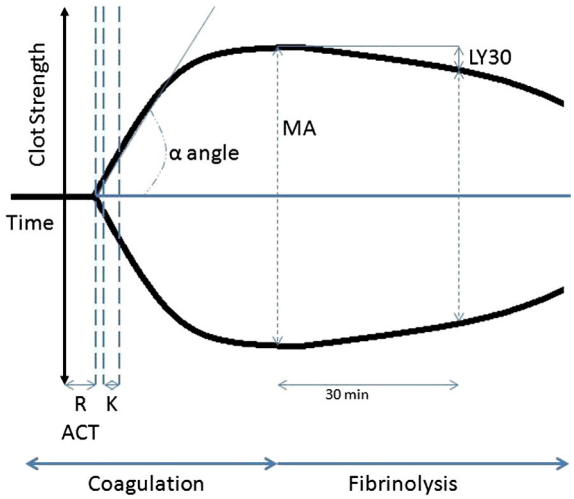

Fig. 1 Rapid thrombelastography (rTEG) tracing. Coagulation is represented by *r*-value or ACT (the time between the initiation of the test and fibrin formation); the *k*-time (time needed for the tracing to reach 20 mm from 2 mm), the α-angle (the rate of clot formation), and the maximal amplitude (MA) (greatest amplitude of the tracing). Fibrinolysis is represented by the LY30 (percent amplitude reduction at 30 min after achievement of MA). R: *r*-value; ACT: activated clotting time; K: *k*-time; MA: maximum amplitude, LY30: percent clot lysis at 30 min.