Prevalence and Impact of Admission Acute Traumatic Coagulopathy on Treatment Intensity, Resource Use, and Mortality: An Evaluation of 956 Severely Injured Children and Adolescents

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BACKGROUND: Acute coagulopathy of trauma in children is of potential importance to clinical outcomes, but knowledge is limited and has only been investigated using conventional coagulation testing. The purpose of this study was to assess the prevalence and impact of arrival coagulopathy, determined by viscoelastic hemostatic testing, in severely injured children.

STUDY DESIGN: Pediatric patients (younger than 17 years of age) who were admitted January 2010 to May 2016 and met highest-level trauma activation were included. Patients were divided into 2 groups (coagulopathy and controls) based on arrival rapid thrombelastography values. Coagulopathy was defined as the presence of any of the following on rapid thrombelastography: activated clotting time $\geq$128 seconds, α-angle $\leq$65 degrees, maximum amplitude $\leq$55 mm, and lysis at 30 minutes from 20-mm amplitude $\geq$3%. Logistic regression was used to adjust for age, sex, blood pressure, mechanism, and injury severity.

RESULTS: Nine hundred and fifty-six patients met inclusion; 507 (57%) were coagulopathic and 449 (43%) were not (noncoagulopathic and control cohort). Coagulopathic patients were younger (median 14 vs 15 years) and more likely to be male (68% vs 60%) and Hispanic (38% vs 31%) (all $p < 0.05$). Coagulopathic patients received more RBC and plasma transfusions and had fewer ICU and ventilator-free days and higher mortality (12% vs 3%; all $p < 0.05$). Of these 956, 197 (21%) sustained severe brain injury—123 (62%) were coagulopathic and 74 (38%) were noncoagulopathic. The mortality difference was even greater for coagulopathic head injuries (31% vs 10%; $p = 0.002$). Adjusting for confounders, admission coagulopathy was an independent predictor of death, with an odds ratio of 3.67 (95% CI 1.768 to 7.632; $p < 0.001$).

CONCLUSIONS: Almost 60% of severely injured children and adolescents arrive with evidence of acute traumatic coagulopathy. The presence of admission coagulopathy is associated with high mortality in children, especially among those with head injuries. (J Am Coll Surg 2017;224: 625–632. © 2017 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Trauma is a leading cause of morbidity and mortality in the US and worldwide.[1,2] For children and adolescents, specifically, unintentional injury is the leading cause of death across the globe, accounting for nearly 1,000,000 deaths per year among those younger than 18 years of age.[2] Pediatric trauma causes an enormous physical,

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Abbreviations and Acronyms

AIS = Abbreviated Injury Scale
CCT = conventional coagulation test
GCS = Glasgow Coma Scale
INR = international normalized ratio
IQR = interquartile range
ISS = Injury Severity Score
PT = prothrombin time
r-TEG = rapid thrombelastography
TBI = traumatic brain injury
TEG = thrombelastography
VHA = viscoelastic hemostatic assay

emotional, and economic burden on patients, families, and society, with an annual estimated cost of >$200 billion in the US alone.[3] Traumatic brain injury (TBI) and hemorrhage are the predominate causes of mortality among pediatric patients; in addition, blunt trauma, vs penetrating, is more common among children than adults, with up to 47% of deaths attributable to motor vehicle crashes.[2,4,5] Acute traumatic coagulopathy is a dysfunctional response in the body's hemostatic system after severe injury and shock,[6] and has been documented in the pediatric trauma population, with an incidence ranging from 28% to 51%.[4,5,7-12]

Viscoelastic hemostatic assays (VHA) have emerged as an efficient method for rapid identification of coagulopathy in the trauma population. Two commonly used platforms for testing the efficiency of blood coagulation are thrombelastography (TEG) and rotational thromboelastometry. These methods can assess function of the coagulation factors and platelets, clotting strength, and fibrinolysis. Results from VHA can predict need for blood transfusions, risk of additional hemorrhage, morbidity, and mortality. Our institution has previously shown that these findings and benefits of TEG can be observed in injured children by identifying hyperfibrinolysis[13] and following the development of hypercoagulability and their risk of venous thromboembolism.[14] In addition, data have shown that conventional coagulation tests (CCTs) could be abandoned in favor of TEG because they better predict the need for and guide the transfusion of early RBCs, plasma, and platelets.[15]

Compared with adults, children have a distinct injury profile and response to trauma. Traumatic brain injury is a more prominent cause of death (as opposed to hemorrhage in adults),[16] overall mortality rates are much lower, and late death after injury[17] and death caused by organ failure or sepsis are a rarity.[18] The factors responsible for the disparate response to injury are largely unknown. There are conflicting data in adults as to whether or not patients with TBI have a higher incidence of coagulopathy on admission compared with similarly injured cohorts.[19,20] Although not specifically examining the link between admission coagulopathic profile and outcomes, there are some data to suggest poorer functional status in children after TBI when coagulopathy is present at the time of admission by CCTs.[7,8,10]

Use of functional assays, such as viscoelastic tests, has been advocated recently to rapidly identify the phenotype of coagulopathy (whether from TBI, hemorrhage, or other source) and to provide timely targeted therapy.[21,22] The purpose of this study was to assess the prevalence and impact of arrival coagulopathy by TEG in severely injured children and adolescents. In addition, we sought to determine specifically the prevalence and impact of coagulopathy in TBI.

METHODS

Study population

The IRBs at the University of Texas Health Science Center at Houston and the Children's Memorial/Memorial Hermann Hospital approved this study. Using the institutional Trauma Registry of the American College of Surgeon's database, we collected data on all pediatric (17 years old and younger) trauma patients admitted during a 6-year period (January 2010 to May 2016) who were the institution's highest-level trauma activations. From this cohort, patient demographics, laboratory and rapid TEG (r-TEG) values, Injury Severity Scores, management interventions, and outcomes were extracted. Exclusion criteria included patients with ≥20% total body surface area burns, or patients who expired within 30 minutes of arrival. Our institutional adult data have been published and were used for the adult comparisons.[15]

Viscoelastic hemostatic assays

Blood specimens for r-TEG were obtained as part of the usual blood samples acquired during the primary or secondary survey evaluation of all major trauma activations (r-TEG samples are obtained within 15 minutes of presentation). Blood was obtained in 2.7-mL citrated tubes (Vacutainer; Becton-Dickinson) and assayed after recalcification. All r-TEG specimens were run on a TEG thrombelastograph 5000 (Haemonetics). Clinical laboratory technicians in the Memorial Hermann emergency department stat laboratory performed all r-TEGs during the defined study period. These same technicians performed all the quality controls on the TEG analyzers, doing so every 8 hours. The following measurements were recorded: activated clotting time (seconds), angle