The Solstrand Remote Damage Control Resuscitation Symposium

Geir Strandenes and Philip C. Spinella

This year the Traumatic Hemostasis and Oxygenation Research (THOR) Network had its second annual conference from June 19 to 21 at the Solstrand Hotel, near Bergen, Norway. The first symposium was held on June 14, 2011, and was a 1-day symposium that focused on prehospital use of fresh whole blood.[1] This year we held a 3-day symposium and broadened the scope to include a wider spectrum of treatment and monitoring options for remote damage control resuscitation (RDCR). As hemorrhage remains a major cause of potentially preventable deaths in both civilian and military combat trauma patients, it was essential to have both perspectives presented at the symposium. The RDCR Symposium was sponsored and organized by the Norwegian Naval Special Operation Commando together with the Norwegian Air Ambulance Foundation. The US Office of Naval Research and the US Department of Defense Combat Casualty Care Research Program also provided support for the Symposium.

While highly controversial, recent experience with DCR concepts have led many trauma centers to incorporate them into their standard practice to include early administration of high ratio plasma to red cell transfusion with limited use of crystalloids and colloids.[2-4] Exporting DCR concepts to the prehospital arena is the essence of RDCR. RDCR is still not well defined though. The main question remains: what defines "remote"? Is it all prehospital care or only when evacuation to surgical care is prolonged? If "remote" is defined as "a prolonged evacuation," how much time is required prior to hospital admission to constitute "remote"?

The main goal of prehospital care for patients with traumatic hemorrhagic shock should be identical to intrahospital care. This is the reduction of mortality and morbidity from hemorrhage by the rapid prevention and treatment of traumatic coagulopathy and shock without exacerbating it. Applying these as prehospital goals has the potential to improve outcomes for those requiring intrahospital DCR therapy. The main barrier to applying RDCR concepts in the prehospital setting has been the availability of blood products and clear evidence of when they are indicated. Advancements in this area of prehospital care have significant potential to improve outcomes for patients with life-threatening hemorrhagic injuries.

Research exploring the etiology of shock and coagulopathy for patients with traumatic injury is essential to determining the prehospital indications for blood products. To facilitate the basic science required to be performed there needs to be consistency in the terms used to define phases of traumatic shock and coagulopathy based upon pathophysiology. There currently is not uniformity on terminology, and this should be a primary goal for all trauma-related societies and research networks to establish together. Another important goal is the development of a common data collection platform throughout the world that incorporates both pre- and intrahospital data, that includes adequate physiologic and laboratory data, and meaningful short- and long-term outcomes. The appropriate design of translational research in this area is dependent upon highly accurate epidemiologic and outcomes data. We cannot move forward substantially without robust information to guide us.

THOR NETWORK OBJECTIVES

The THOR Network is a multidisciplinary group of investigators, clinicians, medics, and educators with a common interest in improving outcomes and safety for patients with severe traumatic injury by advancing prehospital and intrahospital care through research, training, and education. The Network's primary focus is identifying the optimal methods to reduce mortality and morbidity from

From the Norwegian Naval Special Operation Commando, Department of Immunology and Transfusion Medicine, Haukeland University Hospital, Bergen, Norway; and Department of Pediatrics, Washington University in St Louis, St Louis, Missouri.

Address reprint requests to: Geir Strandenes, MD, Department of Immunology and Transfusion Medicine, Haukeland University Hospital, 5021 Bergen, Norway; e-mail: geir@docfish.no.

doi: 10.1111/trf.12029

TRANSFUSION 2013;53:6S-8S.

traumatic hemorrhagic shock by optimizing the identification and treatment of shock and coagulopathy. Currently, Network investigators are performing studies which are advancing the measurement of tissue oxygenation, cellular shock, functional measures of hemostasis, immunologic, coagulation, and endothelial effects as well as determining the effect on outcomes of different resuscitation fluids and blood products. Investigators are also pioneering studies in the area of developing blood products or hemostatic agents that can be transported to austere environments such as freeze- or spray-dried products. The research, training programs, and education the Network performs include both prehospital and hospital phases of care with attention to both military and civilian application.

CONFERENCE GOALS

The goal of the conference was to share knowledge, stimulate innovative ideas, and network to improve research, training programs, and education on RDCR topics. Of the many unanswered questions regarding optimal RDCR the following are a few that were highlighted in this year's symposium:

1) Are there methods to monitor and evaluate for shock and coagulopathy that can be used to guide prehospital resuscitation?
2) What is the role for crystalloids/colloids to resuscitate prehospital life-threatening bleeding?
3) Can the efficacy and safety of all blood products be improved upon with alternative processing and storage methods?
4) What is the role of adjunctive hemostatic agents such as fibrinogen concentrates, prothrombin complex concentrates, or antifibrinolytics in the prehospital resuscitation of life-threatening bleeding?
5) What strategies should be used to most efficiently implement RDCR principles in the prehospital arena?
6) Are there indications for whole blood transfusions for delayed evacuations?
7) Can whole blood be reengineered with lyophilized or frozen plasma, platelets, and red blood cells?

Symposium speakers represented a diverse background with military or civilian experience, and included representation from emergency medicine, anesthesia, surgery, critical care, transfusion medicine, hematology, and basic science. Speakers presented information on topics ranging from current DCR techniques and outcomes to research on freeze-dried plasma, platelets, and red cells. Additional topics included portable devices to measure shock and coagulopathy, practical and feasibility aspects of whole blood buddy transfusion, and taking battlefield evacuation concepts to the streets of London. Attendees and speakers were represented from 11 different countries: Austria, Australia, Canada, France, Denmark, Germany, Israel, Norway, Sweden, the United Kingdom, and the United States. The Symposium agenda and presentations held during the conference are published on the THOR Network Web site: http://www.RDCR.org.

The ideal prehospital resuscitation strategy for patients with life-threatening bleeding is controversial, though some facts are indisputable. Studies from both civilian and military trauma epidemiology show that the majority of deaths occur prior to reaching a surgical facility.[5-8] Hemorrhage is a major mechanism of death in combat injuries, and death from hemorrhage represents 80% of those potentially salvageable.[9] In the civilian community trauma represents the leading cause of death in the age group from 1 to 44, and 50% of deaths within the first 24 hours are due to hemorrhage.[10] Today we know that traumatic coagulopathy appears very early and is highly lethal.[11-13] These facts lead us to the conclusion that one of the most important "gaps" to be filled in the management of the exsanguinating patient appears in the prehospital phase. Making blood products available as far forward as possible might improve survival, especially from noncompressible injuries. Historically the same conclusion was presented in *War Medicine* in May of 1941: "these observers pointed out that since shock and hemorrhage are acute conditions, they must be treated at the earliest possible moment. The goal of any service supplying blood and plasma should be to make them available as far forward in the combat zone as possible."[14]

Many believe the next large breakthrough in improving outcomes for patients with traumatic injuries will come from improvement in prehospital survival.[15] Applying DCR concepts will be needed to achieve this goal. The specific methods and products needed to perform RDCR are yet to be determined. The THOR Network through our annual Solstrand RDCR Symposium is committed to promoting the research, training, and education that will be needed to determine optimal resuscitation strategies for RDCR with the ultimate goal of reducing death from hemorrhage in the prehospital setting.

The following supplement is a collection of manuscripts from speakers at this year's RDCR Symposium. As Co-chairs of THOR and the RDCR Symposium, we are very proud of the quality of manuscripts provided for this supplement by many leaders in the world on this topic of RDCR. We hope that this supplement is informative and stimulates investigation, training, and education in this important clinical topic.

REFERENCES

1. Spinella PC, Strandenes G, Rein EB, Seghatchian J, Hervig T. Symposium on fresh whole blood for severe hemorrhagic shock: from in-hospital to far forward resuscitations. Transfus Apher Sci 2012;46:113-7.

2. Borgman MA, Spinella PC, Perkins JG, Grathwohl KW, Repine T, Beekley AC, Sebesta J, Jenkins D, Wade CE, Holcomb JB. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. J Trauma 2007;63:805-13.
3. Duchesne JC, Hunt JP, Wahl G, Marr AB, Wang YZ, Weintraub SE, Wright MJ, McSwain NE Jr. Review of current blood transfusions strategies in a mature level I trauma center: were we wrong for the last 60 years? J Trauma 2008; 65:272-6; discussion 276-8.
4. Gonzalez EA, Moore FA, Holcomb JB, Miller CC, Kozar RA, Todd SR, Cocanour CS, Balldin BC, McKinley BA. Fresh frozen plasma should be given earlier to patients requiring massive transfusion. J Trauma Acute Care Surg 2007;62: 112-9.
5. Acosta JA, Yang JC, Winchell RJ, Simons RK, Fortlage DA, Hollingsworth-Fridlund P, Hoyt DB. Lethal injuries and time to death in a level I trauma center. J Am Coll Surg 1998;186:528-33.
6. Gerhardt RT, De Lorenzo RA, Oliver J, Holcomb JB, Pfaff JA. Out-of-hospital combat casualty care in the current war in Iraq. Ann Emerg Med 2009;53:169-74.
7. MacLeod JB, Cohn SM, Johnson EW, McKenney MG. Trauma deaths in the first hour: are they all unsalvageable injuries? Am J Surg 2007;193:195-9.
8. Demetriades D, Murray J, Charalambides K, Alo K, Velmahos G, Rhee P, Chan L. Trauma fatalities: time and location of hospital deaths. J Am Coll Surg 2004;198:20-6.
9. Eastridge BJ, Hardin M, Cantrell J, Oetjen-Gerdes L, Zubko T, Mallak C, Wade CE, Simmons J, Mace J, Mabry R, Bolenbaucher R, Blackbourne LH. Died of wounds on the battlefield: causation and implications for improving combat casualty care. J Trauma 2011;71:S4-8.
10. Nunez TC, Cotton BA. Transfusion therapy in hemorrhagic shock. Curr Opin Crit Care 2009;15:536-41.
11. Hess JR, Brohi K, Dutton RP, Hauser CJ, Holcomb JB, Kluger Y, Mackway-Jones K, Parr MJ, Rizoli SB, Yukioka T, Hoyt DB, Bouillon B. The coagulopathy of trauma: a review of mechanisms. J Trauma 2008;65:748-54.
12. Brohi K, Singh J, Heron M, Coats T. Acute traumatic coagulopathy. J Trauma 2003;54:1127-30.
13. Patregnani JT, Borgman MA, Maegele M, Wade CE, Blackbourne LH, Spinella PC. Coagulopathy and shock on admission is associated with mortality for children with traumatic injuries at combat support hospitals. Pediatr Crit Care Med 2012;13:273-7.
14. DeGowin EL, Hardin RC. A plan for collection, transportation and administration of whole blood and of plasma in warfare. War Med 1941;1:326-41.
15. Gerhardt RT, Berry JA, Blackbourne LH. Analysis of lifesaving interventions performed by out-of-hospital combat medical personnel. J Trauma 2011;71:S109-13.