Zero preventable deaths after traumatic injury: An achievable goal

Philip Charles Spinella, MD, FCCM, *St Louis, Missouri*

Trauma systems have been improving outcomes for patients with injuries for decades. Advancements have been made due to improvements in blood storage, prehospital and interhospital transport systems, and refinement of resuscitative and surgical techniques. Despite these improvements in trauma care, there are still many gaps that remain that impede further improving outcomes. These deficiencies have been difficult to address in part due to lack of a well defined and continuously learning health system for trauma that provides a universal means of improving care, education, research, and guiding the national leadership in health, defense, and other branches of government.

Civilian and military trauma systems have been developing and contributing simultaneously to the improvement of trauma systems over time, and it will take continued collaboration to achieve additional advancements in the future. The goal of improving outcomes for patients with traumatic injury and reducing unnecessary death and disability has always been a high priority. In the early 1990s after an analysis of outcomes from combat operations in Mogdishu, Somalia,[1] two US military-led efforts have significantly guided the current goal of zero-preventable deaths after traumatic injury. First the US Tactical Combat Casualty Care Committee was developed with a goal of constructing a robust set of presurgical care guidelines that could be implemented by all military providers.[2] Soon thereafter, the US Army Ranger's implemented Tactical Combat Casualty Care Committee guidelines for presurgical care, with a goal of zero preventable deaths after traumatic injury.[3] These goals were met due to a strong leadership culture, accountability, shared responsibility, extensive training, and maintenance of medical skills.[4]

These accomplishments have raised expectations and set an example for how to develop and implement best practice guidelines.[2,3] Many excellent trauma systems are operational around the United States and the world, but what is still lacking is a highly organized approach to how these systems learn from their experiences and how it adapts with increasing knowledge. A learning health care system(s) (LHCS) (is the term used to describe a robust organized approach to improving outcomes by using an iterative process that continually examines patient data and outcomes in real time. In 2012, the National Academy of Sciences Engineering and Medicine published recommendations describing how a LHCS can provide best care at lower cost.[5] The US Military Joint Trauma System (JTS) has many elements of a LHCS, and while care provided within the JTS has led to the best outcomes that have ever been recorded (case fatality rate [CFR] of 9.3 compared with 20–23 in Korean and Vietnam Wars), US military medicine leaders acknowledge that there is room for improvement.[6]

This review of a lecture presented at the Trauma Hemostasis and Oxygenation Research (THOR) Network's 2016 RDCR Symposium provides highlights from the National Academy of Sciences, Engineering and Medicine's Report on A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury.[7] It is a brief summary of an extensive report that provides background information regarding the urgency for improving outcomes for patients with traumatic injury, potential solutions as well as barriers to improving outcomes, and how trauma systems can improve by using a LHCS model.

EPIDEMIOLOGY AND OUTCOMES

There were 5.1 million trauma deaths worldwide in 2010, accounting for nearly 10% of all deaths. Unintentional injury-related deaths in children are estimated to be 730,000 a year worldwide.[7] Unfortunately, the burden of injury is expected to rise internationally in the coming decades. In the United States, trauma is the third overall leading cause of death for all ages, and it is the leading cause of death for those aged 1 to 46 years.[7] Trauma is also the most common cause of life-years lost, before 75 years of age, compared with all other etiologies.

Preventable deaths after traumatic injury has been defined as "casualties whose lives could have been saved by appropriate and timely medical care, regardless of tactical, logistical, or environmental issues. The recently published report by the National Academy of Sciences, Engineering, and Medicine states that preventable deaths after injury should be determined by thorough review of medical examiner reports and all available prehospital and hospital medical records.[7] A multidisciplinary panel of experts, using consensus rule format should review the compiled data for each fatality and determine if the primary anatomic cause of death was potentially preventable through the delivery of appropriate and timely medical care. Variables of interest during such reviews include mechanism of injury, injury descriptions, and medical interventions performed.

Table 1 displays the rates of preventable deaths according to prehospital or in-hospital settings. The rate of deaths that are

Submitted: March 6, 2017, Accepted: March 13, 2017, Published online: March 22, 2017.
From the Division of Critical Care, Department of Pediatrics (P.C.S.), Washington University in St Louis, St. Louis, Missouri; and U.S. Army Institute of Surgical Research (P.C.S.), JBSA-FT Sam Houston, Texas.
The opinions or assertions expressed herein are the private views of the authors and are not to be construed as official or as reflecting the views of the US Department of the Army or the US Department of Defense.
Address for reprints: Philip C. Spinella, MD, Pediatric Critical Care Translational Research Program and Blood Research Program, Department of Pediatrics, Washington University in St Louis School of Medicine, Campus Box 8116, One Children's Place, Northwest Tower 10th Floor, St Louis, MO 63110; email: spinella_p@kids.wustl.edu.

DOI: 10.1097/TA.0000000000001425

TABLE 1. Military and Civilian Preventable Deaths After Traumatic Injury

	Military Data	Civilian Data
Preventable deaths (%)	27.5*	20**
Prehospital deaths (%)	90†	—
Prehospital preventable deaths after traumatic injury (%)	25†	29‡
Prehospital preventable hemorrhagic deaths after traumatic injury (%)	90†	64‡
In-hospital (%)	10§	—
In-hospital preventable deaths after traumatic injury(%)	50§	—
In-hospital preventable hemorrhagic deaths after traumatic injury (%)	80§	—

*Calculated from Eastridge et al.[8,9]
**Kwon et al.[10]
†Eastridge et al.[9]
‡Davis et al.[11]
§Eastridge et al.[8]
–, data not available.

preventable after traumatic injury are between 20–27.5%, and of these preventable deaths due to hemorrhage range between 64% and 90%.[8–11] In 2014 there were over 147,000 civilian deaths from traumatic injury of which 10,000 were children (<18 years of age). Therefore, there are roughly 30,000 preventable deaths after traumatic injury per year in the United States. There are no data specifically for children, but if 20% of pediatric deaths are also preventable, then 2,000 children per year in the United States have preventable deaths after traumatic injury.

There are more deaths per year in the United States from traumatic injury than have occurred in the past 15 years of combat in both Afghanistan and Iraq. Since 2001, there have been approximately 2 million US civilian trauma-related deaths, whereas in Afghanistan and Iraq, there have been approximately 6,850 trauma-related deaths during the same time period.

Estimating the incidence of preventable death due to hemorrhage after injury is important to understand the scope of problem and to establish urgency. Based on data compiled by Eastridge for both prehospital and in hospital deaths (Table 1), when the 4,569 combat deaths that occurred from 2001 to 2011 are considered, there were approximately 1,100 preventable deaths due to hemorrhage after injury when accounting for both prehospital and in-hospital deaths.[8,9] Estimating preventable deaths due to hemorrhage after injury in civilian settings is more difficult due to data that are not available regarding the incidence of preventable deaths after injury in prehospital vs in-hospital locations. To provide a general estimate though, if the military statistics of 90% of trauma deaths occur prehospital can be translated to the civilian sector, and 50% of in-hospital deaths are preventable due to hemorrhage, then due to the 147,000 deaths per year in the United States from injury, it can be estimated that approximately 18,400 preventable deaths due to hemorrhage after injury occur per year in the United States. The estimate includes 16,934 deaths per year in the prehospital phase of care and 1,470 deaths per year for the in-hospital phase of care in the United States alone. Current studies are ongoing to examine the rate of preventable deaths due to hemorrhage after injury in the United States.[12] Until this study is complete, there are no direct civilian data that allow for the calculation of prehospital or in-hospital deaths that are preventable due to hemorrhage after traumatic injury.

Since these estimates only include US statistics, it is apparent that there is great urgency internationally to focus efforts on reducing preventable deaths due to hemorrhage after traumatic injury. Based on the above data, 12% rate of all deaths in the United States per year are preventable hemorrhagic deaths after traumatic injury. If this statistic is generalizable to the 5.1 million deaths per year internationally,[7] then there are approximately 612,000 deaths per year in civilian settings globally that are preventable hemorrhagic deaths after injury.

Success of the US Military's JTS has yielded the lowest CFR ever recorded in the modern combat era. The cumulative CFR, which is the percentage of fatalities among all wounded, during the Korean and Vietnam Wars ranged between 20–23%. In Afghanistan and Iraq, the cumulative CFR was 9.3%.[7] The improved CFR compared with those from the Korean and Vietnam war era's is a testament to not only the strengths of the US Military JTSs ability to improve care over time but also from incorporating lessons learned from civilian trauma systems since the end of the Vietnam Conflict, such as advent of the concept of damage control surgery.[13] The ability of the US military's JTS to adapt over time has been well documented by Rasmussen and others, where data were rapidly analyzed and changes were made to improve outcomes.[6] Examples such as tourniquet use and damage control resuscitation techniques are among the many changes implemented with the use of "focused empiricism" over the last 15 years. The improved CFR is also due to improvements in the system learned from experts in the civilian sector since the Vietnam war. Damage control surgery techniques and improvements in prehospital emergency medical systems are clear examples of civilian advancements that have been learned and adopted by the military trauma system. Although there has been bidirectional learning from military to civilian trauma systems, improvements in the integration of both systems are needed for further advancement to occur and reduce the number of preventable deaths. As outlined in the National Academy of Sciences, Engineering and Medicine's report on "A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury," the integration of both military and civilian health care systems are needed to achieve a goal of zero preventable deaths after injury.[7] The main recommendations from this report are listed in Table 2.

LHCS MODEL

LHCSs have been extensively reviewed to include the 2012 report by the Institute of Medicine (now called the National Academy of Sciences, Engineering, and Medicine).[5] The main elements of a LHCS as they relate to a trauma system are reviewed in Table 3. Additional tools that augment the standard LHCS model include implementation science principles, and cost-effectiveness analyses. Implementation science is a structured approach to changing practice or behavior based on scientific evidence. It is also described as the systematic study of how a specific set of activities and designed strategies are used to successfully integrate an evidence-based intervention within

TABLE 2. Recommendations of the National Academy of Sciences, Engineering, and Medicine for a National Trauma Care System

Recommendation 1	The White House should set a national aim of achieving zero preventable deaths after injury and minimizing trauma-related disability.
Recommendation 2	The White House should lead the integration of military and civilian trauma care to establish a national trauma care system. This initiative would include assigning a locus of accountability
Recommendation 3	The Secretary of Defense should ensure combatant commanders and the Defense Health Agency (DHA) Director are responsible and held accountable for the integrity and quality of the execution of the trauma care system in support of the aim of zero preventable deaths after injury and minimizing disability.
Recommendation 4	The Secretary of Health and Human Services (HHS) should designate and fully support a locus of responsibility and authority within HHS for leading a sustained effort to achieve the national aim of zero preventable deaths after injury and minimizing disability. This leadership role should include coordination with governmental (federal, state, and local), academic, and private-sector partners and should address care from the point of injury to rehabilitation and postacute care.
Recommendation 5	The Secretary of Health and Human Services and the Secretary of Defense, together with their governmental, private, and academic partners, should work jointly to ensure that military and civilian trauma systems collect and share common data spanning the entire continuum of care. Within that integrated data network, measures related to prevention, mortality, disability, mental health, patient experience, and other intermediate and final clinical and cost outcomes should be made readily accessible and useful to all relevant providers and agencies.
Recommendation 6	To support the development, continuous refinement, and dissemination of best practices, the designated leaders of the recommended national trauma care system should establish processes for real-time access to patient-level data from across the continuum of care and just-in-time access to high-quality knowledge for trauma care teams and those who support them.
Recommendation 7	To strengthen trauma research and ensure that the resources available for this research are commensurate with the importance of injury and the potential for improvement in patient outcomes, the White House should issue an executive order mandating the establishment of a National Trauma Research Action Plan requiring a resourced, coordinated, joint approach to trauma care research across the U.S. Department of Defense, the U.S. Department of Health and Human Services (National Institutes of Health, Agency for Healthcare Research and Quality, Centers for Disease Control and Prevention, U.S. Food and Drug Administration, Patient-Centered Outcomes Research Institute), the U.S. Department of Transportation, the U.S. Department of Veterans Affairs, and others (academic institutions, professional societies, foundations).
Recommendation 8	To accelerate progress toward the aim of zero preventable deaths after injury and minimizing disability, regulatory agencies should revise research regulations and reduce misinterpretation of the regulations through policy statements (i.e., guidance documents).
Recommendation 9	All military and civilian trauma systems should participate in a structured trauma quality improvement process.
Recommendation 10	Congress, in consultation with the U.S. Department of Health and Human Services, should identify, evaluate, and implement mechanisms that ensure the inclusion of prehospital care (e.g., emergency medical services) as a seamless component of health care delivery rather than merely a transport mechanism.

(Reprinted[7] with permission from the National Academy of Sciences and courtesy of the National Academies Press 2016, Washington, DC).

specific settings. Main principles of implementation science include learning what motivates a group of learners or what is most important to them and to then use this knowledge to educate and change behavior. Another guiding principle of implementation science is to make it easier for the target audience to practice medicine in an optimal manner and to make it more difficult for them to not do the things you do not want them to do. Another key element of implementation science is to maintain knowledge and changed behavior through continued education and positive feedback methods. Thorough reviews on implementation science principles have been previously published.[14]

In order for LCHS system principles to be used by trauma systems, there needs to be a significant increase in trauma research. The lack of data to determine best practices in trauma care is a major impediment to developing a robust LHCS. Without data to inform best practices and continued research to further improve outcomes, an LHCS is not able to incorporate new concepts or ideas to evaluate and adopt or reject. Even though injury accounts for the highest percent of years of potential life lost before the age of 75 years, compared with all other conditions include cancer and heart disease (Fig. 1), and is the most frequent cause of death for the ages of 1 to 46 years, it is conversely the least funded relative to its burden on society.[7] In an analysis by the National Institutes of Health (NIH) of diseases relative to their burden according to disability adjusted life years, injury was the least funded compared to all other conditions analyzed (Fig. 2).[7] Even though injury accounts for 10% of the total disability adjusted life years in the United States per year, only 1% of the NIH's budget is designated to injury research. In 2013, 367 million dollars was allocated for injury research out of the approximately 30 billion dollar NIH budget and only 31.7 million was directed towards clinical research on the acute phase of resuscitation. This equates to 0.001% of the NIH budget for a disease that is responsible for the highest percent of years of potential life lost before the age of 75 years. The funding for trauma research by the Department of Defense is also sparse and tenuous. In 2013, 1.02 billion dollars was allocated for military medical research with 200 million earmarked for combat casualty research. Only 50% of this budget was from Congressional Special Interest funds. These funds are distributed on a year to year basis and as a result are at high risk of not being reallocated.[7]

The lack of trauma research funding support illuminates a substantial limitation in not only developing a foundation for a robust learning health care trauma system, but it also

TABLE 3. Components of a Continuously Learning Trauma Care System

Digital Capture of the Trauma Patient Care Experience	Patient care experiences across the continuum of care are digitally captured and linked in information systems, including trauma registries, such that each patient experience yields information on the effectiveness, quality, and value of the trauma care delivered. Bottom-up design of data systems, where care generates the data, ensures that data capture is seamlessly integrated into the provider workflow and is available in real time for performance improvement primarily and research secondarily.
Coordinated Performance Improvement and Research to Generate Evidence-Based Best Trauma Care Practices	The supply of knowledge is continuously and reliably expanded and improved through the systematic capture and translation of information generated by coordinated performance improvement and research activities.
Processes and Tools for Timely Dissemination of Trauma Knowledge	Trauma care providers have access to tools such as continuously updated clinical practice guidelines and clinical decision support tools to capture, organize, and disseminate the best available information to guide decision making and reduce variation in care and outcomes. Clinical decision support tools and telemedicine make knowledge of best trauma care practices available at the point of care.
Systems for Ensuring an Expert Trauma Care Workforce[a]	Continuous learning and improvement are designed into trauma system processes. Ongoing individual skill building and team training, as well as feedback loops, build and sustain an expert trauma care workforce.
Patient-Centered Trauma Care	The trauma care process is managed around the patient experience, feedback is sought from trauma patients when the process is evaluated for improvement, and patients are involved in redesign of the trauma system and have a voice in trauma research. Patient-centered care features timely access to high-quality prehospital, definitive, and rehabilitative care, with seamless transitions between each of these echelons to ensure that physical and psychologic health care needs are met.
Leadership-Instilled Culture of Learning	Leadership will influence the extent to which a culture of learning and improvement permeates a trauma system. Leadership instills a culture of learning by defining learning as a central priority of a trauma system, removing barriers to improving care systems and, most notably at the point of care, setting quantifiable aims against which progress can continually be measured and promoting a non-punitive environment.
Transparency and Aligned Incentives for Quality Trauma Care	Drawing on data from trauma registries and other information systems, performance improvement programs support the evolution and improvement of trauma systems by benchmarking systems' performance against that of other similar organizations and by making performance information available at the provider, team, center, and system levels. Multiple complementary incentives are aligned to encourage continuous improvement and reward high-quality care.
Aligned Authority and Accountability for Trauma System Leadership	Responsibility, authority, and resources are aligned to enable leadership to steward the system. Defined leadership is accountable for trauma capabilities and system performance, with the authority to create and enforce policy and ensure that the many stakeholders involved work together to provide seamless, quality care.

[a]In an expert trauma care workforce, as defined by the committee, each interdisciplinary trauma team at all roles of care includes an expert for every discipline represented. These expert-level providers oversee the care provided by their team members, all of whom must be minimally proficient in trauma care (i.e., appropriately credentialed with current experience caring for trauma patients).

(Reprinted[7] with permission from the National Academy of Sciences and courtesy of the National Academies Press © 2016, Washington, DC).

undermines attracting investigators to pursue trauma related research. There is a great need for an Institute to be developed within the NIH devoted to traumatic injury. The lack of a Trauma Branch within the NIH is a major impediment to reallocating research funds to become commensurate with the burden that traumatic injury has on the population. Increased investment in trauma research has a high potential to improve outcomes, just as increased investment has had on improving outcomes to include mortality for conditions such as HIV/AIDS, cardiac disease and cancer.

POTENTIAL SOLUTIONS

Since the most common cause of preventable deaths after injury are due to hemorrhage, then it is natural that initial investigation focus on reducing death from hemorrhage for patients with traumatic injury. The fact that the majority of military deaths occur in the prehospital phase of care and that it is likely that this is similarly true in the civilian world indicate that reducing death from hemorrhage during the prehospital phase of resuscitation is the most efficient approach to improving outcomes for patients with traumatic injury. It is clear that death from compressible injuries can be dramatically reduced with the appropriate use of tourniquets. Education on the use of these devices and the broad implementation of their use is essential to achieve the goal of zero preventable deaths after injury. The "Stop the Bleed" campaign is an excellent example of a US Department of Defense initiative to educate by-standers on the principles of preventing death from hemorrhage from extremity injuries.[16]

Recent data are emerging that indicates reduced transport time to a surgical facility and a blood product based resuscitation is associated with improved survival.[17] Increased ratios (1:1:1) compared to lower ratios (1:1:2) for plasma, platelets, and RBCs, respectively, have been documented to reduce death from hemorrhage and the time to hemostasis in adult trauma patients

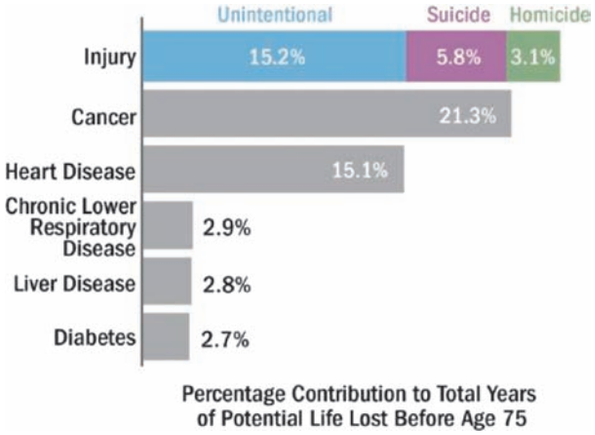

Figure 1. Leading causes of years of potential life lost before age 75, United States, 2014. Source: Public domain data retrieved from NCIPC, 2015d.[15]

at risk for life threatening hemorrhage.[18] There are data that suggest that a whole blood based approach compared to components may improve survival.[19] The use of group O whole blood and storage for at least 14 to 21 days has dramatically improved its availability and as a result a few trauma centers have begun to evaluate its efficacy and safety in both adult and pediatric trauma populations.[20] Examples of high-priority translational research to achieve the goal of zero preventable deaths after injury are listed in Table 4.

TRANSDISCIPLINARY APPROACH

Historically medical societies, medical associations, and research networks are insular, and as a result, there is lack of an exchange of ideas, knowledge, and experience that inhibits change and the modification of existing ideas/technologies due to an "echo chamber" phenomenon. One of the key aspects of an LHCS is a transdisciplinary approach that is patient-centered.

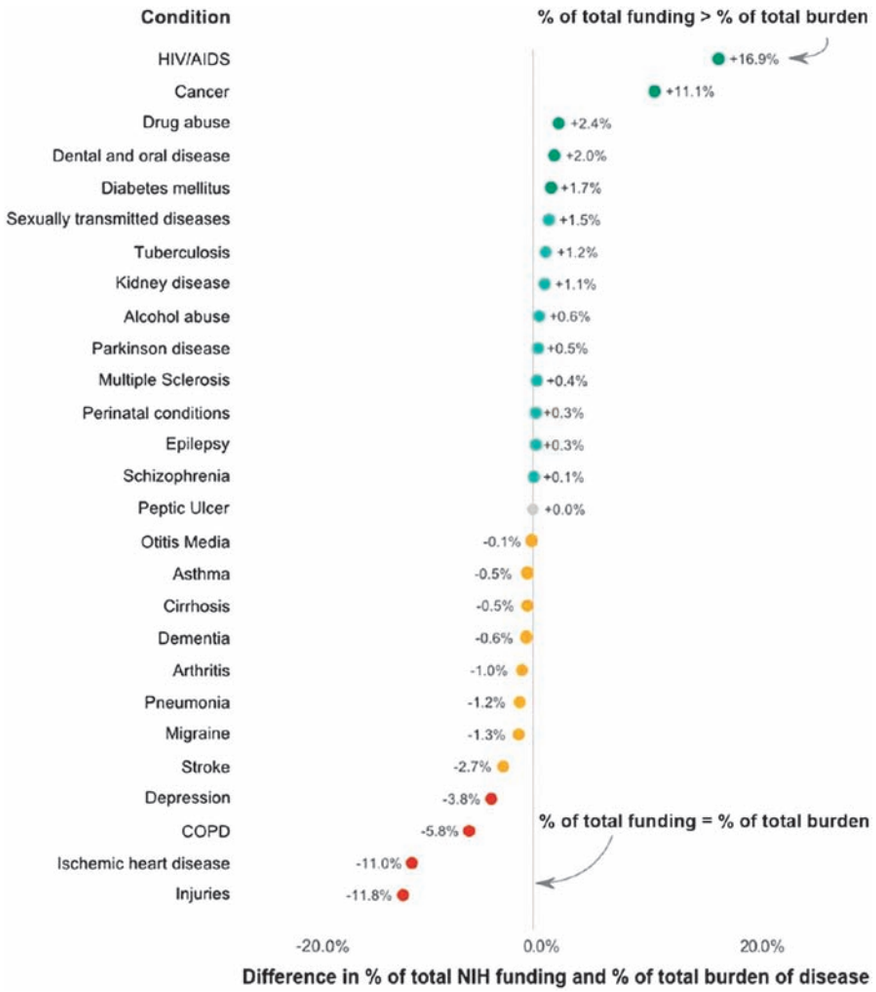

Figure 2. Funding Percent Compared to Burden for Conditions Funded by the NIH. NIH funding for medical conditions relative to their total disease burden (COPD, chronic obstructive pulmonary disease; HIV/AIDS, human immunodeficiency virus/acquired immunodeficiency syndrome; NIH, National Institutes of Health.). Credit: Figure created by Catherine A. Richards, PhD, MPH, from data abstracted from Moses H 3rd, Matheson DH, Cairns-Smith S, George BP, Palisch C, Dorsey ER. The anatomy of medical research: US and international comparisons. *JAMA.* 2015;313(2):174–89.

TABLE 4. Examples of Translational Research Priorities to Achieve the Goal of Zero Preventable Deaths after Injury

Develop and evaluate optimal monitoring methods to evaluate hemostatic capacity and oxygen debt
Determine if point of care monitoring in the prehospital phase of resuscitation can be used to improve outcomes?
Determine if hypotensive resuscitation is appropriate for patients who have transport times greater than 30 min, and does a blood based resuscitation strategy change the threshold for blood pressure goals?
Determine appropriate indications and dosing of blood products in the prehospital phase of resuscitation
Determine appropriate indications and dosing of Intravenous hemostatic adjuncts such as antifibrinolytics and coagulation factor concentrates
Determine if whole blood is superior to the use of individual blood components for hemorrhagic shock
Determine if platelets stored at 2–6°C improve outcomes compared to platelets at 20–24°C
Determine the optimal use of blood products and hemostatic adjuncts for patients with severe traumatic brain injury
Determine the efficacy, safety, and cost-effectiveness for pathogen reduction technologies on all blood products for patients with hemorrhagic shock
Determine the efficacy and safety of lyophilized or cryopreserved blood products
Determine the efficacy and safety of oxygen carriers
Determine the efficacy and safety of mechanical and topical hemostatic agents
Examples include; REBOA, Injectable foams, hemostatic bandages
Evaluate if methods that reduce metabolism, or induce of survival genes improve outcomes?
Examples; induced hypothermia, valproic acid, suspended animation techniques
Determine which educational methods via implementation science techniques are most efficient in improving trauma care knowledge and its maintenance over time?

The THOR Network is a patient-focused, international transdisciplinary network of first responders, clinicians, clinical trialists, and basic scientists, military and civilian providers and policy makers.[21] The THOR mission is to reduce the risk of death from traumatic hemorrhagic shock by improving the acute phase of treatment in both presurgical and postsurgical phases of care. It has approximately 300 members from over 22 countries.

THOR has developed collaborations with other organizations to further its mission. The NATO Blood Research Committee has recently co-located one of its bi-annual meetings with the THOR meeting in Norway to allow for a regular exchange of ideas and experience between civilian and military leaders in trauma resuscitation. THOR has also developed a collaboration with the American Association of Blood Banks (AABB). A Joint THOR-AABB standing working group has been established where the purpose is to identify opportunities to advance transfusion medicine clinical practice, support innovation of new products, and further knowledge transfer to reduce the risk of death from hemorrhagic shock. Initial charges to the group include improving educational programs regarding hemorrhagic shock epidemiology, therapeutic options for patients with life threatening bleeding, and current outcomes, improved data collection platforms for patients with life threatening bleeding, and standard changes regarding whole blood use and methods for tittering blood products. This standing joint AABB-THOR working group reports directly to the Clinical, Scientific, Research Council of the AABB Board of Directors. The working group has submitted a proposal that will change AABB regulations to permit the use of Group O whole blood for patients with life-threatening hemorrhagic shock of all etiologies.

The interactions between military and civilian providers at the annual THOR Network conference on Remote Damage Control Resuscitation has directly led to changes in both Military and Civilian standards of practice in Norway, Sweden, France, Netherlands, Canada, Israel, Australia, and the United States.[15] These changes have included the incorporation of cold-stored whole blood, cold-stored platelets, lyophilized plasma, and tranexamic acid for prehospital care. Changes have even occurred in the Royal Caribbean Cruise Line industry where they have implemented and improved upon their walking blood donor program for passengers with life-threatening bleeding while out at sea. THOR Network collaborations are examples of how the trauma community needs to further integrate civilian and military trauma teams and work together towards achieving the goal of zero preventable deaths after injury.

CONCLUSION

Trauma is the most common cause of death between the ages of 1–46 and is the cause of the most common cause of life-years lost, before the age of 75 years, compared to all other etiologies. Mortality from hemorrhage is the most common cause of preventable death after traumatic injury. Zero preventable deaths after traumatic injury is an achievable goal. To achieve this goal a systematic approach is needed that can be modeled as an LHCS. Trauma research is the lowest funded illness per burden of disease compared to all other diseases. Increased resources and an integrated military and civilian trauma system is needed to achieve zero preventable deaths after injury in the United States. The THOR Network is facilitating the integration of military and civilian trauma systems internationally as it continues work with many organizations to achieve the goal of zero preventable deaths after traumatic injury.

DISCLOSURE

Philip Spinella, TerumoBCT, New Health Sciences, Cerus, Entegrion, Vascular Solutions.

REFERENCES

1. Mabry RL, Holcomb JB, Baker AM, Cloonan CC, Uhorchak JM, Perkins DE, Canfield AJ, Hagmann JH. United States Army Rangers in Somalia: an analysis of combat casualties on an urban battlefield. *J Trauma*. 2000; 49(3):515–528; discussion 28–9.
2. Butler FK. Leadership lessons learned in tactical combat casualty care. *J Trauma Acute Care Surg*. 2017;82(6 Supp 1):TK–TK.

3. Kotwal RSMH, Miles EA, Conklin CC, Hall MT, McChrystal SA. Leadership and a casualty response system for eliminating preventable death. *J Trauma Acute Care Surg*. 2017;82(6 Supp 1):TK–TK.
4. Kotwal RS, Montgomery HR, Kotwal BM, Champion HR, Butler FK Jr, Mabry RL, Cain JS, Blackbourne LH, Mechler KK, Holcomb JB. Eliminating preventable death on the battlefield. *Arch Surg*. 2011;146(12): 1350–1358.
5. Committee on the Learning Healthcare System in America IoM. Best Care at Lower Cost: The Path to Continuously Learning Health Care in America. In: Smith MSR, Stuckhardt L, et al., editor: National Academies Press; 2013.
6. Rasmussen TE, Kellermann AL. Wartime lessons—shaping a national trauma action plan. *N Engl J Med*. 2016;375(17):1612–1615.
7. Committee on Military Trauma Care's Learning Health System and Its Translation to the Civilian Sector; Board on Health Sciences Policy; Board on the Health of Select Populations; Health and Medicine Division; National Academies of Sciences, Engineering, and Medicine; Berwick D, Downey A, Cornett E, editors. *A National Trauma Care System*: *Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury.* Washington, DC: National Academies Press (US); 2016; Sep.
8. Eastridge BJ, Hardin M, Cantrell J, Oetjen-Gerdes L, Zubko T, Mallak C, Wade CE, Simmons J, Mace J, Mabry R, et al. Died of wounds on the battlefield: causation and implications for improving combat casualty care. *J Trauma*. 2011;71(1 Suppl):S4–S8.
9. Eastridge BJ, Mabry RL, Seguin P, Cantrell J, Tops T, Uribe P, Mallett O, Zubko T, Oetjen-Gerdes L, Rasmussen TE, et al. Death on the battlefield (2001–2011): implications for the future of combat casualty care. *J Trauma Acute Care Surg*. 2012;73(6 Suppl 5):S431–S437.
10. Kwon AM, Garbett NC, Kloecker GH. Pooled preventable death rates in trauma patients : Meta analysis and systematic review since 1990. *Eur J Trauma Emerg Surg*. 2014;40(3):279–285.
11. Davis JS, Satahoo SS, Butler FK, Dermer H, Naranjo D, Julien K, Van Haren RM, Namias N, Blackbourne LH, Schulman CI. An analysis of prehospital deaths: who can we save? *J Trauma Acute Care Surg*. 2014;77(2):213–218.
12. CNTR's first DoD research proposal to be funded [news release]. Coalition for National Trauma Research. August 2016. http://coalitionntr.org/2016/08/16/cntrs-first-dod-research-proposal-to-be-funded. Accessed March 6, 2017.
13. Rotondo MF, Schwab CW, McGonigal MD, Phillips GR 3rd, Fruchterman TM, Kauder DR, Latenser BA, Angood PA. 'Damage control': an approach for improved survival in exsanguinating penetrating abdominal injury. *J Trauma*. 1993;35(3):375–382; discussion 82–3.
14. Glasgow RE, Vinson C, Chambers D, Khoury MJ, Kaplan RM, Hunter C. National Institutes of Health approaches to dissemination and implementation science: current and future directions. *Am J Public Health*. 2012;102(7): 1274–1281.
15. Pidcoke HF, Spinella PC. RDCR Symposium fifth-year anniversary edition: global prehospital care rooted in a history of military innovation. *Transfusion*. 2016;56(Suppl 2):S107–S109.
16. Stop the Bleed. US Department of Homeland Security web site. https://www.dhs.gov/stopthebleed. Updated October 11, 2016. Accessed February 20, 2017.
17. Kotwal RS, Howard JT, Orman JA, Tarpey BW, Bailey JA, Champion HR, Mabry RL, Holcomb JB, Gross KR. The effect of a golden hour policy on the morbidity and mortality of combat casualties. *JAMA Surg*. 2016; 151(1):15–24.
18. Holcomb JB, Tilley BC, Baraniuk S, Fox EE, Wade CE, Podbielski JM, del Junco DJ, Brasel KJ, Bulger EM, Callcut RA, et al. Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial. *JAMA*. 2015;313(5):471–482.
19. Spinella PC, Perkins JG, Grathwohl KW, Beekley AC, Holcomb JB. Warm fresh whole blood is independently associated with improved survival for patients with combat-related traumatic injuries. *J Trauma*. 2009;66(4 Suppl): S69–S76.
20. Spinella PC, Cap AP. Whole blood: back to the future. *Curr Opin Hematol*. 2016;23(6):536–542.
21. Trauma Hemostasis & Oxygenation Research Network. [February 20th, 2017]. http://rdcr.org/. Accessed February 20, 2017.