A Perfect Storm: 2019 Scudder Oration on Trauma

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A perfect storm: a particularly violent storm arising from a rare combination of adverse meteorological phenomena.

Wikipedia (accessed August 2, 2019)

Thank you, Drs Bulger, Stewart, and Hoyt, for this extraordinary honor of delivering the 2019 Scudder Oration on Trauma. I would also like to take this opportunity to welcome all of you to San Francisco. Just 3 miles south of here is the San Francisco General Hospital/Zuckerberg Trauma Center (SFGH), where I have worked for the past 30 years and been supported by an outstanding group of faculty members, trauma/critical care fellows, and University of California San Francisco surgery residents. I follow in the footsteps of 4 previous Scudder Orators from the SFGH including:

1. 1982—FW Blaisdell: "The Nature and Consequences of Traumatic Shock"[1]
2. 1989—DD Trunkey: "What Is Wrong with Trauma Care"?[2]
3. 1991—GF Sheldon: "Trauma Manpower in the Decade of Aftershock"[3]
4. 2006—FR Lewis: "Physiology for the 21st Century: Cardiopulmonary Function in Sepsis" (unpublished) (Fig. 1)

It was Dr Blaisdell who provided me with the title for this talk when he described for me the perfect storm that occurred in San Francisco in the 1960s. It started with the hippie phenomenon originating in the Haight-Ashbury district of San Francisco, a neighborhood that would become the setting for the "Summer of Love" in 1967. Idealistic youth from across the nation flocked to Haight-Ashbury to participate in the counterculture, where LSD, marijuana, and methamphetamine dominated the scene.[4] Meanwhile, over in Berkeley, political activism was thriving, and violent protests against the Vietnam War eventually crossed over the San Francisco Bay as well.[5] Coupled with the release of a large number of previously incarcerated mentally ill patients into the streets on the antipsychotic drug chlorpromazine, San Francisco was converted from the "City of Love" to a "City of Crime and Violence."[6] In response, Dr Blaisdell redesigned the surgical service at SFGH such that there was a dedicated trauma surgical team in house 24/7. Because SFGH was owned by the city and county of San Francisco, as was the ambulance service, it was easy to direct all injured patients into the newly organized trauma center.[7] Therefore, SFGH became the second major trauma center in the US (with Cook County hospital in Chicago being the first) and it became the first city in the nation with an organized trauma system.[8] As a result, the number of patients with penetrating injuries treated at SFGH rose from the steady rate of 100 annually up until 1964 to almost 400 in 1969.[7]

PUNCTUATED EQUILIBRIUM THEORY AND THE MILITARY HEALTH SYSTEM STRATEGIC PARTNERSHIP AMERICAN COLLEGE OF SURGEONS

Surgeons in a current war never begin where the surgeons in the previous war left off: they always go through another learning period. All military medicine, insofar as civilians are concerned, is a discontinuous specialty. Consequently, in every new war the same stupid mistakes are made again and soldiers lose their lives or limbs because the doctor was ignorant of past experience. I cannot overemphasize the need to study military medicine and surgery.

Col Edward D Churchill, MD, 1951[9]

A perfect storm can exist only with the right levels of humidity, ionic charge, and temperature. That said, the term *perfect storm* does have a rather negative connotation. On a more positive note, a similar paradigm flows from the discipline of public policy, the Punctuated

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Abbreviations and Acronyms

AAST	= American Association for the Surgery of Trauma
ACS-COT	= American College of Surgeons-Committee on Trauma
JTS	= Joint Trauma System
KSA	= knowledge, skills, and abilities
MCP	= military-civilian partnership
MHSSPACS	= Military Health System Strategic Partnership with the American College of Surgeons
MTF	= military treatment facility
NASEM	= National Academies of Science, Engineering, and Medicine
NDAA	= National Defense Appropriations Act
NTI	= National Trauma Institute

Equilibrium Theory, which states that policy change can occur rapidly when there is a convergence of interest groups, policy makers, and an opportunity window.[10] In 2014, David Hoyt, MD, FACS, who has had a lifetime interest in military surgery, was at the helm of the American College of Surgeons (ACS) as the executive director. COL (ret) Norman Rich, MD, FACS, USA and Captain Eric Elster, MD, FACS, USN, both decorated military surgeons, were directing the Department of Surgery at the Uniformed Services University for the Health Sciences, and Brig Gen Jonathan Woodson, MD, FACS, USAR, was serving as the undersecretary of defense for health affairs. These 4 individuals represented the interest group that had strong connections with the policy makers, and the window of opportunity was the beginning of the withdrawal of US troops from Iraq and Afghanistan, with the accompanying fear that Churchill's prophecy would repeat itself. By 2014, the US had been at war for more than a decade (our longest war in history), during which a comprehensive trauma system (the Joint Theater Trauma System, JTTS) had been built up to include combat casualty treatment centers in Iraq and Afghanistan, Landstuhl Regional Medical Center (Germany), and the military receiving hospitals in the US (Walter Reed Army Medical Center and the National Naval Hospital in Bethesda, and Brooke Army Medical Center in San Antonio). This elaborate trauma system was modeled after the civilian trauma system in the US, which, in turn, was designed based on military experiences during the Korean and Vietnam wars.[11] This contemporary JTTS resulted in a steady decrease in combat case fatality rates despite increasingly severe injuries sustained by wounded troops.[12-14] The most recent analysis of data documents that between 2001 and 2017, the combat case fatality rates (defined as the number of troops killed in action plus those who died of wounds divided by the sum of those killed in action plus those wounded in action) decreased in Afghanistan from 20% to 8.6%; in Iraq it went from 20.4% to 10%[15] (Fig. 2). Survival for critically injured casualties with Injury Severity Scores of 25 to 75 increased from 2.2% to 39.9% in Afghanistan and from 8.9% to 32.9% in Iraq. These remarkable results are attributed to a mature and continuously learning trauma

Figure 1. The 4 previous Scudder Orators from the San Francisco General and Hospital Trauma Center.

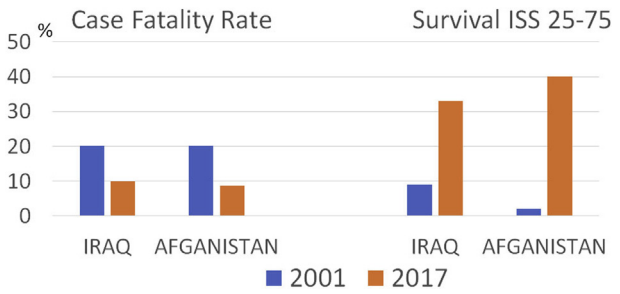

Figure 2. Survival rates of combat casualties in Iraq and Afghanistan comparing 2001 with 2017. ISS, Injury Severity Score. (Reprinted with from Howard and colleagues[15] with permission from the American Medical Association).

system and, in particular, to 3 interventions: the use of tourniquets, novel blood transfusion therapies, and shorter prehospital transport times.

But as stated previously, after every major conflict, the lessons learned in war are frequently forgotten during peacetime. This so-called "Walker Dip" was coined by Surgeon Commodore Alasdair Walker, the United Kingdom's Military Health Services' medical director, who attributed the past loss of lessons learned during interwar periods to loss of leader emphasis, the impact of fiscal constraints, the impact of garrison mentality, and loss of institutional experience[16] (Fig. 3). One potential solution to these issues is for the military to partner with a civilian organization with institutional memory. With this in mind, Drs Hoyt, Rich, Woodson, and Elster created the Military Health System Strategic Partnership with the American College of Surgeons (MHSSPACS), with an agreement signed at this very meeting 5 years ago.[17] The goals of this partnership are to share information in the following 4 areas: trauma systems, trauma education and training, trauma/surgical quality, and trauma research.

This Punctuated Equilibrium paradigm was completed with the passage of the 2017 National Defense Appropriations Act (NDAA).[18] This legislation (which was enhanced by the NDAA 2018) provides for 3 innovative directives for the military.[19] The first is development and sustainment of a Joint Trauma System (JTS) that unites the 3 branches of the Medical Corps (Army, Navy, and Air Force). The JTS serves as the reference body for all trauma care within US Military Treatment Facilities (MTF) worldwide, develops standards of clinical trauma care, and facilitates the translation of research into practice. Second, the NDAA tasked every major MTF with becoming a trauma center and participating in their local civilian trauma system or partnering with civilian trauma centers for training in and sustainment of trauma skills. Additionally, the NDAA provides for establishment of a Joint Trauma Education and Training Directorate to ensure that military trauma providers maintain deployment readiness.

THE CLINICAL READINESS PROGRAM

Maintaining readiness and clinical skills is the primary mission of the Military Health System (MHS). Despite this mission, however, the majority of surgeons in the military spend their garrison professional career providing elective and emergency general surgery care for military service members, their families, and retirees. In fact, the MHS is one of the largest healthcare systems in the US, delivering health services to 9.4 million patients in 700 military facilities worldwide.[20] Outside of deployment, the majority of military surgeons do not routinely care for trauma patients. Currently, even when deployed, the operational tempo is so slow that trauma surgical volume

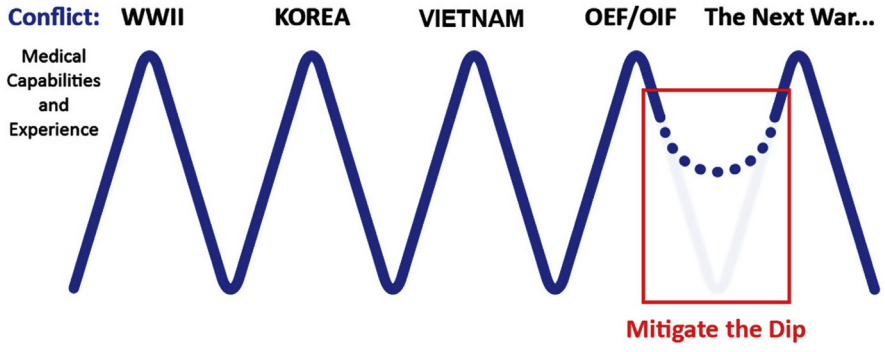

Figure 3. The Walker Dip. Taken from Surgeon Commodore Alasdair Walker, the United Kingdom's Military Health Services Medical Director's remarks to the Military Health System Research Symposium in 2013, (unpublished).

has diminished dramatically.[21] How, then, can we expect military surgeons to be prepared at all times for the deployment mission? The solution is a comprehensive clinical readiness program that includes the following 4 elements:

1. The military trauma system
2. Military-civilian partnerships for training and sustainment
3. Periodic assessment of readiness knowledge points and surgical skills
4. A continuous learning trauma system informed by research.

THE MILITARY TRAUMA SYSTEM

> *The end of the wars in Afghanistan and Iraq represents a unique moment in history in that there now exists a military trauma system built on a learning system framework and an organized civilian trauma system that is well positioned to assimilate and distribute the recent wartime trauma lessons learned and to serve as a repository and incubator for innovation in trauma care during the interwar period. Together these two developments present an opportunity to integrate military and civilian trauma systems.*
> From: The National Academies of Sciences, Engineering and Medicine (NASEM) report: A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths after Injury. 2016[22]

The extremely comprehensive report by the NASEM recognized the current deficiencies in both the civilian and military trauma care systems in the US and strongly advocated for a fully integrated system. The authors emphasized the fact that 20% to 30% of potential trauma patients in our country (an estimated 45 million people) have no access to a major trauma center within 1 hour of their injury (Fig. 4).[23] They further advocated for development of integrated, permanent joint civilian and military trauma system training platforms to create and sustain an expert trauma workforce. The report warns that failure to capture the lessons learned from the recent 15 years of conflict would have deadly consequences, with detrimental effects on the quality of trauma care in both the military and the civilian sectors. As stated by Rasmussen,[24] enactment of the Academies' National Trauma Action Plan has the potential to improve the nation's health and well-being and assure that "the first casualties of the next war will experience better outcomes than the casualties of the last war and all Americans will benefit from the hard-won lessons learned on the battlefield."

As mentioned earlier in this manuscript, few MTF care for trauma patients in the US. Currently there is only one level 1 trauma center in the military, at San Antonio Army Medical Center in San Antonio, TX. However, after the NDAA directive, a few other MTFs are now participating or planning to participate in their local civilian trauma system (Table 1). In other areas of the country, combat casualty teams will receive their trauma training in civilian centers.

MILITARY CIVILIAN PARTNERSHIPS FOR TRAUMA TRAINING, SUSTAINMENT, AND READINESS

The concept of military surgeons and other members of the combat casualty care teams receiving training in civilian trauma centers is not new. Five formal military training platforms were stood up in the early 2000s, including the University of Southern California/Los Angeles County Trauma Center (Navy), St Louis University, the University of Cincinnati, and the University of Maryland/Shock Trauma Center (all Air Force), and the University of Florida/Ryder Trauma Center (Army). Other military-civilian partnerships (MCP) were formed with universities in proximity to military bases including the University of Texas, San Antonio; Wright Patterson University, Dayton; the University of Pennsylvania, Philadelphia; the University of California, Davis; and the University Medical Center of Southern Nevada, Las Vegas.[25] Additionally, the US Army has recently contracted for training purposes with the University of Oregon in Portland and Cooper University in New Jersey. As a background for developing additional MCP and in preparation for his 2014 Scudder Oration, Captain (ret) C William Schwab, MD, FACS, USN interviewed several military surgeons with recent deployment experience to gather data on common procedures performed in the theater of war as well as areas in which these surgeons felt that additional training might have been useful.[26] Within the realm of traditional general surgery, these military surgeons listed chest, vascular, liver, and pancreatic injuries as areas in which additional pre-deployment exposure was desirable. Dr Schwab also created an extensive list of important elements to be considered in selecting civilian trauma centers for military training, including patient volume, types of injuries, training facilities, and opportunities for military surgeons to practice semi-independently at the civilian center. Similarly, Dr Demetriades focused his 2018 Excelsior Surgical Society/Edward D Churchill Lecture on civilian and military trauma training and outlined some key lessons learned from the LA County-USC Navy Trauma training

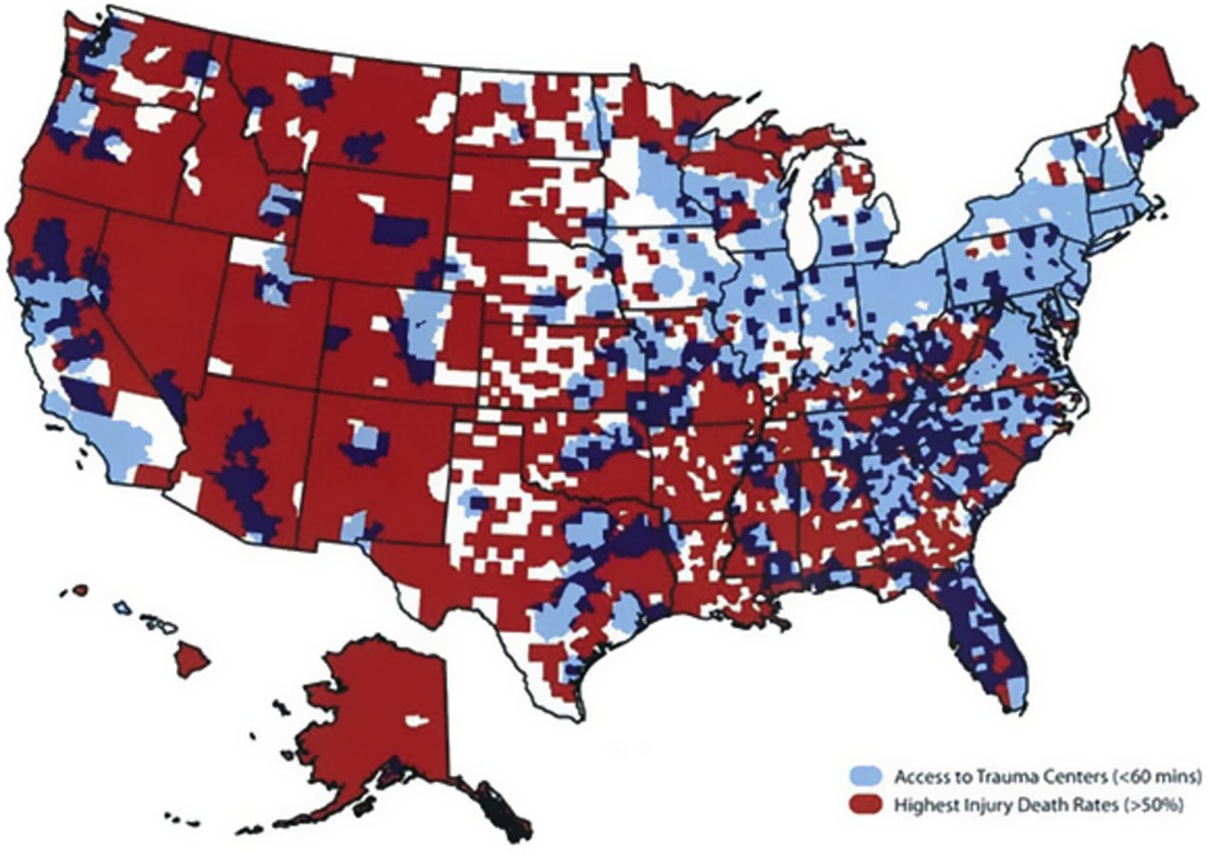

Figure 4. Map of the US demonstrating areas of the country (in red) where there is no access to a major trauma center within 1 hour of injury. (Map provided courtesy of Dr Charles Branas).

program.[27] In particular, he emphasized that it is essential to completely integrate key military personnel in the civilian trauma program as clinicians, teachers, and researchers as well.

Martin and others[28] recently highlighted the important role that civilian professional societies have in fostering MCP, especially in offering educational opportunities for military surgeons. These authors reported that an often-discussed byproduct of an all-volunteer military force is the increasing sense of isolation and alienation of service members from their civilian counterparts and vice versa. Less than 10% of civilians have had any previous military experience, and less than 0.5% of those living in the US are currently serving. However, organizations including the ACS, the American Association for the Surgery of Trauma, the Eastern Association for the Surgery of Trauma, the Society of Vascular Surgery, the American Burn Association, the Society of Critical Care Medicine,

Table 1. Military Trauma Centers in the US

Institution	Verified American College of Surgeons level
San Antonio Army Military Medical Center	1
Dwight Eisenhower Army Medical Center	Pursuing level 3
Fort Belvoir	Pursuing level 3
Landstuhl Regional Medical Center	3
Mike O'Callaghan Military Medical Center	Pursuing level 3
Naval Medical Center Lejeune	3
Tripler Army Medical Center	2
Walter Reed National Military Medical Center	2
Womack Army Medical Center	3

Table 2. The Military Health System Strategic Partnership with the American College of Surgeons "Blue Book" Criteria for Military Civilian Training Centers

Standard	Representative example
Institutional commitment	Documented support from the highest level of the hospital administration, the dean of the medical school, etc.
Governance/administration	Job description with protected time for the civilian surgeon champion of the partnership.
Human resources	Committed teaching faculty in trauma, surgical specialty, nursing, etc.
Physical resources	Annual trauma volume, case mix, teaching facility, etc.
Education component	Graded military curriculum with scheduled advancement; continuing medical education opportunity, etc.
Program evaluation	Financial report; assessment of impact on graduate medical education.

and the American Academy of Orthopaedic Surgeons (including the Orthopaedic Trauma Association) have consistently offered support for training, development, and capabilities of military surgeons over the past decade of combat operations.

An excellent example of this type of collaboration from civilian professional societies to the military mission is the Senior Visiting Surgeon program. Funded jointly by the ACS, the American Association for the Surgery of Trauma, and the Department of Defense, it allowed civilian trauma surgeons to participate in the care of injured troops evacuated from Iraq and Afghanistan to Landstuhl Regional Trauma Center in Germany.[29] Between the years 2005 and 2012, more than 200 trauma and vascular surgeons volunteered 2 to 4 weeks of their time to work at Landstuhl, providing a 2-way exchange of combat casualty trauma care knowledge between the military and the civilian surgeons.[30,31] The Orthopaedic Trauma Association also supported civilian orthopaedic surgeons volunteering in Germany. Although the program was sun-downed in 2012, when civilian assistance was no longer needed, the renewed Excelsior Surgical Society at the ACS is developing plans for professional exchange programs between civilian and military treatment facilities.

In June 2019, Congress passed the Pandemic and All-Hazards Preparedness and Advancing Innovation Act.[32] Contained within this legislation is Section 1291: Military and Civilian Partnership for Trauma Readiness Grant Program. The monies appropriated by this bill would provide $1 million/year for a period of 3 years to civilian trauma centers that qualify to train a full combat casualty care team, $100,000/year for training of an individual physician, and $50,000/year for an allied health provider. The monies are designed to cover such costs as delivery of educational courses, administrative assistance, liability fees, etc. While the exact mechanism of how and when these grants will be available, and how many civilian centers are needed, are uncertain at the time of this writing, the MHSSPACS has already been conducting meetings to develop a set of guidelines that could be used for selection and subsequent evaluation of interested programs.[33] The MHSSPACS "Blue Book "contains a set of standards that would need to be verified during an on-site visit of centers that apply for this funding (Table 2).

PERIODIC ASSESSMENT OF READINESS KNOWLEDGE POINTS AND SURGICAL SKILLS

The military has developed metrics to rigorously measure the expeditionary knowledge, skills, and abilities of our medical personnel to ensure continued excellence on the battlefield and in future operations.

Secretary of Defense Dr Mark Esper at his confirmation hearings in the Senate, July 2019.

Whether the members of a combat casualty care team train in an MTF or in a civilian trauma center, periodic assessment of knowledge points and hands-on assessment of skills is essential in order to demonstrate a state of constant readiness. The members of the combat casualty care team are listed in Table 3. It is important to understand the difference between an expeditionary general surgeon and a military trauma surgeon for the purposes of this discussion. The expeditionary general surgeon is meant to describe a surgeon who is deployed to a military role 2 facility or to a small far-forward team such as a Golden Hour Offset Surgical Team (GHOST-T) or an Expeditionary Resuscitative Surgical Team (ERST), where he or she is commonly the only general surgeon with limited holding facilities. The role of the expeditionary surgeon is to provide damage control surgical interventions before transfer to a higher level of care. A military trauma surgeon is typically deployed to a role 3 or higher MTF and must be capable of providing definitive surgical care as well as directing the trauma system within that deployed environment. Therefore, the skill sets and knowledge points for these 2 distinct types of surgeons will necessarily differ significantly. The education

Table 3. Members of the Combat Casualty Care Team

Combat casualty care team
Essential members:
General/expeditionary surgeon
Orthopaedic surgeon
Emergency medicine physician
Critical care medicine physician
Anesthesiologist
Emergency/trauma nurse
Critical care nurse
Trauma surgeon
Combat casualty care team plus*
Plastic surgeon
Urologic surgeon
Neurosurgeon
Vascular surgeon
Cardiothoracic surgeon
Ophthalmologist
Ear nose throat surgeon
Oral maxillofacial surgeon

*Not found at every military treatment facility.

committee of the MHSSPACS elected to focus first on the expeditionary surgeon. A tri-service team of 14 military surgeons with deployment experience were brought together at the headquarters of the ACS to begin the process of identifying key knowledge points and surgical skills required for the expeditionary surgeon.[33] The primary references used were the JTS Clinical Practice Guidelines (https://JTS/AMEDD.army.mil/index.cfm/PI_CPGs/cpgs.). These 64 guidelines are updated on a periodic basis, usually every 3 years, or when new knowledge dictates a change. We also used the actual roster of cases performed in Iraq and Afghanistan at role 2 facilities gathered from the Department of Defense Trauma Registry (DODTR) as well as other information gathered from military surgeons with deployment experience.[34] The knowledge, skills, and abilities (KSA) were grouped into the following 8 expeditionary domains: wounds and amputations, head and neck injuries, torso trauma, transfusion and resuscitation, airway and breathing, critical care and prevention, military specific, and universal domains (such as professionalism, practice based learning, etc). These KSA were vetted by a separate group of military surgeons for their relevance in the deployed situation. This process was followed by a series of meetings during which an item bank of more than 500 questions focusing on the knowledge points was developed with the aid of a psychometrician. Subsequently, 2 versions of a 200-item beta test were developed and delivered in an electronic format to 113 military surgeons. The test was able to discriminate, with a high degree of sensitivity, differences between trauma surgeons and/or those with extensive deployment experience and surgeons from other disciplines and/or those with little or no deployment history, therefore establishing content validity. It also identified knowledge gaps that can be emphasized in the aligned curriculum (see below).

Figure 5. The first Advanced Surgical Skills for Exposure in Trauma (ASSET)-plus course conducted at the University of Maryland in April 2019 and supported by the Military Health System Strategic Partnership with the American College of Surgeons.

In order to evaluate the skill set needed for deployment, we used the ACS-Committee on Trauma's (ACS-COT) ASSET Course (Advanced Surgical Skills for Exposure in Trauma) and added additional elements to include neurosurgical, orthopaedic, ophthalmologic, and obstetrical surgical skills (so-called ASSET-plus course). For the trauma exposures, perfused cadavers are used, with a 1:1 ratio of students to faculty. Simulators are added for demonstration and for practicing a craniotomy, a lateral canthotomy, placement of an external fixator, and for an emergency Cesarean section. This 2-day course has now been given 4 times under the direction of COL (ret) Mark Bowyer, MD, FACS USAF, and has been well received by both students and faculty (Fig. 5).

Both the skill set and the knowledge points are tied to an aligned multimodal curriculum being developed through the MHSSPACS by Joseph Galante, MD, FACS COM (ret) USNR and his committee. This electronic curriculum is housed on the ACS website and contains a set of questions, pictures, videos, and touchpoints divided by topics. When knowledge gaps or deterioration of skills are identified on periodic testing (a process similar to maintenance of competency), the curriculum can be accessed in preparation for retesting before deployment, or at any time a refresher seems warranted (Fig. 6). Although this project is still in development, we are aware that it has already been accessed by a deployed surgeon as he was preparing for a certain surgical procedure. This

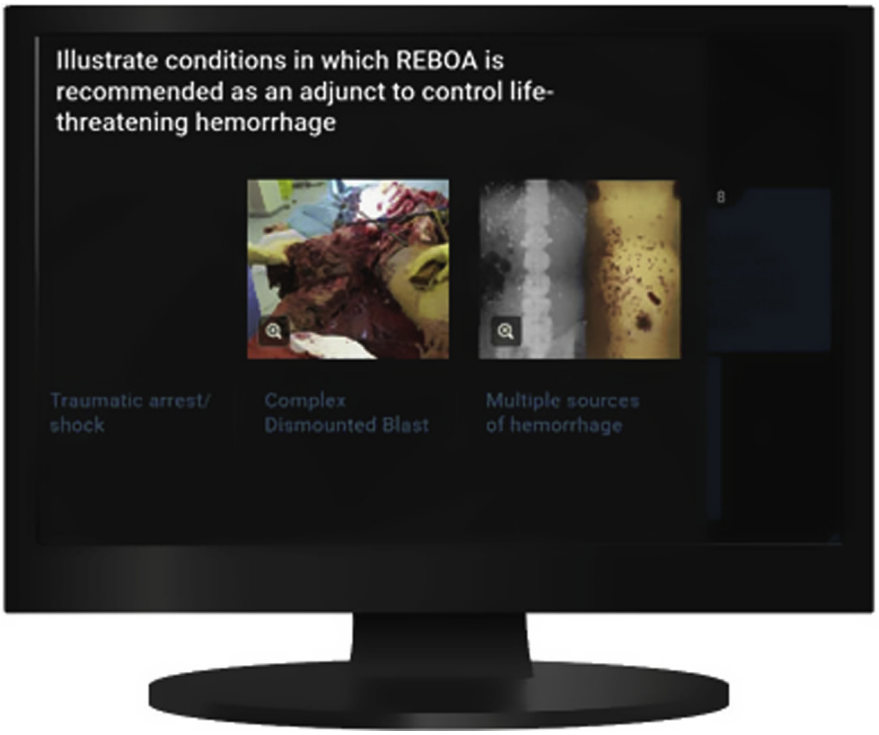

Figure 6. Screen shot demonstrating the electronic multimedia curriculum developed by the Military Health System Strategic Partnership with the American College of Surgeons.

entire KSA project is being replicated by other groups representing the combat casualty care team, as listed in Table 3. The MHSSPACS, together with representative members of the Committee on Trauma and the American Association for the Surgery of Trauma (AAST), is currently focusing on the knowledge points for a deploying trauma surgeon using an expanded blueprint with 11 sections (Table 4). This entire KSA project, which includes periodic testing of both knowledge points and a defined set of surgical skills, is unique in surgery and serves as a model to consider as the entire maintenance of competency process in surgery is reorganized (Fig. 7).

MILITARY-RELEVANT RESEARCH AND THE NATIONAL TRAUMA INSTITUTE

The fourth element of the clinical readiness project involves the conduct of research in the civilian setting that informs the continuously learning military and civilian trauma systems. Conducting research in the deployed environment is extremely challenging, and it most frequently includes collecting observational data, with limited transference to the civilian setting.[35] On the other hand, innovative advances used during war time can be prospectively studied in those US trauma centers with research infrastructure. For the past decade, the National Trauma Institute (NTI) has led the charge in conducting military-relevant research outside of the Department of Defense. Founded in 2003 by Ronald Stewart, MD, FACS, the current medical director of the ACS-COT, the Trauma Institute of San Antonio (TRISAT) supported research grants for 3 level 1 trauma centers including the University of Texas Health Science Centers in San Antonio, the Willford Hall Medical Center, and Brooke Army Medical Center (see also: https://www.NatonalTraumaInstitute.org). In 2006, the TRISAT Board voted to take the organization national, establishing a national board of directors representing all of the major trauma organizations, and chartered as the NTI. In 2008, NTI managed its first federal research grant for $1.6 million secured via a direct congressional appropriation with the support of Texas Senator Kay Bailey Hutchinson. In 2009, a second federal research grant for $2.1 million was secured, and the first round of Request for Proposals (RFP) was issued for the resulting $3.9 million. Through this process, 16 trauma research studies were funded, including some single center studies, multicenter studies, observational studies, and randomized controlled studies. These grants were primarily awarded to young trauma surgeon investigators. Throughout the studies, NTI managed the contracts and subcontracts, the Department of Defense's Human

Table 4. The Trauma Surgery Knowledge, Skills, and Ability Blueprint

Domain	Subdomain (example)
Abdominal and pelvic	Gastrointestinal/abdomen/pelvic/genitourinary/gynecologic
Transfusion and resuscitation	Damage control resuscitation/emergency room thoracotomy/REBOA/whole blood transfusion
Burn	Burn care/inhalation injury
Head, neck, spine	Traumatic brain injury/cervical spine evaluation/spinal cord injury
Wound, amputation, fracture	Compartment syndrome/war wounds
Critical care/prevention	Infectious disease/cardiovascular/pediatric/renal/metabolic/venous thromboembolism
Vascular	Thoracic/neck/abdominal/extremity
Critical care airway, ventilation, pain	Respiratory failure/pain/delirium/trauma anesthesia
Thoracic	Pulmonary/cardiac/esophageal injury
Trauma system	Continuum of care/en route care/tactical combat casualty care/performance improvement
Military specific	Unexploded ordinance management/working dog/detainee care

REBOA, resuscitative endovascular balloon occlusion of the aorta.

Research Protection (HRPO) applications, regularly scheduled research conferences and teleconferences, and quarterly reports. All but 1 of these studies was successfully completed and published, a record comparing very favorably to other federally funded studies.[36] By 2011, however, Congress had dissolved the earmark process and NTI was forced to seek new avenues to secure research funding. Through a series of lobbying efforts and meetings with congressional representatives, NTI was successful in securing $5 million to develop The National Trauma Research Repository (NTTR).[37] Under the direction of the principal investigator, COL (ret) Donald Jenkins MD, FACS, USAF, a set of Human Subjects Protection guidelines were developed for this repository, as was a data dictionary for common elements. The NTTR is a key piece of national research infrastructure and is set to become a vast repository offering thousands of data points from hundreds of studies. It also meets federal requirements for data sharing. The NTI is currently supporting 5 major federal grants including the NTTR, all funded through the Department of Defense via the US Army Research and Material Command structure (USAMRMC) (Table 5). Each of these grants has its foundation in current military experience and is aligned with the concept of wartime lessons shaping the National Trauma Action Plan.[38]

In 2011, COL (ret) Brian Eastridge MD, FACS, USA conducted a study of prehospital deaths that occurred in Iraq and Afghanistan over a 10-year period using the Armed Forces Medical Examiner Service Mortality

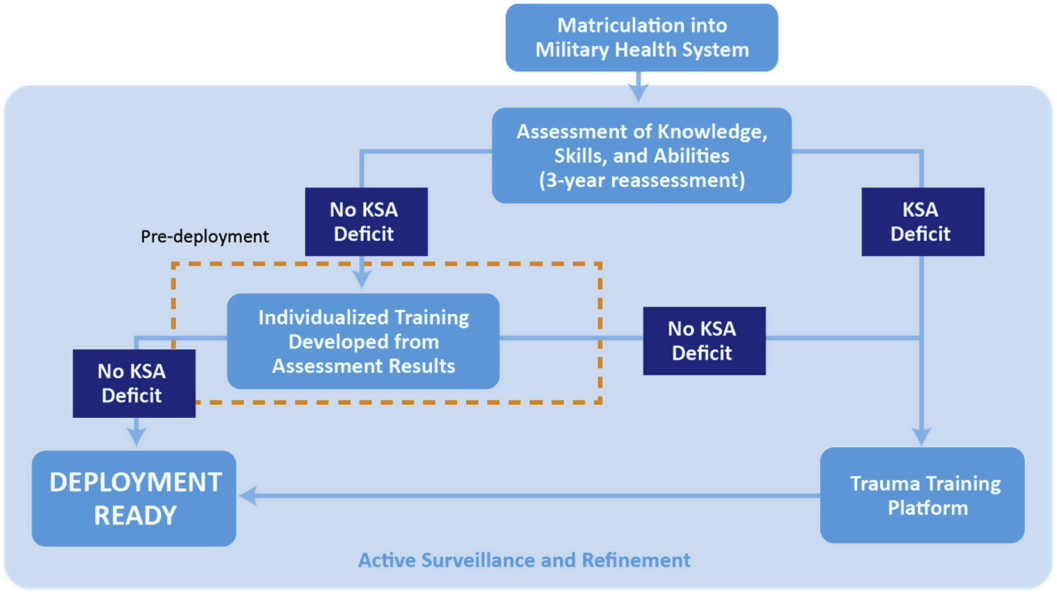

Figure 7. Cyclic assessment of knowledge, skills, and ability (KSA) for military surgeons developed by the Military Health System Strategic Partnership with the American College of Surgeons.

Table 5. Current Active National Trauma Institute/Consortium for National Trauma Research Grants

Principal investigator	Title	Military relevance
COL (ret) Donald Jenkins, MD, FACS, USAF	The National Trauma Research Repository (NTTR)	Meets DoD requirement for data sharing.[37]
COL (ret) l Brian Eastridge, MD, FACS, USA	Multi-institutional, multi-disciplinary, injury mortality investigation in the civilian pre-hospital environment (MIMIC)	Builds on previous study of death on the battlefield.[39]
HG Cryer, MD, FACS	Transfusion of stored fresh whole blood in a civilian trauma center	Use of fresh whole blood transfusion in combat-related injury.[43]
M Margaret Knudson, MD, FACS	CLOTT: Consortium of Leaders in the Study of Traumatic Thromboembolism	Numerous military papers on prevalence of venous thromboembolism in combat-related injuries; direct observations at Landstuhl Regional Medical Center.
Eileen Bulger, MD, FACS	National Trauma Research Action Plan (NTRAP)	Aligns with DoD priorities.[38]

DoD, Department of Defense.

Surveillance Division.[39] Of the 4,596 deaths examined, 24% were believed to be potentially survivable, with the greatest number of these deaths related to hemorrhage. The investigators concluded that improvements in prehospital hemorrhage control, airway management, and a shorter time to definitive care would be needed to reduce the rate of preventable combat casualty deaths. Armed with this experience, Dr Eastridge successfully competed for Department of Defense grant support to conduct a similar study to be performed in the US, termed the Multi-Institutional Injury Mortality Investigation in the Civilian Pre-hospital Environment (MIMIC).[40] A selected group of subject matter experts and medical examiners from several states are examining autopsy data in order to define the cause of death in trauma patients who never make it to the trauma center. This study is also using Geographic Information System technology to examine proximity of the death to a level 1 or 2 trauma center.

The protocols for a damage control resuscitation using a balanced ratio of red blood cells (RBC), plasma, and platelets are largely based on the recent success of this method in saving lives on the battlefield.[41] However, in the austere environment, blood components may be in short supply and whole blood, often supplied by the "walking blood bank" of prescreened fellow soldiers, airmen, sailors or marines, is used.[42] Military investigators have described an improved survival for patients with combat-related injuries who received warm fresh whole blood as part of a damage control resuscitation when compared with those who received packed RBC.[43,44] In the civilian setting, a direct transfusion from a donor to a recipient is impractical, but the use of whole blood rather than its component parts is being reconsidered in the setting of trauma. Therefore, Dr Gill Cryer's National Trauma Institute-supported research grant is timely, as he investigates the use of stored fresh whole blood in a civilian trauma center with a particular focus on coagulation parameters in leuko-reduced compared with unfiltered whole blood under standard refrigeration conditions.

The severity of the injuries sustained by wounded troops, especially with the high rate of amputations associated with dismount injuries, and coupled with prolonged immobilization during air transport, sets the stage for post-traumatic venous thromboembolic (VTE) events. In a study performed at the evacuation hospital in Landstuhl, Germany, combat casualties admitted to the ICU had an overall deep venous thrombosis rate of 6.4%, and 1.4% had suffered a pulmonary embolism. However, when universal screening was used in order to detect these potential complications before transfer to the continental US, the incidence of deep venous thrombosis detected by duplex ultrasound was 14% and the pulmonary embolism rate detected on surveillance chest CT scans rose to 4.4%. (COL [ret] Raymond Fang MD, FACS, USAF personal communication). We and others had hypothesized that some of these "pulmonary emboli" represented primary thrombi rather than emboli and are often associated with chest trauma.[45] If indeed these are thrombi already in the pulmonary system and are asymptomatic, the question arises as to the need to treat them with potentially dangerous pharmacologic agents that may aggravate bleeding in the setting of trauma. This question is currently being address by the CLOTT study group (Consortium of Leaders in the study of Traumatic Thromboembolism) in 17 level 1 trauma centers from across the country via an NTI-supported Department of Defense grant. An additional related question being

investigated on the CLOTT grant is the association between the presence of fibrinolytic shutdown after injury and the development of venous thromboembolism.[46-48]

In 2018, the NTI together with The Consortium for National Trauma Research were successful in securing funding for the development and implementation of a National Trauma Research Action Plan (NTRAP). The Consortium for National Trauma Research is supported by the AAST, Eastern Association for the Surgery of Trauma, the Western Trauma Association, and the ACS-COT in addition to NTI, and the principal investigator for this grant is Eileen Bulger, MD, FACS, current chair of the ACS-COT committee on trauma. The research agenda for the National Trauma Research Action Plan aligns with both the Department of Defense research priorities and the goals outlined in the NASEM report. In addition to establishing a comprehensive trauma research agenda, the goals of this grant include coordination of multicenter clinical trials using the strength of the ACS-COT's TQIP and advocating as 1 voice for funding for trauma research at a level commensurate with the burden of the disease.[49]

To date, NTI has generated and/or managed more than $80 million directed toward trauma research for 22 studies in 35 cities and 25 states involving more than 70 investigators. To the staff at NTI, Sharon, Michelle, Monica, Pam, Lizette, Amy, Nick, and Ana, the trauma community is indebted to you for all that you have done to help improve the care of injured patients here in our country and on battlefields worldwide.

MILITARY-CIVILIAN PARTNERSHIPS: A BENEFIT TO US ALL

The majority of us attending this lecture are civilian surgeons with no previous military experience. As such, you might be wondering what benefit the clinical readiness program based on military-civilian partnerships (MCP) that I have just described has for you. First, let's consider the trauma system. According to the NASEM report, a comprehensive trauma system that includes both military and civilian centers has the capacity to save an estimated 20,000 to 30,000 lives in our country each year.[22] This is particularly relevant to many rural areas of the US, where advanced trauma care is lacking (Fig. 4). Military collaboration is also essential in response to natural and increasingly prevalent man-made disasters. Even as I was composing this manuscript, there were 3 mass casualty shooting events within a week in which, in total, 28 people were killed and 49 more were wounded (Gilroy Garlic Festival, Gilroy CA; Walmart Massacre, El Paso TX; Dayton Nightclub, Ohio; August 2019). The US in general, and the civilian trauma centers in particular, would do well to fully incorporate the lessons learned from mass casualty events that occurred in Iraq and Afghanistan, including care at the point of injury, care during transport, and hospital-based care.[50-52] Three recent examples of the benefit of MCP in enhancing mass casualty response can be cited.[53] In December 2017, an Amtrak train derailed near Tacoma, WA, resulting in a crash that involved both the entire passenger train as well as multiple vehicles on the highway. This event occurred immediately outside of the gates of Joint Base Lewis-McChord, and multiple bystander-rescuers and first responders were active duty military personnel. This military base is also the home of Madigan Army Medical Center, which serves as a level 2 trauma center for the state of Washington. Accordingly, 20 patients were taken to Madigan for life-saving care provided by military surgeons with deployment experience. Earlier that same year, Air Force surgeons were able to respond to the Las Vegas massacre to provide trauma care because of a partnership between the Nellis Air Force Base and the University Medical Center. Shortly thereafter, the San Antonio Military Medical Center (SAMMC), the military's only level 1 trauma center (Table 1), received approximately half of the victims of the deadly Sutherland Springs church shooting in Texas. More recently, I was able to directly observe a state-wide disaster drill in Hawaii, where Tripler Army Medical Center played a key role. From this discussion, it should be clear that a fully integrated military-civilian trauma system created through military-civilian partnerships enhances our national security by assuring that our military combat casualty teams are always deployment ready, while providing leadership from our military colleagues in responding to disasters and mass casualty events both here and abroad.

Let's consider the educational component of the Clinical Readiness Program developed through MCP. Given that there are no official "boards" for trauma surgery at the current time, shouldn't every trauma surgeon be able to pass the written exam being developed for the military trauma surgeons if the military-specific content were removed? Perhaps it should be required of our second-year trauma fellows as part of the AAST-accredited Acute Care Surgery fellowship. Of additional importance is a periodic demonstration of surgical skills as they relate to trauma care, which is not currently required in the civilian setting. If we demand it of our military colleagues, shouldn't we, too, be willing to ask it of ourselves? Or consider perhaps a situation in which it has been some time since you have performed a 4-compartment fasciotomy. We have a video hosted on the ACS website as part of the MHSSPACS M-curriculum that you can view on

Table 6. Benefits of the Clinical Readiness Program Based on Military-Civilian Partnerships with the Civilian Sector

Benefit
Expansion of the US trauma system to include 45 million additional people
Potential to save 30,000 additional lives/year after injury
Enhanced national security by assuring an "always ready" deployable combat casualty care team
Two-way exchange of knowledge from the battlefield to civilian trauma care and vice versa
Complementing the trauma workforce in civilian trauma center with military providers
Augmented response to mass casualty and disaster events at home and abroad
Improvement in surgical quality for more than 9 million people, including our warfighters
Development of a new model to assure competency and currency for both military and civilian surgeons
Establishment of a collaborative trauma research agenda
Offer opportunity for civilian surgeons to "serve"

your smartphone on your way to the operating room. Are you preparing for a global surgery rotation and a bit rusty on the technique of performing a Caesarian-section? We have an app for that (or at least a simulator!).

One additional initiative of the MHSSPACS is related to surgical quality. Over a relatively short period of time, the ACS NSQIP was incorporated into every major MTF. A recent review of NSQIP data demonstrates trends toward improved quality of care throughout the Military Health System, one of the largest healthcare systems in the country.[54] We anticipate the ability to transfer data from the JTS/Department of Defense Trauma Registry (DODTR) for noncombat related patients treated at MTF into the TQIP in the very near future. As a nation, we all benefit from keeping 9.4 million military personnel and their beneficiaries healthy, while keeping our warfighters healthy is essential to our national security. Additionally, military-civilian collaboration in research ensures the best possible care for trauma patients, whether they are injured on the battlefield or on the streets here at home. And finally, partnering with our military colleagues is an opportunity for all of us to "serve" (Table 6).

ANOTHER PERFECT STORM

In 1942, 3 events occurred that forever changed America. At that period in time, America was still shell-shocked from the attack on Pearl Harbor on December 7, 1941, where hundreds of Japanese fighter planes descended on the base, destroying 20 American naval vessels including 8 battleships and more than 300 airplanes, while killing at least 2,400 Americans and wounding another 1,000. Meanwhile, Henry J Kaiser, who started as a paver and manufactured cement, had opened his shipyard in Richmond, CA and astonished the world by building a military ship in 4 days, 15 hours, and 29 minutes, setting a record that will likely never be beaten.[55] In July of that same year, a group of women demonstrated outside the headquarters of the International Brotherhood of Boilermakers, Iron Shipbuilders, and Helpers of America in San Francisco, insisting that with the shortage of male workers due to deployment, they should be allowed to work in the shipyard. Thus began the career of "Rosie the Riveter" (Naomi Parker Fraley who served as the model for the iconic poster). Today, Rosie stands for all the home-front workers, but especially for the 6 million women who played a vital part in the wartime labor force. On a side note, Henry Kaiser was convinced that keeping his workers healthy improved both their productivity and their morale. His shipyard was supported by a field hospital named the Permanente Hospital. Healthcare insurance at that Kaiser hospital cost his shipyard workers 50 cents per week!

In a way, most of us here in the audience are "Rosies" in that we will never deploy. But I hope that I have convinced you that we can still support our military's mission with great benefit to all of us through Military Civilian Partnerships.

SENATOR TAMMY DUCKWORTH

On November 12, 2004, Captain Tammy Duckworth (Illinois National Guard) was flying a Black Hawk back to her base in Iraq when her helicopter was hit with a rocket-propelled grenade. The resulting crash took both of her legs, but thanks to rapid evacuation and treatment in the Combat Support Hospital in Baghdad she survived. Shortly after her injury, she ran for Congress in Illinois, eventually serving 2 terms in the US House of Representatives representing Illinois's Eighth Congressional District. In 2016 she was elected to the US Senate, where she currently serves. As you might expect, Senator Duckworth has a vested interest in military trauma care, military civilian partnerships, and trauma research, but I am going to let her address you in her own words. (Note: Address to the ACS Clinical Congress from Senator Duckworth can be viewed at https://www.facs.org/quality-programs/trauma/about-trauma/scudder).

CONCLUSIONS

In his 1991 Fitts lecture for the AAST, Dr Donald Trunkey said: "The bottom line is that military medicine is not being supported by the surgical community. This lack of support is of particular concern to me since support from academic centers is almost nonexistent."[56] Let us honor Dr Trunkey's considerable legacy by fully embracing military-civilian partnerships in order to:

1. Insure a constant state of readiness.
2. Advance trauma knowledge points and skills for both military and civilian surgeons.
3. Encourage collaborative trauma research.
4. Enhance responses to mass casualty and disaster events.
5. Expand trauma coverage to all who reside in the US.

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