

Battlefield trauma care then and now: A decade of Tactical Combat Casualty Care

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Maughon¹ reported in 1970 that 193 of a cohort of 2,600 casualties that were killed in action in Vietnam died of isolated extremity hemorrhage. The percentage of fatalities that resulted from exsanguination from extremity wounds was 7.9%; this was the leading cause of preventable death among US military casualties in the Vietnam War. Maughon commented at the time that little progress had been made in battlefield trauma care in the last 100 years.

A sobering postscript to Maughon's observations in 1970 is found in the preventable death analyses done by Holcomb et al.² and Kelly et al.³ in the current conflicts. Holcomb et al. found a 15% incidence of potentially preventable fatalities in his article that reviewed all Special Operations deaths in Iraq and Afghanistan from the initiation of hostilities until November 2004. He found that 25% (3 of 12) fatalities with potentially survivable injuries might have been saved by the simple application of a tourniquet. The larger causes of death analysis by Kelly et al. studied 982 fatalities from the first 5 years of the conflicts in Afghanistan and Iraq. He documented that 77 of 232 potentially preventable deaths from the Armed Forces Medical Examiner records resulted from failure to use a tourniquet; exsanguination from isolated extremity wounds thus caused 7.8% of the combat-related deaths reported in the article of Kelly et al.. The failure to make progress in addressing the leading cause of preventable deaths on the battlefield in the 30 years between the Vietnam and Afghanistan wars, despite the ready availability of the requisite technology, dramatically underscores Maughon's point about the lack of progress in battlefield trauma care.

The decade of conflict in Iraq and Afghanistan has, however, seen sweeping changes in the prehospital care of combat casualties. This section reviews the concepts of battlefield trauma care at the start of the war, how changes to this care have been implemented, the current state of battlefield trauma care, and the available metrics of success.

BATTLEFIELD TRAUMA CARE THEN: 2001

In the absence of a Department of Defense (DOD) level group with a charter to provide the services with updated best-practice battlefield trauma care guidelines, the prehospital

trauma care techniques being taught to US combat medical personnel at the start of the war were based on courses developed for management of trauma in noncombat settings.

Based on these courses, battlefield trauma care as practiced by our combat medics, corpsmen, and pararescuemen (PJs) at the start of the war included the elements listed in Table 1.

The choice of which battlefield trauma care courses to use in training medics was a decision reached by individual services or units. There was not effective interservice coordination on battlefield trauma care training provided before Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF). Some groups within the military sought to advance the level of battlefield trauma care by adopting practices intended for physician-led trauma teams in the emergency department for use by combat medical personnel. Advanced prehospital providers were being trained to use techniques such as diagnostic peritoneal lavage, venous cutdowns, and pericardiocentesis on the battlefield. These techniques are difficult to train and sustain and have not been shown to improve survival in combat casualties.

Published reports of potentially preventable deaths among US military fatalities in the early years of hostilities in Iraq and Afghanistan ranged from 15% to 28%.^{2,3} Both of these studies reflect the standards of trauma care as practiced in the first half of the war. Note also that not all potentially preventable deaths result from deficiencies in care provided. Some reflect tactical situations that made medical care impossible in the time window in which interventions may have been lifesaving; others may reflect prolonged times to definitive care in immature theaters of war.

Tactical Combat Casualty Care

In the mid-1990s, a Special Operations medical research project was undertaken with the goal of improving combat trauma outcomes through optimization of the care rendered in the tactical prehospital environment. This research effort developed a new concept called *Tactical Combat Casualty Care* (TCCC). The core principles of TCCC are to avoid preventable deaths and to combine good medicine with good tactics. This project reviewed the available evidence in prehospital trauma care with a focus on tactical applications and resulted in a article titled "Tactical Combat Casualty Care in Special Operations," which was published as a supplement to the journal *Military Medicine* in August 1996.⁴ This original TCCC article included a proposed set of prehospital trauma care guidelines that were customized for use on the battlefield and provided strong emphasis on the most common historical causes of preventable death in combat.

The TCCC guidelines were quickly adopted by the Navy Sea, Air, and Land (SEAL) community, the 75th Ranger

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The opinions and assertions expressed by the authors are theirs alone and do not necessarily reflect the views of the Department of the Army or the Department of Defense.

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TABLE 1. Battlefield Trauma Care Then (2001)

In the absence of a DOD-level group with a charter to provide the services with updated best-practice battlefield trauma care recommendations, the prehospital trauma care techniques being taught to US combat medics, corpsmen, and pararescuemen at the start of the conflicts in Afghanistan and Iraq were based on courses developed for management of trauma in noncombat settings and included the following elements:

- To render care with no structured consideration of the evolving tactical situation
- Not to use tourniquets to control extremity hemorrhage
- To manage external hemorrhage with prolonged direct pressure, thereby precluding the medic from attending to other injuries or rendering care to other casualties
- No use of hemostatic dressings
- Two large-bore intravenous lines started on all patients with significant trauma
- Treatment of hypovolemic shock with large-volume crystalloid fluid resuscitation
- No special considerations made for traumatic brain injury with respect to avoiding hypotension or hypoxia
- Management of the airway in facial trauma or unconscious casualties with endotracheal intubation
- No specific techniques or equipment to prevent hypothermia and secondary coagulopathy in combat casualties
- Management of pain in combat casualties with intramuscularly administered morphine—a battlefield analgesia technology that dates back to the Civil War
- No intraosseous access techniques
- No prehospital electronic monitoring techniques
- No effective nonparenteral analgesic medications
- No prehospital antibiotics
- No delineation of which casualties might benefit most from supplemental oxygen
- Spinal precautions applied broadly to casualties with significant trauma, without consideration of tactical concerns or mechanism of injury

Regiment, and later by a few other military units.^{5–9} At the onset of hostilities in the current conflicts, however, most US military units had not made the transition to TCCC-based concepts for managing trauma in the prehospital tactical environment. With increasing reports of success from units using the techniques advocated by TCCC, this new approach to battlefield trauma care began to spread throughout the US military as the conflicts progressed.

The Committee on TCCC

The triservice Committee on TCCC (CoTCCC) was begun in 2001 as a US Special Operations Command (USSOCOM) biomedical research effort to ensure that emerging technology and information is incorporated into the TCCC guidelines on an ongoing basis. The membership of the CoTCCC includes combat medics, corpsmen, and PJs as well as physicians and physician assistants. The CoTCCC was first established at the Naval Operational Medicine Institute with funding provided by the USSOCOM biomedical research program. It was supported by the Navy Bureau of Medicine and Surgery from fiscal year 2004 through 2009. In fiscal years 2007 to 2010, the Office of the Surgeon General of the Army and the US Army Institute of Surgical Research (USAISR) also provided strong support for the activities of the CoTCCC.^{10,11}

In 2007, because of the increasing visibility of TCCC in the conflicts in Iraq and Afghanistan, the CoTCCC was realigned at the direction of Assistant Secretary of Defense (ASD) for Health Affairs to function as a subgroup of the Trauma and Injury Subcommittee of the Defense Health Board (DHB). The DHB is the senior external medical advisory group to the Secretary of Defense.¹⁰

TCCC—Strategic Partners

TCCC soon developed strong partnerships with other organizations committed to improving prehospital trauma care.

The TCCC guidelines were included in the fourth edition of the *Prehospital Trauma Life Support Manual*. The trauma care recommendations found in the *Prehospital Trauma Life Support Manual* carry the endorsement of the American College of Surgeons' Committee on Trauma and the National Association of EMTs, making TCCC the first set of battlefield trauma care guidelines to have earned this dual endorsement. There is now a military edition of the *Prehospital Trauma Life Support Manual* that focuses on the principles of TCCC.¹² Further, the Prehospital Trauma Life Support Executive Council has undertaken a program to provide TCCC training to law enforcement agencies and the militaries of allied countries when these groups request it.

TCCC next developed a critical partnership with the USAISR in 2004 to 2005. The USAISR assumed a leadership position within the DOD in developing and evaluating technology focused on the TCCC provider. This resulted in the rapid fielding of lifesaving devices such as tourniquets and hemostatic agents.^{13–15} The USAISR also participated in the USSOCOM TCCC Transition Initiative to ensure that lifesaving new technologies and training were fast-tracked to deploying Special Operations units and that feedback about this training and equipment was obtained upon the units' return from combat operations.^{11,16,17} The most recent development in this very successful partnership has been the establishment of a dedicated TCCC research group within the USAISR to address ongoing battlefield trauma care research, development, test, and evaluation issues.

The most recent strategic partnership for TCCC has been with the Joint Trauma System (JTS). This system was established by the USAISR with assistance from the US Central Command, the service Surgeons General, and the Assistant Secretary of Defense for Health Affairs as a means of improving trauma care for the nation's combat casualties.¹⁸ The JTS uses various performance improvement initiatives including a weekly teleconference to review all combat casualties from the

preceding week, a robust set of clinical practice guidelines to provide evidence-based recommendations for trauma care, and the Joint Theater Trauma Registry—the world’s largest combat data set—to facilitate improvements in trauma care and guide future trauma-related research. TCCC at present works extensively with the JTS to provide input on prehospital trauma care issues and to identify items in the JTS clinical practice guidelines that might be appropriate for use in the prehospital setting.

The 10-year timeline for the TCCC effort is listed in Table 2.

BATTLEFIELD TRAUMA CARE NOW: 2011

US combat medics, corpsmen, and PJs are now taught battlefield trauma care techniques based on the TCCC guidelines.¹⁰ These guidelines are reviewed quarterly and updated as needed by the CoTCCC. Changes proposed by the CoTCCC are reviewed by both the Trauma and Injury

Subcommittee and the Core Board of the Defense Health Board. Once approved, updated versions of the TCCC guidelines are posted on both the Military Health System and the PHTLS Web sites.¹² At 3-year to 4-year intervals, the TCCC guidelines are also published in updated versions of the Military Edition of the *Prehospital Trauma Life Support Manual*.¹²

TCCC-based training is now provided to combat medical personnel and includes the elements listed in Table 3.¹⁰

TCCC: What is the Evidence?

The changes in battlefield trauma care outlined in Table 2 are dramatic and unprecedented. However, how do we know that they are saving lives on the battlefield? Numerous reports published in the medical literature and collected from combat first responders have now documented that TCCC is saving lives and is improving the tactical flow of missions on which casualties have occurred.

TABLE 2. TCCC Timeline

Date	Event/Accomplishment
1993 1995	TCCC research project conducted as a combined effort of the US Special Operations Command and the Casualty Care Research Center at the Uniformed Services University of the Health Sciences (USUHS).
August 1996	“Tactical Combat Casualty Care in Special Operations” published as a supplement to the journal <i>Military Medicine</i> .
April 1997	Rear Admiral Tom Richards establishes TCCC as the Navy SEAL standard of care for managing combat trauma on the battlefield.
1998	TCCC was used as the basis for the for new Ranger First Responder Course and mandated for all Rangers by Regimental Commander COL Stan McChrystal.
1999	TCCC guidelines published in the fourth edition of the <i>Prehospital Trauma Life Support Manual</i> ; PHTLS is endorsed by the American College of Surgeons Committee on Trauma and the National Association of EMTs.
2001 2004	“Just-in-time” TCCC training provided to SEAL units deploying in support of combat operations in OEF/OIF.
2001	USSOCOM supports the establishment of the Committee on TCCC at the Naval Operational Medicine Institute (CAPT Doug Freer, Commanding Officer).
August 2002	First meeting of the CoTCCC is held at the Naval Operational Medicine Institute in Pensacola, Florida; first CoTCCC chairman is CAPT Steve Giebner.
September 2004	TCCC Transition Initiative initiated by USSOCOM and executed by USAISR (COL John Holcomb, Commander). Deploying SOF units receive TCCC training and equipment under the leadership of SFC Dom Greydanus.
January 2005	US Central Command (USCENTCOM) directs that all combatants entering the CENTCOM area of responsibility have a Combat Application Tourniquet (C-A-T®) and a HemCon dressing. (Col Doug Robb, CENTCOM Surgeon).
March 2005	TCCC equipment and training mandated by USSOCOM for all SOF units deploying in support of combat operations.
March 2005	US Army Surgeon General directs that CAT tourniquets be issued to all Soldiers deploying in support of combat operations in OEF/OIF.
September 2005	USAISR publishes <i>Laboratory Evaluation of Battlefield Tourniquets in Human Volunteers</i> . CAT, SOFT-T and EMT tourniquets found to be 100% effective at eliminating distal arterial blood flow.
November 2007	CoTCCC relocated to function under the Defense Health Board at the direction of DASD Ms. Ellen Embrey.
2008 2009	COL John Kragh’s landmark series of tourniquet articles published; largest series of tourniquet use patients in history; Conclusion battlefield tourniquets are saving lives and not causing loss of limbs
2009	Based on COL Kragh’s research, an estimate that 1,000 2,000 lives have been saved to date in US casualties by the use of battlefield tourniquets was provided to the US Army Medical Research and Materiel Command.
August 2009	Defense Health Board recommends that TCCC training be provided to all US service members deploying in support of combat operations.
2010	All services in the US military and most coalition partner nations using TCCC to train combat medical personnel in the management of trauma on the battlefield.
April 2010	US Army Training and Doctrine Command mandates TCCC training for Army Combat Lifesaver Course (COL Karen O’Brien, TRADOC Surgeon).
February 2011	America, Britain, Canada, Australia, New Zealand Armies’ Program recommends TCCC as the standard of care for combat first-aid training in member nations.
August 2011	COL Russ Kotwal’s article “Eliminating preventable death on the battlefield” published in <i>Archives of Surgery</i> ; describes Ranger TCCC-based casualty response system and documents the lowest rate of preventable deaths ever reported from a major conflict.

TABLE 3. Battlefield Trauma Care Now (2011)

US combat medics, corpsmen, and paramedics are now taught battlefield trauma care techniques based on the TCCC guidelines. These guidelines are reviewed quarterly and updated as needed by the CoTCCC. Changes proposed by the CoTCCC are reviewed by both the Trauma and Injury Subcommittee and the Core Board of the Defense Health Board.¹⁰ Once approved, updated versions of the TCCC guidelines are posted on both the Military Health System and the PHTLS Web sites. At 3-year to 4-year intervals, the TCCC guidelines are also published in updated versions of the military edition of the Prehospital Trauma Life Support Manual.¹² Current TCCC guidelines include the following:

Phased care in the tactical environment to ensure that good medicine is combined with good small unit tactics. The three defined phases of care are as follows:

- Care under fire
- Tactical field care
- TACEVAC care

Casualty and medic actions during the care under fire phase that focus on gaining and maintaining the tactical advantage, with only tourniquets currently recommended as standard medical care in this phase.

The aggressive use of tourniquets to control life-threatening extremity hemorrhage.⁴

The use of Combat Gauze to control life-threatening hemorrhage from external bleeding at sites that are not amenable to tourniquet use.^{19,20}

Use of nasopharyngeal airways to protect the airway when there is no airway obstruction from direct maxillofacial or neck trauma.

Initial management of the airway in maxillofacial trauma by having the casualty sit up and lean forward if possible, thus allowing blood to simply drain out of the oropharynx and clearing the airway.

Surgical airways for maxillofacial or neck trauma when airway compromise is present and the sit-up and lean-forward position is not feasible or not successful

Aggressive needle thoracostomy for tension pneumothorax

A different approach to spinal precautions the use of this technique is not emphasized for casualties with penetrating trauma only but still recommended for use as tactically feasible when blunt trauma is present.

Intravenous access only when it is required for medications or fluid resuscitation

The preferential use of a saline lock for intravenous access as opposed to having to have an intravenous line running with fluids to keep the vein open.

The use of intraosseous techniques when vascular access is needed but difficult to obtain

Hypotensive resuscitation with Hextend as outlined in the articles by Holcomb²¹ and Champion²²

Casualties who have experienced traumatic brain injury are treated with more aggressive fluid resuscitation and supplemental oxygen as needed to avoid hypotension and hypoxia.

More rapid and effective battlefield analgesia through the use of intravenously administered morphine and oral transmucosal fentanyl citrate lozenges²³

Prevention of hypothermia and secondary coagulopathy with improved technology to prevent heat loss in casualties²⁴

The use of fluoroquinolones and ertapenem or cefotetan for battlefield antibiotics to reduce preventable deaths from wound infections.²⁵

Tactical scenario-based combat trauma training to emphasize that battlefield trauma care as provided in a tactical casualty scenario must be consistent with good small-unit tactics.^{26,27,28,29}

The use of 1:1 plasma and packed red blood cells for casualties who are in shock during the TACEVAC phase of care.^{30,31,32,33}

Better definition of which casualties are likely to derive the most benefit from supplemental oxygen during TACEVAC³⁴

The use of tranexamic acid to help prevent death from noncompressible hemorrhage^{35, 37}

The use of the Combat Ready Clamp to control junctional hemorrhage³⁸

The use as described for fentanyl lozenges, tranexamic acid, moxifloxacin, ertapenem, and cefotetan is unlabeled use of Food and Drug Administration approved medications.

Reports from combatant units that have adopted TCCC as their standard for battlefield trauma care have been uniformly positive. Tarpey⁶ described the Third Infantry Division experience with TCCC: "The adoption and implementation of the principles of TCCC by the medical platoon of TF 1-15 IN in OIF 1 resulted in overwhelming success. Over 25 days of continuous combat with 32 friendly casualties, many of them serious, we had 0 KIA and 0 Died of Wounds, while simultaneously caring for a significant number of Iraqi civilian and military casualties." An article describing the experience of the 101st Airborne Division with TCCC stated that "by teaching and using (TCCC) ideas, the 101st has achieved one of the highest casualty survival rates in combat of any unit in the Army."³⁸

Bottoms,³⁹ reporting in *Tip of the Spear*, the official publication of the US Special Operations Command, stated that "Multiple reports from SOF First Responders have credited TCCC techniques and equipment with saving lives on the battlefield." General Doug Brown,⁴⁰ the Commander of the US Special Operations Command, sent a letter of appreciation to the Army Surgeon General for the outstanding work done by the USAISR in establishing the TCCC Transition

Initiative, a pilot program to fast-track new TCCC training and equipment to deploying Special Operations Forces (SOF) units and then collect data about the success of these measures. This letter stated that these efforts had "...produced remarkable advances in our force's ability to successfully manage battlefield trauma."

Madigan Army Medical Center used TCCC as the cornerstone for a training course to prepare 1,317 combat medics for deployment to Iraq or Afghanistan. Of the 140 medics who subsequently deployed to Iraq for 1 year, "99% indicated that the principles taught in the TCCC course helped with the management of injured casualties during their deployment."⁴¹

The US military casualty survival rate in this conflict is the highest that it has ever been. Body armor, improved definitive care and evacuation strategies, and the JTS have all contributed to this success, but TCCC has been the prehospital component of this major success.⁴²

The studies of Kragh et al.^{43,44} on tourniquet use in Iraq and Afghanistan have documented a remarkable incidence of lives saved with prehospital tourniquet use without causing preventable loss of limb from tourniquet ischemia.

Studies of hemostatic agents used in combat have documented the efficacy of the previous agents HemCon and QuikClot.^{45,46} The newer hemostatic agent Combat Gauze has been shown to be superior to HemCon and QuikClot in an animal model of lethal arterial bleeding,²⁰ the initial report on battlefield use of Combat Gauze indicated good success in combat casualties.⁴⁷

The Defense Health Board memo of August 6, 2009, noted that several Special Operations units, which have trained all of their combatants in TCCC since before the onset of the current conflicts, reported that they had had no preventable battlefield fatalities in their units for the entire duration of the conflicts to date, an unprecedented accomplishment in battlefield trauma care. The DHB memo recommended TCCC training for all deploying combatants and medical department personnel, as did a subsequent DHB memo in 2011.^{48,49}

The Army Surgeon General's Task Force on Dismounted Complex Blast Injury noted the success of TCCC in treating one of the most severe subset of combat casualties in the conflicts in Iraq and Afghanistan. The report called for an increased emphasis on TCCC techniques and training.⁵⁰

The 75th Ranger Regiment reported that the incidence of preventable deaths in 419 battle injury casualties sustained by that unit, which began training all combatants in TCCC before the start of the current conflicts, was found to be 3% (as contrasted to the preventable death percentages of 15% to 28% from Kelly et al. and Holcomb et al. in other studies where the combatant units had not necessarily had TCCC training). The incidence of preventable deaths in the article of Kotwal et al.⁵ from failure to perform required interventions in the prehospital phase of care was zero. This is the lowest incidence of preventable deaths ever reported from a major conflict.

The achievements mentioned previously were reviewed and discussed at the Tenth Anniversary Meeting and Dinner of the CoTCCC in November 2011. A message to the CoTCCC from former US Surgeon General Richard Carmona⁵¹ on that occasion stated in part, "...Tonight is not only an opportunity for us to celebrate the extraordinary advances in combat casualty care that the CoTCCC has led, but also a chance for our warriors and a grateful nation to appreciate the unwavering selfless service and immense contributions of the CoTCCC... I would venture to say that the CoTCCC has been one of the greatest contributions to combat casualty care in history." A message from Vice President Joe Biden⁵² to the CoTCCC noted in part that, "...Your work is absolutely vital to helping us uphold our obligation, our sacred obligation, not only to our service members who fight, but also to the families and loved ones who support them... you have quite literally saved thousands of lives... I wish every single American understood just what you have done for our warriors. I wish they knew as much as I know; I wish they could see what I've seen about the heroic efforts you have made on behalf of our warriors...."

TCCC in the US Military and Coalition Partners

After a decade of war, TCCC is now used by all services in the US military as the standard for training medics to manage combat trauma on the battlefield.^{10,50,53-57} TCCC is taught to new Soldiers by the Army Training and Doctrine Command as part of its combat lifesaver training program.⁵⁶ TCCC has

been adopted as the standard of care by many coalition partner nations, and has been recommended as the standard of care for combat first-aid training in member nations by the America, Britain, Canada, Australia, New Zealand Armies' Program.⁵⁸ A recent article from the Canadian military noted that Canadian forces (CF) have experienced increasingly severe injuries in the current conflicts, but that despite this, the CF "...experienced the highest casualty survival rate in history. Though this success is multifactorial, the determination and resolve of CF leadership to develop and deliver comprehensive, multileveled TCCC packages to soldiers and medics is a significant reason for that and has unquestionably saved the lives of Canadian, Coalition, and Afghan Security Forces."⁵⁹

TCCC Transition to Civilian Trauma Care

Some of the concepts and successes noted in TCCC are gaining increasing acceptance in civilian trauma care systems, including tourniquets, hemostatic agents, intraosseous devices, hypotensive resuscitation, and modified spinal protection techniques for penetrating injury.⁶⁰⁻⁷⁴

A unique subset of civilian users is the civilian Tactical Emergency Medical Support community. This group also has to care for trauma victims in a tactical, albeit nonmilitary, setting. An increasing number of Tactical Emergency Medical Support organizations are adopting (and adapting) TCCC for their purposes.⁷⁵

DEFINING THE GAP: DECEMBER 2011

Training

Establishing best practice guidelines is the first step toward improving trauma care, but transitioning them effectively is an entirely different proposition with a different set of challenges. Best practice guidelines only enable best practice; they do not guarantee it, especially if there are training challenges to be overcome. Combat leaders, from the senior leaders who make large-scale equipping and training decisions to small-unit leaders, both officer and enlisted, who must know what to expect from their medics on the battlefield, all need overview training in TCCC. Line leadership buy-in is the sine qua non of sustained advances in the military.^{5,9} All combatants must be trained in TCCC to care for themselves and their buddies in combat if no medic is available. The SEALs, the 75th Ranger Regiment, USSOCOM, and the Army have led the way on this.^{5,56,57} Military physicians and other medical department personnel who are assigned to combatant units, who supervise combat medical personnel or who will be deploying in support of combat operations, all need to be trained in TCCC. At this point, there is no DoD-wide program in place to assure that this will reliably happen. Finally, all of these groups need refresher training in TCCC within 6 months of deploying in support of combat operations to bring them up to date on the latest developments in TCCC. The TCCC guidelines are dynamic and change frequently to reflect new information and technology as it becomes available. Our war fighters should go to war with an up-to-date knowledge base and the best available equipment and trauma care strategies.^{48,49}

Freeze-Dried Plasma

Large-volume crystalloid resuscitation for victims of hemorrhagic shock is an intervention whose time is clearly over. The state of the art in 2011 is damage-control resuscitation using a balanced mix of plasma, red blood cells, and platelets to approximate as closely as possible the whole blood that was shed. Use of blood products in the far-forward combat environment is usually not feasible except in air evacuation platforms. Reconstituted dried plasma has been identified as the best option for fluid resuscitation fluid at present, but there is not currently an Food and Drug Administration–approved product to meet this need. The US Special Operations community, with support from the CoTCCC and the DHB, is presently leading the effort to make a dried plasma product available to medical personnel in combat units.^{76–78}

Tactical Evacuation Care Improvements

Combat units are typically significantly constrained with regard to the ability to provide advanced medical care for combat casualties in the Care Under Fire and Tactical Field Care phases because of personnel, tactical, and logistical constraints. As noted in the 1996 TCCC article, the Tactical Evacuation (TACEVAC) phase of care provides an opportunity for additional medical personnel and equipment to be made available to care for casualties. This opportunity has been incompletely used in Iraq and Afghanistan. Recent reviews of this topic have offered the possibility for significant improvements in care through providing evacuation providers trained to at least the critical care flight paramedic level, ensuring that blood and plasma are available for casualties in hemorrhagic shock, using the most capable evacuation platforms available, ensuring TCCC training for all evacuation providers, and having advanced airway options, intravenously administered medications, and other interventions routinely available for critical casualties.^{50,79–81}

TCCC Care Documentation

The difficulty of documenting care on the battlefield is well-recognized. Successful accomplishment of this task, however, can be accomplished through command attention and the use of tools such as the Ranger-developed TCCC Care Card and the Ranger Prehospital Trauma Registry.⁵ Process improvement in TCCC in the future will depend heavily on the DoD's ability to ensure that this documentation is routinely performed. The tools are there; we need to have our combat leadership ensure that they are used.⁴⁹

Battlefield Trauma Care Research, Development, Testing, and Evaluation

Military medicine has many goals and priorities. There is, however, no research need that should supersede the need to ensure that optimal battlefield trauma care is provided to all of our combat wounded. Making sure that preventable deaths are in fact prevented to the greatest extent possible and that casualties have the best possible functional recovery should be the top priority and resourced accordingly. Research efforts that offer the greatest impact on these goals should be selected and funded. For battlefield trauma care, these research areas should focus on hemorrhage control and treatment of shock.^{82–84}

Insofar as possible, subject matter experts should help to define specific projects rather than simply selecting broad areas of research to maximize speed and efficiency in developing usable research products. The CoTCCC and the DHB have recently done this for battlefield trauma care.⁸⁵

CONCLUSION

Why have all of the advances in battlefield trauma care noted previously occurred in the relatively short span of a decade after many years of minimal change? The most obvious answer is the continuing presence of America's longest armed conflict, which has allowed the benefits of lifesaving innovations in combat trauma care to be seen in near real-time and thus accelerate the transition process. The other factor, however, has been the CoTCCC, which has provided an intense and sustained triservice effort to update battlefield trauma care best practice guidelines; the presence of both military and civilian trauma experts, medical researchers, medical educators, and combat medical personnel on the CoTCCC positions the group uniquely well to accomplish this task.

With the advancements on hospital care and evacuation techniques as well as development of the JTS, the US military and its coalition partners now have the best definitive care and evacuation capabilities for the management of combat trauma in history. The ongoing role of TCCC is to make sure that our casualties get to the hospital alive so that they can benefit from it.

Taken as a whole, the innovations described previously represent a complete revamp in battlefield trauma care. TCCC has helped combat units to achieve unprecedented casualty survival rates when those units train all of their combatant personnel in these techniques.

Moreover, with the CoTCCC working in concert with other groups—such as the JTS, the other elements of the DHB, the American College of Surgeons' Committee on Trauma, the PHTLS Executive Council, the USAISR, Defense Medical Materiel Program Office, coalition partner nations, military combat medical schoolhouses, and the offices of the service Surgeons General—a definitive mechanism has been established with which to ensure that TCCC guidelines and US battlefield trauma care keep pace with accumulated experience, new medical evidence, and emerging technology.

The price in lives that we have paid to recognize the need for TCCC and to effect its transition has been high; both TCCC training and the CoTCCC need to be sustained in peacetime so that we do not pay this price again in the next conflict.

AUTHORSHIP

L.B. proposed this review; F.B. conducted literature searches. F.B. and L.B. participated in writing, revising, and editing the manuscript and creating the figures and tables.

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We recognize the role of the USAISR in developing many of these advances in battlefield trauma care as well as the successful efforts of the CoTCCC, the Naval Operations Medicine Institute, PHTLS, the Defense Medical Materiel Program Office, the Trauma and Injury Subcommittee of the Defense Health Board, the Defense Health Board, and the JTS to turn advances in trauma care into lives saved in the battlefield.

DISCLOSURE

The authors declare no conflicts of interest.

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