

# A review of the landscape: Challenges and gaps in trauma response to civilian high threat mass casualty incidents

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**ABSTRACT:** The ultimate goal of the emergency response and trauma system is to reduce potentially preventable death from trauma. Tremendous advances in trauma care emerged from the past 15 years of United States' combat engagements around the globe. Unfortunately, combat and insurgency tactics have also metastasized to the civilian world, resulting in increasingly complex and dynamic acts of intentional mass violence. These high threat active violent incidents (AVIs) pose significant preparedness, response, and clinical care challenges to the civilian healthcare systems. Currently, there are several operational and policy gaps that limit the successful preparedness and response to AVIs and dynamic MCIs in the United States. (*J Trauma Acute Care Surg.* 2018;84: S21–S27. Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.)

On October 1, 2017, a gunman in Las Vegas rained down bullets from the 32nd floor of the Mandalay Bay hotel onto a crowd of concertgoers killing 58 and wounding over 500 people.<sup>1</sup> The incident again highlighted many of the challenges that first responders and trauma systems face in responding to dynamic mass casualty incidents (MCIs) and active violent incidents (AVIs). An AVI is defined as high threat incidents where a person or persons are actively engaged in killing or wounding civilians at the time of first responder activation.

AVIs like the Boston bombing (2013), the Orlando Pulse Nightclub (2016) shooting, and the Las Vegas massacre (2017) are becoming more sophisticated. Modern AVI perpetrators study past attacks and system response to evolve their tactics, techniques, and procedures to maximize mortality and political impact.<sup>2–6</sup> The results are increasingly well-planned and coordinated attacks that are often timed to overwhelm the first response system. These incidents challenge many of the foundations upon which our trauma system is based, such as static triage, “cold zones”, and patient transportation.

The ultimate goal of the emergency response and trauma system is to reduce potentially preventable death from trauma. Currently, there are several operational and policy gaps that limit the successful preparedness and response to AVIs and dynamic MCIs in the United States.

## The Data Gap: We Cannot Improve What We Do Not Measure

Data analysis and evidence should shape clinical practice guidelines, inform public policy decisions, and drive evolving

operational response. In the United States, there are several major data gaps restraining the improvement of high threat mass casualty incidents response.

First, there exists no consolidated database on potentially preventable death in civilian high threat emergency casualty care.<sup>7</sup> The U.S. military addressed this challenge in part by creating the Joint Theater Trauma Registry (JTTR). The resulting landmark combat population studies drove the evolution and institutionalization of the military Tactical Combat Casualty Care (TCCC) guidelines and the practice of Damage Control Resuscitation (DCR).<sup>8–10</sup> TCCC and DCR are now considered the standard for combat casualty care and largely responsible for the lowest combat case fatality rates in history.<sup>11</sup>

Although growing combat data can provide a foundation for developing civilian high threat trauma guidelines, the operational environment, patient physiology, and epidemiology of combat wounds and civilian terror attacks differ. For example, the military data does not include the number of combatants saved by body armor, an important consideration when examining civilian attacks. In addition, the bulk of combat data does not address important questions related to pediatrics, medical comorbidities, or differences in operational tactics and priorities.

There is only one civilian-based study to date that has attempted to replicate the extensive work done in the military research community highlighting three primary barriers to collection of relevant real-time clinical data in the civilian environment.<sup>7</sup> First, the criminal nature of these acts brings variable and often opaque regulations to bear regarding information sharing. For example, medical examiners have different standards for performing autopsies and legal restrictions on releasing information based upon the state in which they practice.<sup>12</sup> Second, there exists no robust, standardized data management system for collecting and analyzing information. Finally, there exists no vetted, secure mechanism for critical information distribution to relevant stakeholders. The resulting knowledge gap in the civilian sector hinders the development and funding of more effective response programs. Without appropriate civilian injury and mortality data, it is difficult to advocate for modern clinical care practices such as whole blood programs or lyophilized plasma (now standard of care in TCCC/DCR).

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The second major data gap relates to understanding and evolving the operational response to high threat AVIs. Though there is consensus in the medical community on the value of sharing best practice, current after action report (AAR) processes are largely descriptive and focus on internal mitigation strategies.<sup>13</sup> Even within large healthcare systems, liability issues—perceived and real—combined with the criminal nature of these incidents often severely limits the ability to share information and create a “learning” response system. Current processes inhibit the rapid acquisition, evaluation, and sharing across systems of critical operational lessons learned after high threat incidents. Quite simply, the evolution of our tactics based on lessons learned is not keeping pace with the increasing need for such information sharing.<sup>14,15</sup>

Israeli disaster response leaders first recognized this gap and developed deployable after action teams to respond to national and global intentional mass casualty incidents. Based upon the Israeli experience and the existing National Transportation Safety Board model for evaluating flight catastrophes, Goralnick et al. piloted a standardized deployable AAR process in response to the Paris and Brussels attacks.<sup>13,14</sup> The American College of Emergency Physicians High Threat Task Force has subsequently recommended the development of a more robust and dynamic AAR process that includes teams of deployable experts.

### Recommendation 1

Create a coordinated mechanism to collect, store, analyze, and rapidly disseminate clinical data from civilian high threat AVIs and intentional MCIs. In 2016, the National Academy of Science, Engineering and Medicine (NASEM) published a report calling for a National Trauma Action Plan that among other things called for a National Trauma Research Agenda.<sup>16</sup> This plan is a laudable, complex, and much-needed “moonshot” that may take a decade to accomplish. The same stakeholders could immediately execute a pilot program targeting high threat MCIs that provides both immediate benefit and lays the foundation for larger systemic improvements. The resulting knowledge management system can model the JTTR and build on existing infrastructure of the National EMS Information System (NEMIS) and National Trauma Data Bank systems. Key stakeholders such as the American College of Emergency Physicians (ACEP) and the American College of Surgeons Committee on Trauma (ACS-COT) should commit resources to partner with relevant government agencies to overcome legal, technologic interoperability, and knowledge distribution challenges.

### Recommendation 2

Develop and implement a standard, rapid post-incident reporting and process improvement system based upon the NTSB “Go team” concept. One public–private model is the creation of a stand-alone, non-profit entity to implement the deployable process improvement teams. Relevant federal partners should support this initiative through prioritized grant funding, provision of regulatory support, guidance on data security, and responsiveness to legislative recommendations. Professional societies such as ACEP and ACS-COT, whose members lead the medical response to all of these domestic incidents, should

provide subject matter expertise and the operational network to implement the dynamic process improvement initiative.

### The Clinical Practice Gap: Remote Damage Control Resuscitation (RDCR)

Military and civilian data indicates that uncontrolled hemorrhage is the leading cause of potentially preventable mortality in trauma.<sup>8</sup> However, the clinical and operational data gaps described above result in practices that are “evidence guided” rather than “evidence based”. Extensive experiences suggest that a comprehensive resuscitation strategy, such as damage control resuscitation (DCR), has the greatest impact on reducing potentially preventable mortality in trauma, especially when implemented early in the course of care. The concept of RDCR is the application of DCR principles beginning at the point of injury. RDCR includes early mechanical hemorrhage control, minimal normotensive resuscitation, limitation of crystalloid infusion, hemostatic resuscitation, and prevention of hypothermia and acidosis.<sup>17,18</sup> RDCR strategies reduce hemorrhage-associated trauma mortality in combat and combined with other appropriately timed life-saving interventions (LSIs) such as needle chest decompression and airway management (RDCR plus) as recommended in the TCCC and Tactical Emergency Casualty Care (TECC) guidelines are considered the current trauma standard of care for combat and civilian high threat casualty care.<sup>19,20</sup>

In the civilian setting, many RDCR principles such as mechanical hemorrhage control, hypothermia prevention, limited crystalloid infusion, and prehospital tranexamic acid (TXA) are gaining broader acceptance.<sup>21–24</sup> However, there remains a significant RDCR capability gap related to the ability to perform balanced blood product resuscitation in the prehospital and non-Level 1 trauma center environment. Few EMS systems have prehospital blood protocols and only an estimated 25% of helicopter EMS systems have blood programs.<sup>25</sup> The majority of non-Level 1 trauma center facilities are wholly incapable of effectively delivering massive transfusions and many community facilities struggle even with the timely administration of component therapy. The 2017 Las Vegas attack resulted over 50 deaths and 500 wounded. These victims were distributed beyond the city’s Level 1 trauma center to level 2 and 3 centers as well as freestanding emergency departments creating significant healthcare system strain and highlighting the requirement for more robust transfusion capabilities.<sup>26</sup>

The hemostatic resuscitation program barriers are myriad, but not insurmountable. The operational challenges of blood product acquisition, quality assurance, and rotation in low utilization practice sites often seem too complex to justify health system investment. Logistics and expense remain the primary impediments to successful non-trauma center blood programs.

At least one viable solution was discovered nearly 80 years ago: freeze-dried plasma (FDP).<sup>27</sup> FDP is lyophilized plasma that was first produced at scale during World War II. In the decades since, multiple trials affirm that FDP maintains functionally equivalent levels of critical clotting factors when compared to fresh frozen plasma (FFP) or thawed plasma and may improve trauma outcomes.<sup>28–30</sup> In addition, increasing animal data suggests a neuroprotective effect of FFP and FDP.<sup>31</sup>

The development and refinement of lyophilization techniques offers logistically streamlined solution to successful

RDCR outside of the trauma center. Studies from France and Norway indicate that FDP can be safely integrated into civilian EMS systems.<sup>32</sup> Secondary benefits include the ability to deploy this resource during routine emergency care for conditions such as intracranial hemorrhage or gastrointestinal bleeding in anticoagulated patients.

Despite extensive international preclinical and clinical evidence that FDP is safe, coagulation factors are maintained, and the product is an effective component of RDCR, there is no FDA-approved lyophilized plasma or platelet product. U.S. production and utilization halted after WWII because of concerns regarding transmission of the hepatitis virus and ultimately the human immunodeficiency virus. French and German medical companies working closely with regulatory bodies developed separate strategies for mitigating this challenge and have developed room temperature—stable, durable, and exceedingly safe FDP products.<sup>33</sup> The U.S. Special Operations Forces administer French and German FDP during RDCR under an Investigative New Drug protocol. However, our citizens do not have the same access to cutting edge trauma care.

### Recommendation 1

As articulated in the 2016 NASEM preventable death report, the National Institutes of Health (NIH) and the Department of Health and Human Services should prioritize Trauma and Injury as a public health crisis and commit resources to the research and development of advanced trauma resuscitation solutions.

### Recommendation 2

The U.S. Food and Drug Administration and NIH should streamline research, development, regulatory approval, and clinical integration of resuscitation products, such as lyophilized plasma and platelets, that support the RDCR principles. High threat AVIs can provide the impetus to drive increased funding for pilot programs exploring and validating improved resuscitation in civilian trauma.

## The Standards and Guidelines Gap: The Tactical Emergency Casualty Care Chain of Survival

The RDCR plus doctrine provides effective *principles of care* for trauma resuscitation in civilian high threat AVIs. Lacking is a national standard framework for the whole-of-community implementation of RDCR plus principles. The result is inconsistent care across our communities.

The U.S. combat experience over the past 15 years provides important lessons and guidance. Combat data suggests that approximately 25% of U.S. military deaths during recent conflicts in Afghanistan and Iraq were potentially preventable.<sup>8</sup> Holcomb et al. reported a rate of potentially preventable deaths of approximately 15% for U.S. Special Operation Forces.<sup>9</sup> However, between 2001 and 2010, the 75th Ranger Regiment reported a 3% preventable mortality rate.<sup>10</sup> One key to success was the Ranger First Responder program that trained all Rangers in the tiered application of TCCC within a comprehensive casualty response system.<sup>34</sup> The Ranger's system was based on a common language that allowed for effective communication, coordination, and collaboration across the trauma care continuum.

Currently, no formal national standard exists to guide similar preparedness and response to high threat civilian AVIs. The lack of common standards limits federal grant opportunities, impedes interagency coordination, and slows knowledge penetration of critical lessons learned. The Committee for Tactical Emergency Casualty Care (C-TECC) was established in 2010 to address this gap. The C-TECC is a volunteer, best-practice development group for trauma care in civilian high threat environments. The C-TECC is modeled after the CoTCCC and is composed of emergency physicians, trauma surgeons, prehospital operational leaders, and military experts. The C-TECC guidelines build upon a foundation of TCCC, RDCR, and the American Heart Association Chain of Survival concepts to create a threat-based, whole-of-community response system applicable to high threat civilian environments (Fig. 1).<sup>35-37</sup>

The TECC framework is best applied in a whole-of-community response rubric. Similar to the experience with the U.S. Army Rangers, this model creates a standardized, scalable casualty care system that spans untrained civilians, law enforcement, medical first responders, and physicians.<sup>38</sup> Common language allows for streamlined training programs and equipment procurement while also improving interagency response coordination. Multiple federal agencies, state governing bodies, and professional organizations endorse the TECC guidelines and integrate them into their response programs.<sup>39-43</sup> However, to drive systemic change and strengthen preparedness and response to AVI, the Federal government and relevant professional societies must commit to expanding funding and standardization of TECC across responder domains.

### Recommendation 1

The relationship between The CoTCCC and the C-TECC should be formalized as separate but cooperative agencies. The DoD, DHS, and relevant professional societies should support this partnership as a key enabler of the NASEM 2016 report on translation of military trauma lessons learned.

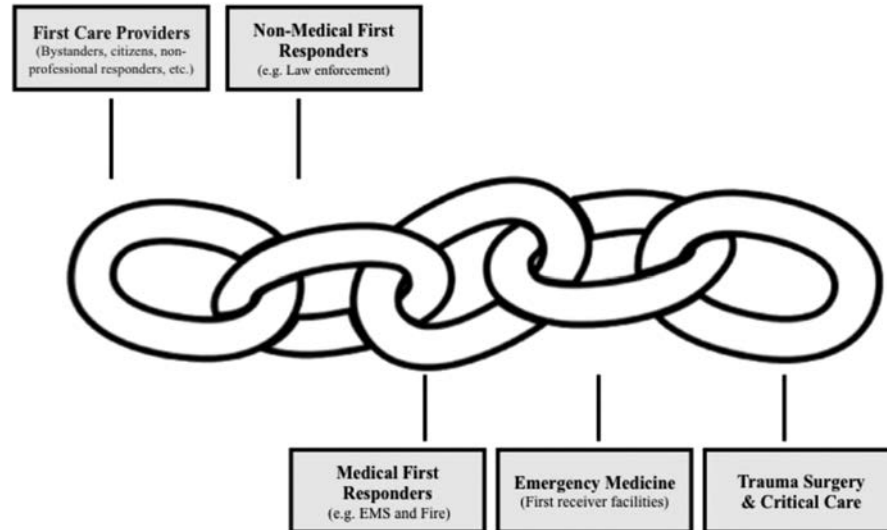
### Recommendation 2

The Federal government and relevant professional societies should commit to expanding funding and standardization of TECC across responder domains to scale application of RDCR plus in high threat AVIs. Increased collaboration between ACEP, the ACS-COT, and other important stakeholders is an important enabling component of this recommendation.

## The Operational Response Gaps

### Executing RDCR Plus in the Civilian Setting

The basic framework for executing an RDCR plus casualty care system such as TECC in the high threat environment has four interconnected components: Access, Assessment, Stabilization, and Evacuation. In civilian AVIs, the operational environment influences each of these key response components and shapes the application of TECC across the continuum of care (Table 1). This truth mandates a paradigm shift in training and preclinical response that incorporates the dynamics of the trigger event into the priorities of clinical care. Currently, the two most dramatic operational response gaps relate to casualty access and evacuation.



**Figure 1.** Tactical Emergency Casualty Care (TECC) Chain of Survival. The TECC Chain of Survival highlights the importance of common language principles that can be applied in a tiered manner across an entire community. This model combines attributes of the Ranger First Responder program and the American Heart Association Chain of Survival for Cardiac Arrest.

**The Access Gap: The People Who Get Us Access to Casualties “Don’t Do Medicine”**

Casualty access is a prerequisite to trauma care and must be considered in any response plan. The manner by which responders access casualties will shape the assessment, stabilization, and evacuation phases of the response. Time from point of injury to first LSI is a critical early step in trauma survival. Perpetrators of AVIs are keenly aware of modern prehospital response structures and plan their attacks to limit first responder access to casualties, destabilize response systems, and even target medical providers. For example, the London bombings in 2005 forced first responders to address a subterranean attack as well as a secondary bus bomb blast that created a highly unstable scene.<sup>44</sup> These barriers significantly limited medical first response. Unfortunately, casualty access is not commonly considered in medical care guidelines and its integration requires a paradigm shift for preparedness and response leaders. There are several strategies to address the access gap and reduce time to LSI. The key is to frame the process in a whole-of-community, all hazards approach based upon common language and targeted life saving interventions.

**Recommendation 1: Empower the Masses**

Bystanders and victims are always first on scene of an AVI and can provide critical immediate LSIs. The successful integration of non-professional responders into the emergency response system has three pillars. First, medical leaders must provide training to non-medical personnel in critical LSIs such as tourniquet application and use of pressure dressings. The Department of Homeland Security Stop the Bleed campaign, FEMA’s “Until Help Arrives”, the Hartford Consensus, and the TECC First Care Provider programs are important national initiatives to train all citizens in the basics of trauma care.<sup>45-47</sup> Second, federal, state, and local governments must fund public

access hemorrhage control initiatives. Finally, professional responders must develop tactics to integrate bystanders when appropriate into the response paradigm. This last pillar is the most difficult and requires examination of core MCI doctrine including scene security, triage, and even casualty evacuation.

**TABLE 1.** Access, Assess, Stabilization, Evacuation: Principle and Barriers

Components of Casualty Care in High Threat Environments	Barriers to Care
Access	<ul style="list-style-type: none"> <li>• Active threat</li> <li>• Barricades</li> <li>• Fire, chemical, gas, smoke, etc.</li> <li>• Location of casualties (e.g., elevated or subterranean)</li> </ul>
Assessment	<ul style="list-style-type: none"> <li>• Active threat</li> <li>• Access to casualty</li> <li>• Large volume of victims</li> <li>• Knowledge</li> <li>• Communication</li> </ul>
Stabilization	<ul style="list-style-type: none"> <li>• Active threat</li> <li>• Wounding patterns</li> <li>• Manpower</li> <li>• Knowledge</li> <li>• Equipment</li> </ul>
Evacuation	<ul style="list-style-type: none"> <li>• Volume of victims</li> <li>• Active threat</li> <li>• Equipment/supplies</li> <li>• Training</li> <li>• Crowds</li> <li>• Manpower</li> <li>• Communication and destination protocols</li> </ul>

### **Recommendation 2: Law Enforcement Response Must Evolve from “Assault” to “Assault Rescue”**

In AVIs, law enforcement officers (LEOs) are often the first professional responders on scene. LEOs’ mission in AVIs is to prevent the further loss of life and destruction of property. Since the 1999 Columbine mass shooting, LEO tactics evolved from a “stage a wait” posture to a more dynamic assault response focused on “stopping the killing”. The Federal Bureau of Investigation suggests that the active threat of many AVIs ends upon law enforcement arrival, scene access, and engagement of the perpetrator(s), and this more aggressive assault posture is an important first step in reducing loss of life.<sup>48</sup> However, a singular focus on stopping the perpetrator(s) actions may be insufficient, as it does not address existing casualties that would benefit from more rapid application of LSIs. After action reports from the Virginia Tech attack, the Boston Bombing, the Orlando massacre, and the Las Vegas Shooting all emphasize the important role that LEOs play in accessing casualties and either implementing LSIs or enabling advanced care providers to move closer to the point of injury.<sup>49,50</sup>

Emergency response leaders must more effectively integrate LEOs into the casualty response system. Civilian LEOs must recognize that their job in AVIs is not simply assault but rather assault rescue targeted to “stop the killing and stop the dying”. For significant impact, this doctrinal evolution must expand beyond the Special Weapons and Tactics community. Patrol officers are typically the first on scene for most AVIs and should all be armed with the knowledge and equipment to save lives. Law enforcement trauma programs such as those in Texas, Minnesota, Northern Virginia, and those endorsed by the National Tactical Officers Association are good models for LEO integration into the casualty response matrix.<sup>51,52</sup> These programs should be scaled and standardized across the nation.

### **Recommendation 3: Scale Integrated EMS/Fire Response Warm Zone Operational Models**

The TECC guidelines delineate three dynamic phases of care: direct threat (hot zone), indirect threat (warm zone), and evacuation care.<sup>34</sup> Though scene safety remains an important tenant of prehospital response, Emergency Medical System (EMS) and Fire Rescue are increasingly embracing a role in the integrated assault rescue model as they move to provide care in the warm zone. As a result, first response agencies must develop more robust risk mitigation strategies. Several integrated response models exist to provide more robust capabilities in the warm zone. The Rescue Task Force (RTF) and the “Warm Corridor” models are two of the more common integrated response models that enable EMS to earlier access to casualties. The RTF model pairs law enforcement officers with Fire/EMS personnel, focusing on TECC LSIs at point of injury and rapid evacuation to definitive care.<sup>53,54</sup> The “warm corridor” model uses law enforcement officers to provide initial scene clearance and then stages them in positions within line of sight to mitigate risk to first responders whose focus is on providing medical care/evacuation.<sup>55</sup> DHHS and DHS should support local communities’ efforts to conduct hazard vulnerability analysis and determine which model of warm zone operations is most relevant to their risk profile.

### **Evacuation Gap: RDCR Requires Coordinated Multimodal Evacuation**

Coordinated casualty evacuation is critical in high threat prehospital trauma response.

A RDCR plus evacuation system provides for rapid, multimodal transport of casualties to definitive care or deploys advanced resuscitation assets closer to the point of injury. In the civilian setting, patient transport historically falls in the EMS domain. However, in high threat AVIs or other MCIs where access and egress may be compromised, casualty evacuation and transport require more operational flexibility.

In certain circumstances, timing of transport may be the most critical consideration. Multiple studies suggest that in urban environments, the utilization of private vehicles or police transport compared to EMS for victims of penetrating torso trauma results in equivalent or improved mortality.<sup>56–59</sup> The response to the 2012 Century Theater shooting supports the important role that law enforcement transport can play in AVIs. During the attack, fleeing victims and bystanders prevented Fire and EMS from accessing seriously injured casualties. As a result, law enforcement transported 75% of the patients during the first 30 minutes of response.<sup>60</sup> No adverse outcomes were reported. Recently, in response to the Orlando Pulse Nightclub shooting, law enforcement and civilians transported multiple casualties to the local trauma center. Though a reasonable and likely appropriate decision, the lack of coordination with the trauma center created unnecessary confusion as patients arrived.

In addition to structured LEO transport, systems should also have the capacity to provide RDCR plus interventions on scene or during transport. In scenarios with prolonged transport times or limited access to definitive care, response plans must integrate prehospital blood transfusion programs that, at minimum, allow for transfusion of warm packed red blood cells and plasma to more efficiently implement comprehensive RDCR.<sup>61</sup> In urban areas, multimodal evacuation plans should be the standard.

Response leaders must understand the operational problems they are trying to solve and align resources to create evacuation plans that are robust and flexible. Evacuation plans should take into account transportation resources, first receiver (hospital) capabilities, and overall casualty flow/distribution patterns.

### **Recommendation 1**

As part of broader Healthcare Coalition preparedness efforts, DHHS and DHS should partner with local response agencies to support models for law enforcement transport of patients during MCIs. These efforts should specifically address operational and liability challenges, provide regulatory support, and target preparedness grants for training and sustainment of integrated evacuation response systems based upon the principles of RDCR plus.

### **Recommendation 2**

The DHHS and/or the Federal Emergency Management Agency should support through grant funding the creation of comprehensive multimodal evacuation functionality that includes, but is not limited to the integration of non-medical transport, access to RDCR enabling resources, real-time first receiver facility data sharing, and improved patient tracking.

## CONCLUSION

The future of trauma response to dynamic, high threat civilian active violent incidents requires a commitment to action from professional medical societies, government partners, and operational response agencies. Trauma care recommendations must be operationally sound and account for the complex inter-agency preparedness, training, and response environment. At its most basic level, leaders must have relevant and timely data to guide clinical practice guidelines and response standards. The TECC guidelines offer the most comprehensive, operational, whole-of-community approach to implementing RDCR in high threat, active violence incidents and dynamic mass casualty incidents. Future funding and research priorities should focus on conducting a civilian preventable death analysis to inform the evolution of the TECC guidelines, implementing whole-of-community response programs, and aggressively investigating whole blood and lyophilized blood products to support pretrauma center resuscitation capability. Now is the time for action.

## AUTHORSHIP

This manuscript is the sole work of the author. The author would like to acknowledge the work of members of the Committee on Tactical Combat Casualty Care, the Committee for Tactical Emergency Casualty Care, the Hartford Consensus, and the American College of Emergency Physicians High Threat Task Force.

## DISCLOSURE

Conflicts of Interest and Source of Funding: D.W.C. is a former voting member and current subject matter expert for the Committee on Tactical Combat Casualty Care, he is the Chair *Emeritus* of the Committee for Tactical Emergency Casualty Care, and he serves as the Co-Chair of the American College of Emergency Physicians High Threat Emergency Casualty Care Task Force. D.W.C. reports receiving an honoraria from Velico Medical.

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