

Response to mass casualty events: from the battlefield to the Stop the Bleed campaign

M Margaret Knudson,¹ George Velmahos,² Zara R Cooper³

¹University of California, San Francisco, California, USA
²Department of Surgery, Massachusetts General Hospital, Boston, Massachusetts, USA

³Division of Trauma, Burns and Surgical Critical Care, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA

Correspondence to

Dr M Margaret Knudson;
Peggy.Knudson@ucsf.edu

Received 15 June 2016
Accepted 16 June 2016

ABSTRACT

In the aftermath of a number of episodes of mass casualty events, we must be reminded of how important it is to be prepared and to reflect on the knowledge accumulated over the past 15 years of war in Iraq and Afghanistan.

INTRODUCTION

On June 9, 2016, a group of surgeons gathered at the headquarters of the American Academy of Orthopedic Surgeons in Chicago to discuss disaster preparedness. The meeting included representatives from the Orthopedic Academy, the Orthopedic Trauma Association, the American College of Surgeons (ACS), the American Association for the Surgery of Trauma, and the US Military. The agenda focused on areas where our efforts in planning and responding to disasters (both man-made and natural) could be enhanced by working collaboratively. The group left after identifying some concrete next steps for future meetings. Three days later, a gunman entered a nightclub in Orlando with military-grade weapons, leaving 49 dead and 53 wounded. In the wake of this tragedy, the AAST's statement on firearm injuries published today in the *Journal of Trauma and Acute Care Surgery* is eerily timely.¹ Similarly, the American Medical Association's House of Delegates at its annual meeting this week passed a resolution to end the ban on gun violence research, recognizing that gun violence is a public health issue.² However, while these are promising developments, trauma surgeons today must continue to care for the victims of these mass casualties. We need to be mindful of how important it is to be prepared and to reflect on the knowledge accumulated over the past 15 years from the wars in Iraq and Afghanistan and from the multiple recent events requiring responses from our trauma centers in the USA.

Combat casualty care

There are numerous lessons from combat casualty care that have implications for mass casualty events in the civilian sector. In 2009, Propper *et al*³ outlined the resources needed to respond to an explosive event, based on their experience in a combat support hospital in Iraq. Of the 50 patients treated by these military surgeons after the event, 48% required a blood transfusion (on average 3.5 units of packed red blood cells and 3.8 units of plasma/patient), 76% underwent immediate operation with a total of 191 total operative procedures (3.8 procedures/casualty), and 50% required intensive care unit admission. These quantitative data provide

some guidance for civilian centers that must remain prepared for similar events. The balanced transfusion protocol first outlined by Borgman *et al*⁴ (now part of the so-called Damage Control Resuscitation) proved to have a mortality advantage, as well as conserved blood products, a precious resource in any mass casualty. Indeed, such goal-directed hemostatic resuscitation, guided by thromboelastography (TEG), has recently been demonstrated to improve survival while preserving blood products in a civilian trauma center.⁵ Eastridge *et al*⁶ reviewed deaths on the battlefield that occurred between 2001 and 2011 and judged over 24% to be potentially preventable, primarily as the result of failure to provide hemorrhage control. Just as Kragh *et al*⁷ had shown that use of the Combat Application Tourniquet (CAT) had a survival benefit in major limb trauma, Korwal *et al*⁸ essentially eliminated preventable deaths on the battlefield largely through extensive Tactical Combat Casualty Care (TCCC) training in the 75th Ranger Regiment, US Army Special Operations Command. TCCC includes rapid control of hemorrhage, relief of tension pneumothorax, and relief of airway obstruction, although the majority of interventions were aimed at hemorrhage control. Undoubtedly, as we continue to identify gaps in knowledge in the care of multiple casualties from the military experience, we will define additional areas where research during the interwar period can help guide treatment in the future.⁹ There are still multiple pressing problems that require solutions, including the prehospital control of intracavitary bleeding or the amelioration of the immediate effects of head injury.

Contemporary civilian experience

Unfortunately, the events occurring with increasing frequency in our unsettled world have provided opportunities for civilian surgeons to gain experience with mass casualties resulting from bomb explosions and active shooter events. In 2009, a perpetrator opened fire at the Soldier Readiness Center at Fort Hood in Killeen, Texas. Within 10 min, 11 people were dead and 32 victims were injured.¹⁰ In reviewing their experience during that mass casualty event, Wild and others from the nearby level 1 trauma center noted that errors in communication in the field resulted in several patients who were miss-triaged. The authors advocated the use of the Simple Triage and Rapid Transport (START) model for initial field triage.¹¹ They also noted the value of a dual command structure once patients reached the hospital (1 physician in the emergency department and another directing the flow in the operating room).

To cite: Knudson MM, Velmahos G, Cooper ZR. *Trauma Surg Acute Care Open* Published Online First: [please include Day Month Year] doi:10.1136/tsaco-2016-000023

Near the finish line of the 117th running of the Boston Marathon in 2013, two improvised explosive devices were detonated by a pair of terrorists. A total of 281 people were injured and 127 patients received care at participating trauma centers. The collaborative response among the seven Boston trauma centers was unprecedented and is undoubtedly responsible for the 0% mortality among those who reached the hospital (3 spectators died immediately at the scene). A total of 75 patients were admitted to a hospital and 54 required operative intervention within the first 48 hours.¹² The majority of injuries were to the lower extremities, including vascular, bony, and soft tissue trauma. Despite the clearly overwhelming success of the Boston Collaborative, there were still areas identified for improvements.¹³ Communication difficulties were reported at all sites, a problem that seems universal during all civilian disasters. Maldistribution of patients and lack of triage tags on casualty victims were also cited by the Boston Trauma Center Chiefs' Collaborative.¹⁴ While we all were impressed with the willingness of first responders and spectators alike to administer first aid, several makeshift field tourniquets such as belts and other articles of clothing were not properly applied and as such did not control bleeding. Most importantly, the trauma surgeons in Boston advocated continued preparation for the next disaster and resisting complacency based on a single experience with a successful outcome.

Although survivors of plane crashes are exceedingly rare, our experience with the crash of Asiana Airlines Flight 214 on landing in San Francisco allowed us to gain experience with the largest multiple casualty event in the history of San Francisco General Hospital and Trauma Center.¹⁴ Among the 307 people aboard that flight, 192 were injured, and 63 were initially transported to our hospital with 10 in critical condition. Despite the high impact of the crash, only two patients died at the scene and only one in the hospital. The most severe injuries sustained from this blunt trauma included spine fractures, traumatic brain injury, and intestinal injuries. In the first 48 hours, 15 operations were performed and 117 total units of blood products were transfused. Different from other disasters, we used CT scanning liberally in order to completely evaluate a large number of patients with the potential for multiple injuries. Providing surgical leadership in the emergency department and the operating room (dual command) was also thought to be important. We documented that 370 nursing overtime hours were required to care for the injured on the day of the event. It is also important to note that this type of disaster lasts for several weeks and requires prolonged engagement of the entire surgical team.

Empowering the public to enhance survivability from intentional mass casualty and active shooter events

Beginning in 2013, shortly after the Sandy Hook shootings, a group of concerned representatives from public safety organizations including law enforcement, fire fighters, prehospital providers, trauma physicians, and the military participated in a series of meetings in Hartford, Connecticut, facilitated by Jacobs *et al.*¹⁵ The Hartford Consensus is focused on providing the public with the education and materials that are needed to prevent death from hemorrhage. The public responders have been termed 'first care providers' or immediate responders, to separate them from the 'first responders' such as emergency medical services and fire fighters.¹⁶ In October 2015, the White House National Security Council staff and its Office of Medical Preparedness Policy launched the national 'Stop the Bleed' campaign (<https://www.dhs.gov/stopthebleed>). This program is intended to teach citizens how to save lives from major trauma

based on the principles of TCCC described above.¹⁷ Combining these two parallel initiatives, Hartford Consensus IV, meeting in Dallas in January 2016, assembled a large group of stakeholders including participants from the Military, the Committee on Trauma (COT) and the ACS, the Federal Bureau of Investigation, Law Enforcement, the National Association of Emergency Medical Technicians and the Department of Homeland Security. The focus of Hartford Consensus IV was to promote education of police and fire in hemorrhage control using military tourniquets and combat gauze and to begin a national campaign to educate the public, promoting the availability of bleeding control kits in places such as schools, malls, theaters, sporting arenas, etc.¹⁸ A recently completed national survey has confirmed that the overwhelming majority of respondents would be both physically able and willing to provide first aid including hemorrhage control to a victim of a shooting or a car crash.¹⁹ Interestingly, some of the survivors of the Orlando disaster stated that they tried to administer care as best they could to those who were injured during the prolonged wait to be rescued from the hostage situation (informal interviews on CNN).

Summary

As tragic as all these mass casualty events truly are, we must not lose sight of the need to thoroughly examine each one for lessons learned (and relearned) in order to continuously prepare for the next one. Partnering with our military colleagues in the new Military Trauma Care's Learning Health System will assure exchange of information and forge ahead a research program designed to improve the care of all who are involved in disasters and mass casualty events. Great lessons have already been learned but more are still to be taught. Adequate trauma research funding by governmental agencies, the military sector, and private industry should become a priority at a time when trauma has claimed so many lives and is unfortunately destined to claim more. Educating, equipping, and then empowering the public could save additional lives similar to the introduction of bystander cardiopulmonary resuscitation. Failure to take action at this time in our history would be the biggest tragedy of all.

Contributors Study design and primary composition were contributed by MMK. Editorial comments and review were contributed by GV and ZRC.

Competing interests None declared.

Provenance and peer review Commissioned; internally peer reviewed.

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REFERENCES

- 1 Streib E, Blake D, Christmas AB, *et al.* American Association for the Surgery of Trauma statement on firearm injuries. *J Trauma Acute Care Surg* 2016;80:849.
- 2 AMA to Congress: Lift Ban on CDC Gun Research. (Jun 15, 2016.) <http://www.medscape.com/viewarticle/864797>
- 3 Propper BW, Rasmussen TE, Davidson SB, *et al.* Surgical response to multiple casualty incidents following single explosive events. *Ann Surg* 2009;250:311–5.
- 4 Borgman MA, Spinella PC, Perkins JG, *et al.* The ratio of blood products transfused affects mortality in patients receiving massive transfusions in a combat support hospital. *J Trauma* 2007;63:805–13.
- 5 Gonzalez E, Moore EE, Moore HB, *et al.* Goal-directed hemostatic resuscitation of trauma-induced coagulopathy: a pragmatic randomized clinical trial comparing a viscoelastic assay to conventional coagulation assays. *Ann Surg* 2016;263:1051–9.
- 6 Eastridge BJ, Mabry RL, Sequin P, *et al.* Death on the battlefield (2001–2011): implications for the future of combat casualty care. *J Trauma Acute Care Surg* 2012;73:S431–37.

- 7 Kragh JF Jr, Walters TJ, Baer DG, *et al.* Practical use of emergency tourniquets to stop bleeding in major limb trauma. *J Trauma* 2008;64:S38–50.
- 8 Kotwal RS, Montgomery HR, Kotwal BM, *et al.* Eliminating preventable death on the battlefield. *Arch Surg* 2011;146:1350–7.
- 9 Elster EA, Butler FK, Rasmussen TE. Implications of combat casualty care for mass casualty events. *JAMA* 2013;310:475–6.
- 10 Wild J, Maher J, Frazee RC, *et al.* The Fort Hood massacre: lessons learned from a high profile mass casualty. *J Trauma Acute Care Surg* 2012;72:1709–13.
- 11 Garner A, Lee A, Harrison K, *et al.* Comparative analysis of multiple casualty incident triage algorithms. *Ann Emerg Med* 2001;38:541–9.
- 12 Gates JD, Arabian S, Biddinger P, *et al.* The initial response to the Boston marathon bombing: lessons learned to prepare for the next disaster. *Ann Surg* 2014;260:960–6.
- 13 Boston Trauma Center Chiefs' Collaborative. Boston marathon bombings: an after-action review. *J Trauma Acute Care Surg* 2014;77:501–3.
- 14 Campion EM, Juillard C, Knudson MM, *et al.* Reconsidering the resources needed for multiple casualty events: lessons learned from the crash of Asiana airlines flight 214. *JAMA Surg* 2016;13:1–6.
- 15 Jacobs LM, Warshaw AL, Burns KJ. Empowering the public to improve survival in mass casualty events. *Ann Surg* 2016;263:860–1.
- 16 Callaway D, Bobko J, Smith ER, *et al.* Building community resilience to dynamic mass casualty incidents: a multiagency white paper kin support of the first care provider. *J Trauma Acute Care Surg* 2016;80:665–9.
- 17 Rasmussen TD, Baer DG, Goolsby C. The giving back: battlefield lesson to national preparedness. *J Trauma Acute Care Surg* 2016;80:166–7.
- 18 Jacobs LM. The Hartford Consensus IV: a call for increased national resilience. *Bull Amer Coll Surg* 2016;191:17–24.
- 19 Jacobs LM, Burns KJ, Langer G, *et al.* The Hartford Consensus: a national survey of the public regarding bleeding control. *J Amer Coll Surg* 2016;222: 948–55.

PRESS RELEASE

TRAUMA SURGERY & ACUTE CARE OPEN

Trauma research funding needed now more than ever, say experts

Mass casualty events, both man-made and natural, set to claim many more lives

Funding for trauma research is needed now more than ever, and should become a priority in the wake of so many lives lost at mass casualty events—including most recently at the Pulse nightclub in Orlando, Florida, say experts in an opinion piece published in the online journal ***Trauma Surgery & Acute Care Open***.

Regrettably, mass casualty events, both manmade and natural, are set to claim yet more lives. And physicians and the public need to be adequately prepared to administer prompt evidenced based interventions to minimize the death toll, write US trauma surgeons from the University of California at San Francisco, Massachusetts General Hospital, and Brigham and Women's Hospital, Boston.

The need to boost US disaster preparedness is very much on the agenda, with several “promising developments,” say the authors.

These include a meeting of leading orthopedic and trauma surgeons and representatives of the US military convened in June in Chicago and the American Association for the Surgery of Trauma's statement on firearm injuries issued in the wake of the Orlando shootings, which left 49 dead and 53 injured.

Similarly, the American Medical Association passed a resolution at its annual meeting last month to advocate for lifting the federal ban on gun violence research in recognition of the fact that gun violence is a public health issue.

And two initiatives—the Hartford Consensus IV, which aims to educate the police and other first responders in how to staunch bleeding using military tourniquets and combat gauze, and the National Stop the Bleed campaign, launched by the White House in October last year, which aims to teach the public how to save the lives of trauma victims—are important, and to be welcomed.

Furthermore, a good deal of knowledge and experience have been accumulated over the past several years from treating casualties in the Iraq and Afghanistan wars, and a string of civilian bombings and shootings, including Fort Hood (2009), the Boston Marathon (2013), and Sandy Hook (2013), the authors point out.

But they caution: “As tragic as these mass casualty events truly are, we must not lose sight of the need to thoroughly examine each one for lessons learned (and relearned) in order to continuously prepare for the next one.”

Collaborating with the military and other relevant parties will also help to foster a research agenda that will ultimately save lives, they say.

But they add: "Great lessons have already been learned, but more are still to be taught. Adequate trauma research funding by governmental agencies, the military sector, and private industry should become a priority at a time when trauma has claimed so many lives and is unfortunately destined to claim more."

They continue: "Educating, equipping, and then empowering the public could save additional lives similar to the introduction of bystander cardiopulmonary resuscitation," warning: "Failure to take action at this time in our history would be the biggest tragedy of all."

About the journal:

Trauma Surgery & Acute Care Open is one of 60 specialist journals published by BMJ. The title is owned by the American Association for the Surgery of Trauma (AAST). The AAST is the premier scholarly organization for surgeons dedicated to the field of trauma and the care of critically ill surgical patients. Founded in 1938, the AAST has approximately 1300 members in 30 countries.

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