Boston Marathon bombings: An after-action review

The Boston Trauma Center Chiefs' Collaborative,
Boston, Massachusetts

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On April 15, 2013, the City of Boston suffered a terrorist attack involving two improvised explosive devices loaded with nails and brass "BBs." These devices were detonated nearly simultaneously at ground level at two separate, crowded sites near the finish line of the Boston Marathon. These explosions created a mass-casualty incident (MCI) on a scale not seen in Boston since the Cocoanut Grove fire. However, unlike the Cocoanut Grove, where in-hospital mortality ranged from 17% to 24%,[1] most patients injured in the Boston Marathon bombing survived. No one who arrived at a trauma center alive subsequently died—including two patients who were pulseless on arrival at the emergency department. This success is due to the excellent work done by health care workers and others at the scenes of the attack[2] and to the aggressive disaster preparation during the past decade by Boston Emergency Medical Services and local hospitals.[3–5]

On May 2, the Chiefs of Trauma (Chiefs) and Trauma Program Coordinators of the Boston Trauma Centers (Beth Israel Deaconess Medical Center, Brigham and Women's Hospital, Boston Medical Center, Boston Children's Hospital, Massachusetts General Hospital, and Tufts Medical Center) met to conduct a formal after-action review (AAR) of their trauma centers and the trauma system's response to this MCI. The AAR followed a traditional military model, where issues were discussed in an open, blame-free environment, focusing on identifying what went well and should be maintained as well as what did not go well and should be improved. The Chiefs agreed to form a consortium to create a joint database and publish comprehensive manuscripts based on the entire cohort of injured men, women, and children. This report is a synopsis of the findings of the AAR that will interest physicians responsible for preparing for or responding to similar MCIs in the future. Data regarding patient demographics, injury characteristics, injury severity, and disposition are contained in a second scientific publication, which is under editorial review at the time this report was submitted.

Timing

The timing of the MCI played an important role in allowing caregivers to save both lives and limbs. April 15, 2013, was Patriots' Day, a local but not Federal holiday, which meant that the Boston hospitals were operating on a nonholiday schedule. However, since Patriots' Day is also the day of the Boston Marathon, an event that shuts down much of the city, the operative schedules were light. The trauma centers were staffed at or near weekday levels, but scheduled elective operative volume was low. As others have noted, the timing of the attack, 2:50 PM, coincided with the change of shift at 3:00 PM, which resulted in a doubling of available support staff at the precise moment extra personnel were needed.[6] Despite the dramatic number of wounded, every injured patient benefited from a dedicated physician and nurse. With abundant personnel and a light operative schedule, the trauma centers were able to transfer patients to available operating rooms within minutes of hospital arrival. The extraordinary availability of critical resources and manpower at the moment of disaster may make the Boston Marathon bombing unique among MCIs. Every chief reported that their center had the capability to manage additional casualties above and beyond the number delivered to them by Boston emergency medical service (EMS). Although the preparation of the EMS/trauma care system played an undisputed role in saving lives, if an event of similar magnitude had occurred at a different hour, the outcome could have been different.

Communication

The Boston EMS radio system notified each trauma center when the scope of the MCI was apparent. All hospital personnel reported that they initially learned of the MCI before the EMS notification through some form of media, including television, radio, or Internet broadcasts covering the event live. All sites reported difficulty with communication among staff members (physicians or other health care workers) via cell phone, although cell phone texting was possible throughout the event.

Patient Volume

Severely injured patients arrived at the trauma centers in two distinct waves. A third wave of less seriously injured patients arrived during the next few hours. The first patients, some in profound shock, arrived at trauma centers within 15 minutes of the first explosion transported by Boston EMS ambulances, police vehicles ("Paddy Wagons"), commercial ambulances, and private automobiles. One patient without a measurable blood pressure arrived at a trauma center's main entrance in a private automobile. Another facility received six critically injured patients in two Boston EMS ambulances, which arrived at the same moment. At least three EMS patient loading sites were hastily set up at the sites of the explosions. Triage among hospitals was conducted centrally from the EMS Command Center. However, some ambulances were redirected by law enforcement authorities who took control of the streets surrounding the blast sites. Patients who were in extremis were not evenly distributed among the centers; one Level I center received no such patients. Specific information regarding the demographics, severity of injury, and triage of patients will be presented in a second publication.

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Field Triage

Less than 50% of the patients arrived at the trauma centers with mass-casualty triage tags affixed to them. Some sites reported seeing no tags at all, and often, the tags were incompletely filled out. Uncertainty about additional explosives in the area created a sense of urgency to ambulance loading. In the rush to get casualties to the hospitals, tags were not attached to the most seriously injured. Fortunately, there was sufficient manpower at all of the receiving centers to permit an experienced trauma surgeon to triage patients as they arrived. This in-hospital expert triage was extremely effective and may have contributed to the excellent outcomes achieved. The nature of bombings like this one, in which multiple explosive devices create a large surge of critically injured patients as well as chaotic and dangerous scenes, suggests that field triage may not always be a realistic expectation.

Aid by First Responders

Another unusual feature of the Boston Marathon bombing was the proximity of a generously staffed medical resuscitation tent in immediate proximity to the blast zones. Injured patients were able to receive immediate care from nurses, physicians, paramedics, emergency medical teams, Boston Police, and National Guardsmen, some of whom had experience in the management of blast victims in war. The early and liberal use of tourniquets on bleeding extremities, possibly reflecting knowledge gained in combat,[7,8] may have contributed to patient outcomes. However, not all tourniquets were applied effectively. Several makeshift field tourniquets such as belts or other articles of clothing did not control bleeding sufficiently. Proper tourniquet technique, such as frequent tightening and occasional double tourniquet application on large extremities, were not used. Training for first responders should address this critical need.

Opportunities for Mutual Aid

Because of the resource-rich circumstances surrounding the Boston Marathon MCI, few sites required outside help. In two circumstances, surgical instruments were shared between trauma centers and in one case between a trauma center and a nearby community hospital. Orthopedic equipment representatives provided one trauma center with needed implants and appliances during the disaster. Had circumstances been different, the Chiefs noted that there is no established method for sharing patients, providers, or instruments. Of note, all MCIs occur while the "usual surgical emergencies," such as acute abdominal, vascular, and cardiac diseases, still occur. In no case was care of such an emergency patient compromised by the Boston Marathon MCI. However, plans should be made for non–MCI-related emergencies, which require no less attention, to be diverted or transferred to other hospitals. Moreover, it may be wise to include equipment suppliers in future MCI planning.

Lessons Learned From the Boston Marathon MCI

Overall Preparedness

(1) Resist complacency. The superb patient outcomes from the Boston Marathon Bombing resulted from not only from excellent predisaster drilling and planning but also from a confluence of fortunate timing and manpower factors that are unlikely to be seen in future MCIs. If these outcomes are to be expected from future MCIs, additional training with more limited personnel resources should be planned. (2) We recommend that major urban centers perform disaster preparedness training drills at a minimum of once per year. Such training should stress hospital-level triage of patients hurriedly transported from an insecure scene.

Communication

(1) MCI planning must take better account of the dependency of modern trauma services on cell phone communication and recognize that texting may be the primary cellular communication available in future MCIs. (2) Additional backup systems for communication within and between hospitals, including personal radio systems, should be developed.

Field Triage and Casualty Disposition

(1) Attacks with explosives create large, chaotic, and insecure scenes. Field triage of large numbers of casualties in such circumstances may be impossible. Planning for future MCIs should take this into account by developing universal and robust hospital-level triage protocols that use experienced surgeons in a triage capacity. (2) Methods should be developed to prevent or reduce the confounding effect on EMS hospital designation by law enforcement leading to uneven allocation of casualties. (3) A feedback system from hospitals to field triage personnel to avoid overloading individual Level 1 centers based on minute-by-minute updates during the early phases of in-hospital triage and treatment should be developed. (4) Disaster planners should consider the redesign of color-coded field triage tags to better document the minimum amount of critical information in the most rapid manner. (5) Disaster planning for future MCIs must recognize that scene triage may not be possible.

Tourniquets

(1) Effective use of tourniquets as first aid should be part of the national first aid curriculum. (2) Military tourniquets should be stocked in all emergency vehicles in sufficient quantity to deal with multiple trauma patients.

Mutual Aid

(1) Better planning for sharing of equipment and non–MCI-related emergencies should be part of systemwide MCI planning.

The Trauma Chiefs recognize that the remarkable success in saving life and limb after the Boston Marathon bombing was a true multidisciplinary victory. That no patient who was not killed outright by the explosions subsequently died is a testament to excellent care provided by hundreds of highly skilled and well-trained professionals working in the field as well as in emergency departments, operating rooms, intensive care units, and hospital wards across the City of Boston.

REFERENCES

1. Faxon NW. The problems of hospital administration: I—the Cocoanut Grove disaster. *Ann Surg*. 1943;117:803–808.
2. Jangi S. Under the medical tent at the Boston Marathon. *N Engl J Med*. 2013;368:1953–1955.
3. Biddinger PD, Baggish A, Harrington L, et al. Be prepared—the Boston Marathon and mass-casualty events.. *N Engl J Med*. 2013;368:1958–1960.
4. Goralnick E, Gates J. We fight like we train. *N Engl J Med*. 2013;368:1960–1961.

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5. Gawande A. *Why Boston's hospitals were ready*, The New Yorker, 2013.
6. Walls RM, Zinner MJ. The Boston Marathon response: why did it work so well?. *JAMA*. 2013;309:2441–2442.
7. Beekley AC, Sebesta JA, Blackbourne LH, et al. Prehospital tourniquet use in Operation Iraqi Freedom: effect on hemorrhage control and outcomes. *J Trauma*. 2008;64(2 Suppl):S28–S37 discussion S37.
8. 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(2 Suppl):S38–S49 discussion S49–S50.

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APPENDIX

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