The Expanded Scope of Emergency Medical Practice Necessary for Initial Disaster Response: Lessons from Haiti

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ABSTRACT

A team of emergency physicians and nurses from Stanford University responded to the devastating January 2010 earthquake in Haiti. Because of the extreme nature of the situation, combined with limited resources, the team provided not only acute medical and surgical care to critically injured and ill victims, but was required to uniquely expand its scope of practice. Using a narrative format and discussion, it is the purpose of this paper to highlight our experience in Haiti and use these to estimate some of the skills and capabilities that will be useful for physicians who respond to similar future disasters.

Introduction

A team of emergency physicians and nurses from Stanford Hospital responded to the devastating January 2010 earthquake in Haiti. Since an international disaster response team had not yet been established at Stanford Hospital, members were selected for their availability, clinical experience, and willingness to encounter a potentially dangerous situation. Due to the extreme number of casualties, severity of injuries, and limited resources, existing in Haiti the team made constant attempts to improvise and expand its scope of practice. Although there is an increasing emphasis on generating disaster-trained practitioners who have completed programs such as Advanced Disaster Life Support (ADLS), many future disaster responders will be like us. They will volunteer and participate with only an emergency medicine background and willingness to help. The purpose of this paper is to highlight our team's experience in Haiti with a view to estimate some of the skills and capabilities that we feel would be useful for emergency medicine practitioners to achieve in advance, so that they may be best prepared to respond to similar future disasters.

Initial Response

After a 7.0 magnitude earthquake struck Haiti on January 12, 2010, a team of four emergency physicians and four nurses from Stanford University responded to Port-au-Prince under the auspices of International Medical Corps, a Los Angeles-based non-governmental organization with a track record of having responded to the 2004 tsunami that struck Sri Lanka. The Stanford doctors and nurses had extensive emergency medicine experience, but none was trained specifically in disaster medicine or response. When the team arrived at the Hôpital de l'Université d'État (HUEH) 4 ½ days after the earthquake, it witnessed massive human and environmental devastation. An estimated 800 to 1,000 critically injured and ill victims awaited treatment within the confines of HUEH, which had been severely crippled by the earthquake (Figure 1). Most buildings were significantly damaged and many had collapsed. There was no running water, electricity, communications system, or sanitation, and only a few care providers on site.

Figure 1 Walkway Inside HUEH, 5 Days After the Earthquake

Upon our arrival, two volunteer orthopedic surgeons from the United States were staffing a pair of operating tables within an approximately 800 square-foot concrete building. Another similarly sized building functioned as the sole preoperative and postoperative treatment location. Most patients remained outside, protected only by sheets, blankets, and tarpaulins suspended from tree limbs or improvised posts. The main goals of the first days after the earthquake prior to our arrival had been necessarily limited to alleviating suffering with pain medications and treating patients that might otherwise rapidly die. There were extremely limited support services and personnel; therefore, our team members functioned in an internal interchangeable fashion, with each person needing to understand the others' skills and responsibilities, as is emphasized for other critical treatment teams, such as Critical Care Air Transport Teams.

Clinical Considerations

Our comments are intended to call attention to clinical considerations that highlight deficiencies in emergency medicine education and practice that are important to all team members responding to an earthquake related disaster. There were also many non-clinical aspects of disaster medicine, such as administration, communications, sanitation, facilities and pharmacy management, and mass casualty triage, for which we also had direct responsibility; it is obvious that these are areas of specialized knowledge for which emergency team responders should receive advance training.

Fracture Management

Extremity and pelvis fractures were common sequelae of falling debris. Since many fractures were open and complex, they were fairly easily diagnosed and then triaged for operative repair. In less obvious cases, ultrasound has been shown to be helpful in diagnosing extremity fractures and, in the absence of functioning radiography equipment, was used in Haiti to diagnose some injuries.[1,2] We recommend that future emergency medicine responders be able to use ultrasound to diagnose bony fractures, pneumothorax and intraperitoneal bleeding, to locate blood vessels for cannulation, and to assist with nerve blocks.

Improvised traction was the main treatment for adults and children with femur fractures. When available, Steinman pins were manually drilled through tibias.[3,4] Weights were improvised using bottles filled with water or cinderblocks suspended over an elevated railing, rigged metal frame, or bedpost (Figure 2). A rope or cloth attached to the weight was fastened to the patient's distal extremity via the Steinman pin or an improvised ankle loop.[5-7] Another method was to create plaster ankle casts with plantar foot loops to serve as attachment points. Closed femur fractures in children were sometimes held in place with hip Spica casts.[8,9] Strips of wood or rigid plastic tubes were incorporated into casts to improve rigidity, particularly when plaster was in short supply. When plaster materials were depleted, splints were constructed of cardboard or wood held in place by strips of cloth. We recommend that future emergency medicine responders be facile at all manner of non-operative and improvised fracture management.

Amputations

With operating room resources overwhelmed, the number of required life-saving amputations exceeded the capacity of trained surgeons. We recommend that future emergency medicine responders be well trained to perform life-saving amputations in order to free trapped persons or remove unsalvageable extremities. An acceptable and uncomplicated amputation technique for open, infected wounds is the guillotine amputation. Ideally, a field amputation kit should include a Gigli saw, Liston amputation knife, scalpel, hemostats, gauze dressings, tourniquets, povidone-iodine solution, gloves, and a method for providing anesthesia.[10] Optimally, the level of amputation should be chosen to free the limb, preserve a weight-bearing area, and maintain skin flaps for a lower extremity stump that will anchor a future prosthesis. Generally, it is best to preserve a distal joint, such as the knee, if this is technically feasible and not anticipated to lead to serious infection.[11] Also, special emphasis should be placed on the utility of tourniquet use, particularly with non-military providers, since it is not a standard part of the in-hospital emergency medicine armamentarium.[12] Indeed, aspects of pre-hospital care, such as scene control, extrication, and litters and carries, that are also practiced by military-trained personnel but not formally taught in detail during an emergency medicine residency, should be incorporated into the preparation of emergency medicine doctors and nurses who intend to respond to disasters.

Fasciotomies

Given the large number of severe crush injuries encountered, and the absence of equipment with which to measure intracompartmental pressures, we decided to

Figure 2 Improvised Traction after Fracture Reduction

perform fasciotomies in nearly all cases with a significant suspicion for compartment syndrome. We recommend that future emergency medicine responders be trained and competent to perform fasciotomies. These may need to be created in the lower and upper extremities.[13,14] To obtain experience, emergency physicians should practice supervised fasciotomies on cadavers or in animal labs, or assist in the operating room prior to needing to perform these procedures during or following a disaster.

Sterilization

We recommend that future emergency medicine responders be prepared to manage their equipment preparation and procedures from start to finish. For instance, wound care involved preparing topical disinfection solutions, managing severe open wounds, debriding infected wounds, and disinfecting surgical instruments and equipment. Equipment cleansing and sterilization were achieved without access to autoclaves. Clinicians should be aware that prions, coccidia, and certain spores, such as those of *Clostridium tetani,* are likely not eliminated without using an autoclave; however, other infectious agents, such as lipid viruses, non-lipid viruses, fungi, vegetative bacteria, and mycobacteria, may still be eradicated.[15] Field disinfection of instruments may be accomplished as follows. The first step is to disassemble tools, soak them in cold water containing a surfactant or proteolytic enzyme, such as PowerZyme™ (Potomac Labs, Rockville, MD), and then scrub them to remove visible organic debris. The next step is total immersion in boiling water for at least one full minute, which kills most non-spore and non-prion pathogens. A "gentle, rolling" boil reduces evaporation and the need for frequent water replacement. Adding sodium bicarbonate to achieve a 2% concentration raises the boiling point and reduces instrument corrosion; alternatively, boiling in water with a 1% concentration of acetic acid (white vinegar) can reduce lime deposits. If it is not possible to boil instruments, then a 30-minute soak in 7.5% hydrogen peroxide solution or 20-minute soak in 2% glutaraldehyde is recommended. Unfortunately, these toxic chemicals can be difficult to transport safely to the disaster scene.

Maggots

Wound myiasis—maggot (larvae) infection—was frequently noted. Though maggots are often thought to be beneficial for necrotic wounds and used in maggot debridement therapy (MDT) to treat diabetic ulcers and other chronic wounds, there is no value in allowing naturally-occurring, uncontrolled wound myiasis to persist, as this does not improve wound care and is more often detrimental. In a field setting, most wound myiasis is caused by the flies *Cochliomyia hominivorax, Chrysomya bezziana,* or *Wohlfahrtia magnifica*. The maggots of these species are obligate parasites that eat live tissue, unlike the maggots used for MDT.[16-18] In addition to destroying viable tissue, flies and larvae transmit bacteria that promote infection (including *C. tetani*). Thus, it is important to treat wound myiasis by by applying larvicides and then irrigating with povidone-iodine solution or applying ivermectin as a 10% topical solution. Alternatively, ivermectin may be administered as a single, oral dose of 200 micrograms per kilogram of body weight. Another effective method is to occlude the wound with petroleum-based ointment or dressings for at least 24 hours, then manually extract the larvae using forceps.[16] That was impractical in our setting, and we did not have access to ivermectin. For our team, irrigation with 10% povidone-iodine solution was effective in removing maggots. We recommend that future emergency medicine responders to earthquake disasters be trained in both usual and unusual manifestations of wound infections and complications, because these will be the most frequent clinical situations encountered in the immediate aftermath of the disaster.

Post-Death Issues

After a disaster, dead bodies are often brought to medical facilities. Upon entering HUEH, we learned that hundreds of bodies had been removed from roadways in front of the treatment areas the previous day. However, dozens of bloated corpses remained nearby and within the hospital compound. For the next few days, until bodies could be removed or crammed into (non-functioning) refrigerators in the hospital morgue, small streams of fluid effluent from dead bodies ran past adjacent treatment and eating areas.

Misconceptions abound among laypeople and healthcare providers concerning health risks from dead and decomposing bodies. Unless the deceased have died of highly communicable diseases, such as cholera, the disease risk from dead bodies is exceptionally low.[19-22]

Knowledge of proper disposal techniques is essential, because disposition of dead bodies has important legal and profound emotional implications.[23] It is important to identify dead persons early, before decomposition distorts recognizable features. This usually happens 24 to 48 hours after death. If possible, facial photographs and fingerprints should be recorded, and identifying possessions, such as identity cards, jewelry and cellular phones, retained. Age, sex, height, and weight determinations may also be useful for victim identification. The bodies should be tagged in some fashion to allow correlation with collected data.

If individual disposal is desired, then bodies are best refrigerated in morgues. In a major catastrophe, when

Figure 3 **Improvised C-spine Stabilization**

there is no electricity or refrigeration, bodies can be maintained for 24 to 48 hours in a single-layer, one meter deep grave surrounded by dry ice and covered by a tarpaulin.[23] In the absence of dry ice, placing bodies into a shallow, organized grave preceding final burial is advised. The location of disposed bodies should be well marked and correlated with identifying information. When feasible, disposal of unidentified or unclaimed bodies should follow local customs.

Death is but one aspect of the enormous emotional toll upon the victims and responders. We recommend that future emergency medicine responders to disasters be cognizant of the predictable emotional turmoil that will afflict victims and responders. Responders will enhance care by recognizing and treating acute anxiety, depression, acute stress disorder and post-traumatic stress disorder in disaster victims, their teammates, and themselves.[24,25]

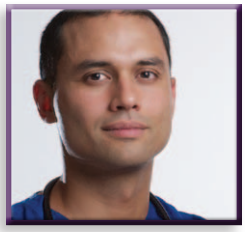
Conclusion

Disaster medicine is a highly specialized field, requiring years of training and experience, but it is to be anticipated that not all responders will have had full, if any, disaster medicine training. The nature of call-outs on extremely short notice to massively underserved areas will inevitably result in deployment of many available emergency medicine responders without disaster medicine training or being still in the process of training, yet with valuable clinical skills to offer. Our experiences responding to the January 12, 2010 earthquake in Haiti reflect the efforts of such a team of emergency doctors and nurses, and highlight the importance of creating in advance cross-functional teams of individuals trained beyond the purview of routine, in-hospital emergency medical care. Clinical skills could be enhanced by practicing techniques under the guidance of specialists and improved in non-disaster settings through more formal training.[26-28] In Haiti's immediate post-earthquake catastrophe, we wish that we could have done more to assist the victims, and hope that others will benefit from our observations to improve their pre-disaster education and training.

References

1. Marshburn TH, Legome E, Sargsyan A, Li SM, Noble VA, et al. (2004). Goal-directed ultrasound in the detection of long-bone fractures. *J Trauma*. 57:329–332.
2. Patel DD, Blumberg SM, Crain EF. (2009). The utility of bedside ultrasonography in identifying fractures and guiding fracture reduction in children. *Pediatr Emerg Care*. 25:221–225.
3. Garcia Renedo RJ, Garces Castillo J, Carranza Bencano A, Cano Luis P, Gomez del Alamo G, et al. (2010). Benefit of the stabilization of long-bone fractures in polytraumatized patients. *Acta Ortop Mex*. 24:3–7.
4. Scannell BP, Waldrop NE, Sasser HC, Sing RF, Bosse MJ. (2010). Skeletal traction versus external fixation in the initial temporization of femoral shaft fractures in severely injured patients. *J Trauma*. 68:633–640.
5. Sabharwal S, Kishan S, Behrens F. (2005). Principles of external fixation of the femur. *Am J Orthop*. (Belle Mead NJ) 34:218–223.
6. Althausen PL, Hak DJ. (2002). Lower extremity traction pins: Indications, technique, and complications. *Am J Orthop*. (Belle Mead NJ) 31:43–47.
7. Hull JB, Bell MJ. (1997). Modern trends for external fixation of fractures in children: A critical review. *J Pediatr Orthop*. B 6:103–109.
8. Wright JG. (2000). The treatment of femoral shaft fractures in children: A systematic overview and critical appraisal of the literature. *Can J Surg*. 43:180–189.
9. Boardman MJ, Herman MJ, Buck B, Pizzutillo PD. (2009). Hip fractures in children. *J Am Acad Orthop Surg* 17:162–173.
10. Sharp CF, Mangram AJ, Lorenzo M, Dunn EL. (2009). A major metropolitan "field amputation" team: A call to arms . . . and legs. *J Trauma*. 67:1158–1161.
11. McIntyre KE, Jr., Bailey SA, Malone JM, Goldstone J. (1984). Guillotine amputation in the treatment of nonsalvageable lower-extremity infections. *Arch Surg*. 119:450–453.
12. Kragh JF, Jr., O'Neill ML, Walters TJ, Jones JA, Baer DG, et al. (2011). Minor morbidity with emergency tourniquet use to stop bleeding in severe limb trauma: Research, history, and reconciling advocates and abolitionists. *Mil Med*. 176:817–823.

13. Maheshwari R, Taitsman LA, Barei DP. (2008). Single-incision fasciotomy for compartmental syndrome of the leg in patients with diaphyseal tibial fractures. *J Orthop Trauma*. 22:723–730.
14. Friedrich JB, Shin AY. (2007). Management of forearm compartment syndrome. *Hand Clin*. 23:245–254, vii.
15. CDC. (2008). Healthcare Infection Control Practices Advisory Committee: Guideline for Disinfection and Sterilization in Healthcare Facilities.
16. McGraw TA, Turiansky GW. (2008). Cutaneous myiasis. *J Am Acad Dermatol*. 58:907–926; quiz 927–909.
17. Hunter S, Langemo D, Thompson P, Hanson D, Anderson J. (2009). Maggot therapy for wound management. *Adv Skin Wound Care*. 22:25–27.
18. Gupta A. (2008). A review of the use of maggots in wound therapy. *Ann Plast Surg*. 60:224–227.
19. de Ville de Goyet C. (2000). Stop propagating disaster myths. *Lancet*. 356:762–764.
20. Health concerns associated with disaster victim identification after a tsunami—Thailand, December 26, 2004–March 31, 2005. *MMWR Morb Mortal Wkly Rep*. 54: 349–352.
21. Gionis TA, Wecht CH, Marshall LW, Jr., Hagigi FA. (2007). Dead bodies, disasters, and the myths about them: Is public health law misinformed? *Am J Disaster Med*. 2:173–188.
22. de Ville de Goyet C. (2004). Epidemics caused by dead bodies: a disaster myth that does not want to die. *Rev Panam Salud Publica*. 15:297–299.
23. Morgan OW, Sribanditmongkol P, Perera C, Sulasmi Y, Van Alphen D, et al. (2006). Mass fatality management following the South Asian tsunami disaster: case studies in Thailand, Indonesia, and Sri Lanka. *PLoS Med*. 3:e195.
24. Kar N. (2009). Psychological impact of disasters on children: Review of assessment and interventions. *World J Pediatr*. 5:5–11.
25. Bruce CA. (2007). Helping patients, families, caregivers, and physicians, in the grieving process. *J Am Osteopath Assoc*. 107:ES33–40.
26. VanRooyen M, Venugopal R, Greenough PG. (2005). International humanitarian assistance: Where do emergency physicians belong? *Emergency Medicine Clinics of North America*. 23:115–+.
27. Coule PL, Schwartz RB. (2009). The national disaster life support programs: a model for competency-based standardized and locally relevant training. *Journal of public health management and practice : JPHMP* 15:S25–30.
28. Subbarao I, Lyznicki JM, Hsu EB, Gebbie KM, Markenson D, et al. (2008). A consensus-based educational framework and competency set for the discipline of disaster medicine and public health preparedness. *Disaster medicine and public health preparedness*. 2:57–68.



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