

Trauma System: The Backbone of Disaster Preparedness

H. Gill Cryer, MD, PhD, and Jonathan R. Hiatt, MD

Background: To describe the Los Angeles County trauma system response to disasters.

Methods: Review of trauma system structure and multicaseualty events.

Results: The Los Angeles County trauma system is made up of 13 level I and II trauma centers with defined catchment areas that serve 10 million people in 88 cities over 4,000 square miles and receive more than 20,000 trauma activations annually. There is an organized disaster plan, which is orchestrated through the Medical Alert Center that coordinates the distribution of casualties from the scene of a multicaseualty event, with the most critically injured patients going to level I centers by air, severe injuries to level I and II centers by ground and air and less severe injuries to local community hospitals by ground. The plan has been used in several multicaseualty events over the last 25 years, the most recent of which occurred 6 hours after this paper was presented.

Conclusion: The system allows for all critically injured patients to be distributed to several trauma centers, so that all can be cared for in a timely fashion without overwhelming any one trauma center and without critically injured patients being taken to nontrauma centers where they cannot receive optimal care. The answer to disaster preparedness in our country is to develop this kind of trauma system in every state. Doing so will improve access of our population to excellent care on a daily basis and will provide a network of trauma centers that can be mobilized to most effectively care for victims of multicaseualty events.

Key Words: Disaster preparedness, Disaster, Trauma, Trauma system, Los Angeles County, Medical alert center, Multicaseualty incidents, Southern California.

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The purpose of this report is to use examples of multicaseualty events that occurred in the Los Angeles County trauma system to make the case that trauma systems should form the foundation for disaster preparedness.

At 10:30 AM, September 12, 2008, we presented this talk at the Pediatric Disaster and Emergency Services National Summit to make the case that trauma systems are the answer to the disaster preparedness problem. Approximately 6 hours later, a Metrolink train collided head on at high speed with a freight train, and the Los Angeles county Trauma

System proved us right. Within 1 hour of the crash, paramedics had extricated the most severely injured patients and distributed them by helicopter to eight trauma centers without overwhelming any one center. Ten patients were in hemorrhagic shock from internal bleeding and went directly from the emergency department to the operating room, three in each of three level I trauma centers and one in a level II trauma center. Numerous other patients required operations throughout the night and over the ensuing days for a variety of problems, including open extremity fractures, pelvic fractures, and take backs after damage control operations.

Would it have been possible for any one hospital to successfully manage these 10 critically injured hypotensive patients at the same time? Possibly, but they did not have to. It is this kind of system that gets the right patient to the right place at the right time even in a multicaseualty event. To make it work requires organization, practice, repetition, and postevent analysis to capitalize on the inevitable lessons learned with each incident. The majority of victims of disasters and multicaseualty events worldwide and in the United States suffer bodily injury.¹ It is clear that such victims are best cared for in a trauma center. Trauma centers are organized to be ready and waiting for any injured patient, with all of the technology and personnel immediately available to quickly diagnose and treat any kind of injury. They do it all the time, and they are good at it. They regularly see multiple critically injured patients daily and often simultaneously. Moreover, there is clear evidence that injured patients cared for in a trauma center are significantly more likely to survive than similarly injured patients cared for in nontrauma centers.^{2,3}

Unfortunately, even the largest and busiest trauma centers can become overwhelmed in a multicaseualty event or disaster situation if they are a stand-alone hospital. It is the trauma system that allows a preplanned response to a multicaseualty event. There are a number of models currently in use, and each has its advantages for specific local factors, depending on population, rural versus urban environment, and County and State political structure. In the State of Washington, as an example, Harborview in Seattle is a large level I trauma center that serves as the kingpin for the system, with multiple outlying level III and IV trauma centers under its umbrella throughout the state. San Francisco, on the other hand, has only one stand-alone level I trauma center.

We use a different model in Los Angeles. In our trauma system, five level I and eight level II trauma centers are spread throughout the county; each center has a designated geographic catchment area, but all centers work together through the Trauma Hospital Advisory Committee for quality improvement and organization. The 13 Los Angeles County

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From the Department of Surgery, David Geffen School of Medicine, University of California Los Angeles, Los Angeles, California.

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Address for reprints: Henry M. Cryer, MD, PhD, Department of Surgery, Ronald Reagan Hospital at the University of California Los Angeles, 757 Westwood Plaza, 8501P, Los Angeles, CA 90095; email: hcryer@mednet.ucla.edu.

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trauma centers serve more than 10 million people in 88 cities over 4,000 square miles and receive more than 20,000 trauma activations annually or a trauma victim every 25 minutes. Although each trauma center is normally responsible only for patients within its specific catchment area, during a multicaseualty disaster event, patients can be distributed to all the trauma centers as well as other nontrauma center hospitals that have agreed to participate.

MATERIALS AND METHODS

We reviewed the Los Angeles County disaster plan and several of the multicaseualty incidents that we have cared for using that plan.

RESULTS

The LA County disaster plan has been predetermined. It follows the concept outlined by MacKersie⁴, and it is designed to distribute the most severely injured patients to level I trauma centers, the severely and moderately injured patients to level II trauma centers, and patients with minor injuries to participating community hospitals. When a multicaseualty event occurs, the Medical Alert Center (MAC) is notified by emergency medical services. MAC then sends out a multicaseualty incident poll to hospitals in the region via the ReddiNet (all but one 9-1-1 receiving facilities in LA County have ReddiNet) for their bed availability. Trauma centers have a priori agreed to take a minimum number of patients without polling (6 trauma patients for level I and 3 patients for level II). The MAC will then relay the bed availability of the area hospitals to the paramedics who will transport the patients accordingly. The MAC will inform the hospitals and trauma centers of patients en route. In practice, this requires coordination of multiple paramedic services, including city fire and county fire, as well as several transport services, including basic life support ambulances, city and county fire, and county sheriff helicopters. A plan alone is of course insufficient. That plan must be practiced with semi-annual drills, and it must be used. Only by continuous scrutiny and use can imperfections in the plan be identified and rectified. Los Angeles has been the site of numerous disasters and multicaseualty events since the inception of the trauma system 25 years ago (Table 1). Further analysis of a few of these events will illustrate how the system is ideally suited for multicaseualty disaster response.

TABLE 1. Multicaseualty Incidents in Southern California 1983–2008

Incident	Year	Number Injured	Number Died*
Westwood disaster	1984	51	1
LAX airline crash	1991	64	34
Rodny King riot	1992	1200	38
Northridge quake	1994	138	33
Santa Monica crash	2003	73	10
Glendale train crash	2005	106	10
Chatsworth train crash	2008	135	25

*Represents total deaths in the incident.

The first illustrative event was the LAX US Air, Sky-West Airline collision in 1991. A 737 landed on a stationary commuter plane in the dark. The two planes fused together and slid down the runway until striking a hanger and bursting into flames. All passengers in the commuter plane were dead at the scene, as were 20 on the 737. There were 30 injured patients able to leave the 737, 13 of them with severe injuries. The injured patients were all transported by helicopter with a single severely injured patient and one or two less severely injured patients to each of the 13 trauma centers in the system. All patients survived, and the impact on each trauma center was minimal. For the trauma centers, it was business as usual and really no different from any other night. We did not even think to write it up. But we do recognize that in some respects we were lucky. The incident happened at the airport that has a city fire station, multiple aircraft for transport, and easy access and outflow for the multiple aircraft used to transport the patients.

The second incident was the Santa Monica farmers' market car crash.⁵ An elderly man lost control of his car and barreled through three blocks of pedestrians in a crowded street that was supposedly blocked off to cars. This incident occurred in a busy part of the city, with little space for helicopters. Of the 73 injured people, eight were dead at the scene and 51 were distributed to area hospitals. Only two of these patients died. Of the 51 patients transported, 15 went to the University of California, Los Angeles by ground ambulance because it was the closest level I trauma center. An additional eight patients were taken by air to four other level I trauma centers, and 28 patients with lesser injuries were taken by ground to four area community hospitals. Again, the majority of severely injured patients were distributed to multiple level I trauma centers.

The most recent disaster was the Chatsworth Metrolink train crash that occurred on the final day of the disaster summit. There were 25 people dead at the scene. Of the 98 Chatsworth patients transported to area hospitals, 25 were transported to four level I trauma centers by air (5–8 patients per center). Four level II trauma centers received 39 patients by air and ground (2–17 patients per center). Eight local community hospitals received 34 patients, all by ground (2–12 per hospital). The field triage status was recorded for 91 patients. Of these, level I and II trauma centers received 27 of 33 (82%) of the immediate critical patients, 25 of 45 (56%) second-tier patients, and 9 of 13 (69%) minor injury patients. Community hospitals received only 6 of 33 (18%) critical patients, 20 of 45 (44%) moderate patients, and 4 of 13 (31%) minor patients. Only one patient transported from the scene died.

DISCUSSION

These examples illustrate the effectiveness of a mature trauma system for disaster preparedness and disaster management. The most severely injured patients are distributed to level I trauma centers, whereas patients with moderate to severe injuries are sent to level II trauma centers, and patients with minor injuries are distributed to community hospitals, resulting in an extremely low mortality rate. The success of this system rests on the concept that disasters are unpredict-

able but not unexpected and that the foundation of disaster preparedness is a well-functioning trauma system with a well-defined disaster plan that is refined by evaluating successes and failures after each incident.

Los Angeles County has embraced this concept, but what of the rest of the country? Unfortunately, very few states, including California, have a comprehensive statewide trauma system.⁶ As mentioned earlier, substantial evidence confirms that trauma centers improve outcomes of injured patients. Although there are numerous studies documenting this observation, the most compelling is the study by MacKenzie et al.² of a comprehensive sample of US hospitals. The authors showed a 25% survival advantage for patients treated in trauma centers, compared with nontrauma centers, after risk adjustment for severity of injury.

Several lines of evidence demonstrate that the establishment of trauma centers is insufficient to ensure that care is available to all who require it.^{1,7} There must also be a triage strategy to identify which patients need trauma center care and to provide a mechanism to ensure that they are transported to a trauma center. For this reason, the idea of regional trauma systems has emerged and it has now been shown that such systems provide an additional 10% survival benefit compared with states without such systems.³ Based on these findings, the importance of the regional trauma system concept has been recognized by Congress, and the Trauma Care Systems Planning and Development Act of 1986 was passed to build a trauma system infrastructure nationally. Although the modest funding (3–6 million dollars per year and multiple years with no funding at all) that this Bill has received over the years has led many states to develop initial assessments and plans for a trauma system, the funds have never been sufficient to actually develop such systems in most states. According to the Health, Resources and Services Administration statistics, only eight states have comprehensive trauma systems in place. Moreover, the Health, Resources and Services Administration statistics indicate that at least 25% of the US population lacks access to 9-1-1, aeromedical transport, or advanced life-support systems.⁸

Emergency department access is also deficient as described by the recent Institute of Medicine report on hospital-based emergency care.⁹ Interestingly, these facts differ markedly from public perception. In a recent national Harris poll,¹⁰ 89% of respondents believed that having a trauma system in place is as important as having state police, and 75% believed that their state has a trauma system in place, 69% would be extremely concerned if they learned this was not the case, and 79% believe that it is extremely important that hospitals in their state are prepared to handle large numbers of patients after a disaster or terrorist attack. Despite these expectations, most states do not have such an infrastructure in place. It is clear from the results of this poll that the American public understands the importance of trauma systems and believes that there is a safety net beneath them, which in many cases does not exist.

The meager appropriation of dollars to the Trauma Care Systems Planning and Development Act pales in comparison to the National Bioterrorism Hospital Preparedness Program

now called the Hospital Preparedness Program, which was passed in 2002 in response to 9/11. In 2006, the federal government granted \$474 billion to this program and zero dollars to the Trauma Care Systems Planning and Development Act. Unfortunately, the priorities of this program have been primarily focused on the ability of local hospitals to respond to biohazards. Most of the money has gone to stockpiling supplies, decontamination tents, and the like on the remote chance that an infectious terrorist attack might occur. It would seem that these funds are misdirected in many cases, because the most likely mass casualty events will be explosions, shootings, natural disasters, and mass casualty accidents associated with bodily injury.

Small disasters and multicasualty events occur every day in most cities in this country. In our view, the best way to prepare for a large-scale multicasualty disaster is to get good at taking care of the smaller ones every day. The means to deal with these mass injuries already exists in the form of well-designed trauma systems. These trauma systems should form the foundation of any disaster preparedness initiative, and development of trauma systems in every state in the Union should be our first priority instead of putting a tent that will never be used in the closet of every US hospital. If these trauma systems are developed nationally, they will be busy every day. Care of the injured patient in our country will improve significantly, and when large-scale multicasualty incidents occur, as our experience tells us that they will, these systems will be able to respond as ours did on the day of this important national disaster summit in Los Angeles. This national disaster summit should serve as a stepping stone to strengthen the trauma community and allow redirection of our priorities along these lines.

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