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Trauma Care in Mass Casualty Incidents

Postępowanie w obrażeniach ciała w zdarzeniach masowych

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The aim of this review is to discuss catastrophes and large-scale events from the perspective of the hospital trauma professional: the emergency physician, trauma surgeon and emergency room nurse.

Celem artykułu jest przedstawienie problemu katastrof i dużych zdarzeń masowych z perspektywy profesjonalistów: lekarzy pracujących na ostrym dyżurze, chirurgów urazowych oraz pielęgniarek opiekujących się pacjentami przyjętymi w trybie nagłym do szpitala.

Did you ever stand in the Emergency Department of your hospital, trying to remain calm and effective while screaming and bleeding casualties from a mining disaster, a roof collapse at a trade hall or a train accident are pouring in through the door? If you haven't yet – chances are that you will. Since the turn of the 21st century, and especially since the large-scale terror attacks of September 2001 and Hurricane Katrina in 2005, there has been a surge of interest in the medical consequences of disasters within the emergency medicine and trauma community.

Yet amid the wailing sirens of approaching ambulances, the terrible sights on television, the hectic activity of trauma teams and the emotional outrage of the public, many of us in the trauma community continue to think of mass casualty incidents primarily as logistical and organizational headaches. We presume that trauma care in disasters is similar to our normal daily practice and that a disaster is, in essence, just "more of the same". This is a dangerous misconception. A mass casualty incident is a unique challenge to a trauma system because a large number of casualties have a dramatic effect on our ability to provide high-quality medical care to critically injured patients [1]. It is therefore surprising that there has been little discussion of how trauma teams should actually be working during mass casualty incidents and how this is different from what we do every day.

The aim of this review is to discuss catastrophes and large-scale events from the perspective of the hospital trauma professional: the emergency physician, trauma surgeon and emergency room

nurse. We will first present the theoretical basis for trauma care in disasters and demonstrate how the special circumstances of such incidents affect the treatment of severely injured patients. We will then translate these principles into practical advice on how to prepare the trauma service for large-scale events. We will not address issues of command and control, first response in the field, communications, logistics and national policy. Instead, we will look at disasters from the clinical perspective of the hospital-based traumatologist.

Definitions and casualty severity distribution

In a disaster scenario, a trauma system is suddenly confronted by a large number of casualties arriving within a short period of time. This unexpected "surge" of patients creates a discrepancy between the casualty load and the resources available to treat them. The casualty load is best described not by the absolute number of arriving patients but by their arrival rate (e.g. 15 casualties per hour). From the trauma care perspective, we distinguish between three types of disaster scenarios [2]:

Multiple casualty incidents involve dozens of casualties and can be effectively managed using local hospital resources. In other words, the casualty load will strain – but not overwhelm – the trauma care resources of a hospital.

Mass casualty incidents involve hundreds of casualties. Despite an effective disaster plan, the casualty load exceeds the capability of the hospital to provide high-quality trauma care for all critically injured patients. Therefore, the term

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"mass casualty" implies some degree of failure to provide optimal trauma care: some severely wounded patients will not receive the level of care they require, others will experience significant delays. The fact that the term "mass casualty" implies some failure of trauma care is a key point in our discussion.

A major medical disaster typically results in thousands of casualties and destruction of organized community support systems. In this scenario, trauma care for individual patients ceases to be an issue. Timely splenectomy for a bleeding patient in shock is impossible because there are no available operating rooms or surgeons. The focus of attention shifts to public health concerns that threaten entire communities. A major medical disaster is no longer about the patient with the epidural hematoma; it is about 3000 patients with cholera in a town demolished by an earthquake. It is also about the late complications of trauma (such as large number of patients with acute renal failure from crush syndrome, as was seen following the major earthquake in Turkey in 1999).

A central feature of every disaster is the casualty severity distribution. Regardless of the etiology or magnitude of the catastrophe, only about 10-15% of survivors presenting to a hospital will be severely wounded and will require high-level trauma care immediately. Most others have minor or non-urgent injuries and can tolerate significant treatment delays [3]. For example, during the Madrid bombing on March 11 2004, ten bombs exploded simultaneously on commuter trains and in train stations across the city. The closest university hospital received 312 casualties within approximately 3 hours (a heavy casualty load of roughly 100 casualties per hour). However, only 29 (9%) of these arriving casualties were in critical condition and only 7 (2%) required immediate surgery (4). A similar severity distribution was reported from the London bombing on July 7, 2005 [5]. This casualty severity distribution is a constant feature of disasters and forms the rationale for planning an effective hospital response.

What is the real goal of our hospital disaster response?

The media and the public naturally focus on total number of casualties from a disaster, and on the death toll. Our perspective as traumatologists is somewhat

different: we must focus on the small number of critically injured patients that are contained within the much larger group of arriving casualties. In other words: we must focus on the 10 percent. From the trauma care perspective, success in dealing with a multiple casualty bus accident (such as the PKS bus disaster near Gdansk in 1994) is not organizing the flow of 40 casualties through our Emergency Department, but providing optimal trauma care to the 4-5 critically injured (but salvageable) patients among them. Saving the lives of the few patients in shock, or with an intracranial bleeding or a bad pelvic fracture – this is the crux of the entire effort. The dozens of patients with superficial lacerations, distal fractures, concussion or severe emotional distress are the distractions. If, because of a disorganized response, we lose two critically injured patients that could have been saved, our disaster response has failed – regardless of the media praise of our "heroic efforts".

From the traumatological perspective, the ultimate goal of the entire hospital disaster plan is to provide the few severely wounded casualties with a level of trauma care that is as close as possible to the care provided to similar patients on a normal day. This goal has always been implicitly understood by traumatologists and is also an expectation of the public. It can only be achieved through diversion of our attention and our trauma resources from the mildly injured to the critically wounded.

Every modern trauma center maintains a dedicated trauma service line (or system) for severely injured patients. As trauma care professionals, this is what we do every day. Our system includes trauma teams, immediate access to technology (such as a CT scanner or a ventilator) and facilities (such as resuscitation bays, operating rooms or angiography suites), all available and prepared for the severely injured patient. This trauma system is typically designed for 1-2 badly wounded patients, but has limited capabilities to treat multiple critical patients simultaneously. The goal of an effective disaster response is therefore to preserve this capability to provide good quality trauma care to the severely wounded in the face of an unusually large casualty load.

Surge capacity and quality of trauma care

How many severe casualties from a large-scale scenario (such as the Katowice Trade Hall roof collapse in 2006) can your

Emergency Department accommodate? The truth is that many of us have an exaggerated view of our institutional capacity. As the event unfolds and more and more casualties arrive, finding an available resuscitation bay and staffing it with an experienced trauma team becomes increasingly difficult. Even in a large university hospital with a dedicated trauma department, the first severely injured patient from that train accident will receive the best available care in a proper resuscitation bay by the trauma team on call. However, the eighth critical casualty is likely to end up in an improvised resuscitation bay, in the hands of a doctor and nurse with little trauma experience. And what about the 20th severe casualty? He or she will be much better off in another hospital, even in a smaller institution with limited resources. You really don't want to be critical casualty number 20 – not even in the very best Emergency Department in Poland...

The point beyond which a good level of trauma care can no longer be sustained for arriving casualties is the surge capacity of the hospital trauma system [3]. When the surge capacity (expressed as a casualty arrival rate, not as an absolute number of patients) is exceeded, we see a gradual decline in the level of care. This gradual failure mode is a salient characteristic of the disaster response of any hospital, and has been analyzed in a recent computer simulation study [6].

So what is the surge capacity of your hospital? One rough estimate based on empirical calculations [7], puts the number at 1 critical patient per hour, per 100 hospital beds. In a 500-bed hospital that would mean roughly 5 severely wounded patients per hour during a normal working day. This surge capacity can double when the hospital disaster plan is deployed in full and staff is called in from home. However, at night and on weekends, the surge capacity is greatly diminished since there is only one trauma team in the hospital.

It is important to emphasize that the surge capacity marks the dividing line between multiple casualty (below surge capacity) and mass casualty incidents (above it). Luckily, genuine mass casualty incidents are very rare, because there is an inverse relationship between the magnitude of a catastrophe and the likelihood that it will happen in reality. Multiple casualty incidents do occur in every hospital from time to time. However, mass casualty incidents that exceed the surge

capacity of a large hospital are extremely rare and most of us are unlikely to experience such an event during our careers. When structural collapse is involved (as in the twin towers in New York City in 2001), there will be many dead – but not many wounded. More importantly, the pre-hospital emergency medical system (EMS) of major cities serves as an effective buffer that keeps the casualty load for every hospital below the surge capacity. We saw a good example of this in Madrid in 2004 and in London a year later [4,5]. Both these terrorist attacks involved multi-focal simultaneous bombings that were deliberately planned to overwhelm the metropolitan disaster response. Both failed to do so. While the total number of casualties in both incidents was well within the range of a mass casualty incident (more than 2000 in Madrid, 775 in London), the metropolitan emergency medical systems responded by distributing the casualties between several hospitals, so that each institution faced only a multiple casualty incident. This "buffering" mechanism was conspicuously absent after the US embassy bombings in Nairobi in 1998, when some 5000 casualties overwhelmed the Kenyatta National Hospital. This poorly documented catastrophe was probably the only genuine mass casualty incident in recent years.

Triage: facts and fiction

Triage is the process of sorting casualties according to treatment priorities. Triage at the hospital door is viewed as a key component of the hospital disaster plan [8]. Traditionally, the triage officer sorts arriving casualties into five categories: immediate (life-threatening injuries), delayed (serious injuries but not immediately life-threatening), minimally injured, expectant (badly wounded patients without hope of survival), or dead. In other words, the triage officer is expected to make very serious life-and-death decisions very rapidly. It is therefore not surprising that in many hospitals the most experienced traumatologist is assigned to be the triage officer. For example, at Bellevue Hospital, the largest trauma center in Manhattan, the triage officer standing at the hospital entrance on the morning of September 11, 2001, was the Chief of Surgery [9].

Experience from real-life incidents has changed this heroic view of triage into a more pragmatic approach [1]. As any trauma professional knows, it is often

impossible to distinguish between "immediate" and "delayed" casualties based only on rapid cursory look of a few seconds on the ambulance dock. It is also frequently impossible to pronounce a casualty dead without a cardiac monitor and a more thorough examination. The "expectant" category is especially problematic because deciding that a casualty is hopeless often depends on the specific circumstances: the same badly injured patient may be deemed potentially salvageable if he or she is an early arrival, but declared hopeless when the Emergency Department is full or overwhelmed.

For all these reasons, realistic triage at the hospital door consists of two categories only: those patients referred to the trauma resuscitation area (and thus enter the hospital trauma system) and all others (10). When the casualty load is expected to exceed the capacity of the Emergency Department, it is useful to separate walking casualties (i.e. those who can sit in chairs and usually have minimal or no physical injuries) from the non-walkers and send them to a designated area outside the Emergency Department, where they can be treated by medical staff that are not trauma specialists.

Even with this simplified approach, triage is often inaccurate. Over-triage is the assignment of non-critical casualties to the trauma resuscitation area. Over-triage rates of 50% or more at the hospital door are routinely reported in disasters [8]. We are concerned about over-triage because these "false positive" casualties compete with true critically wounded patients for the attention of trauma teams. Under-triage is the erroneous assignment of a critical casualty to the non-urgent area in the Emergency Department. While reported under-triage rates are low, each case represents a medical error that can directly result in preventable morbidity or even mortality.

Can triage accuracy be improved? There is no evidence that a senior traumatologist will do a better job at triage than a less experienced team member, or that a surgeon or emergency physician will do it better than a nurse [11]. So, instead of assigning the most experienced traumatologist to the ambulance dock, a more practical approach is to accept that triage at the hospital door will always be inaccurate and to implement an ongoing iterative process of re-evaluation where triage at the door is only the first step. Triage continues through repeated re-assessments of each patient inside and

beyond the Emergency Department. As each casualty is evaluated again and again, errors made during initial triage are identified and corrected [11].

Practical considerations in the Emergency Department

The hospital disaster response is initiated when the hospital is alerted about an unusually large number of incoming casualties. Full mobilization of the hospital disaster response is time-consuming, disruptive to normal activities, costly – and often unnecessary. Most institutions therefore use a tiered response [9], with a "small" plan for limited events (e.g. 10-20 casualties, 2-4 critically injured) and a "full scale" plan for mass casualty incidents. The former relies on existing in-house staff and resources, while the latter mobilizes the entire range of staff and resources that the hospital can recruit, including bringing staff from home and interrupting normal hospital operations. The "small" plan is used in real life from time to time. The large one is reserved mainly for disaster drills. As an illustrative example, in the entire recent Israeli experience with dozens of urban bombings (2000 - 2004), there has not been a single incident where the full-scale disaster plan of a hospital had to be deployed. During this wave of urban terrorism, the only instance in which the Emergency Department of the Hadassah University Hospital in Jerusalem came very close to capacity was a floor collapse in a wedding hall, resulting in some 250 casualties.

The hospital disaster plan must make absolutely clear who is authorized to activate the disaster response. This can be initiated by a senior hospital administrator, or by a local manager such as the nurse in charge in the Emergency Department. The former reflects a traditional top-down organizational mentality, but comes at the price of significant delays. Empowering the attending emergency physician in the Emergency Department or the nurse in charge to activate the disaster plan reflects a more flexible approach with much faster activation of the hospital response.

The first few minutes (between receiving notification and the arrival of the first ambulance) are critical to the success of the hospital response. The critical facilities that must be notified immediately are the Emergency Department, the Operating Room, Intensive Care Unit, imaging (mostly the CT scanner) and the blood

bank. Each facility then activates its own internal disaster plan.

The first priority in the Emergency Department is rapid evacuation to create physical space (empty beds) for incoming casualties [3,10]. Based on their medical condition, patients can be rapidly discharged, admitted to the floors, or transferred to a pre-designated location outside the Emergency Department. Emergency equipment is rapidly deployed, and additional staff (doctors and nurses) is mobilized either from home or from the hospital floors and clinics.

The emergency physician in charge and the nurse in charge "run the house" together. They are responsible for all medical, administrative and logistical aspects of the Emergency Department during a catastrophe. But someone must also make difficult clinical decisions about the severely injured patients. The Israeli experience emphasizes the role of a "surgeon in charge", a trauma surgeon responsible for making all key clinical decisions in the trauma resuscitation area of the Emergency Department [12]. The important difference between daily trauma care and a disaster scenario is that in the latter situation, a trauma team leader working on a critically injured patient in the resuscitation bay does not have the autonomy to make independent clinical decisions. The need for an operation, a CT scan or an Intensive Care bed may be obvious, yet the facility may not be available because other patients have priority. Every clinical decision must therefore be considered in the larger context of the overall situation. One experienced traumatologist must maintain medical control of the entire trauma resuscitation area, where the critically wounded patients are treated. This "surgeon in charge" continuously roams between the severely injured patients and has direct responsibility for making all key clinical decisions [10,12]. Early during the wave of urban bombings in Israel in the 1990's, trauma surgeons learned that their most effective place is not as triage officers on the ambulance dock but inside the trauma resuscitation area of the Emergency Department, directing the care of the most severely injured patients (and also correcting errors made in initial triage).

Beyond the Emergency Department

Operating Room availability is not a major concern in disasters because only

very few casualties require emergency operative procedures. Furthermore, in large-scale events such as the bombings in Madrid or London, there was a time interval of more than an hour between activation of the hospital disaster plan and the first operative procedure. During normal working hours, all elective operative lists are cancelled. An experienced surgeon is put in charge of the entire Operating Room suite, as we describe in the next section.

Contrary to the situation in the Operating Rooms, the availability of Intensive Care beds is a source of grave concern, especially in urban bombing incidents [13], where roughly one of every four admitted patient will need an intensive care bed. A mass burn incident (such as the Rhode Island nightclub fire in 2003 or the Kamien Pomorski homeless hostel fire in 2009) is another type of catastrophe in which an acute shortage of intensive care beds for severely burned patient can be anticipated. A burn disaster often involves transfer of burn patients not only to other hospitals but even to other geographical regions. After the Volendam disco fire in the Netherlands in 2001, some 20 severe burn patients were sent to specialized burn units in Belgium and Germany.

The hospital disaster plan must therefore include protocols to rapidly expand the Intensive Care bed capacity of the hospital. This is typically accomplished by using facilities such as the post-anesthesia care unit (recovery room) in the Operating Room suite to accommodate an overflow of ventilated patients. During Tropical Storm Alison that in Houston in June 2001, a large university hospital (Hermann Hospital) had to be evacuated due to flooding and power failure. The entire surgical and cardio-vascular intensive care unit was transferred to the post-anesthesia care unit of an adjacent city hospital.

The crucial role of clinical decisions

Hospital administrators, used to operate within top-down hierarchical organizations often do not realize that in a disaster, the major engine that drives the hospital response are not bureaucratic decisions made in the administrator's office but clinical decisions made at the bedside. The movement of casualties between facilities (e.g. from the Emergency Department to the CT scanner or to the Operating Room) depends entirely on clinical decisions, not administrative

ones. No patient will enter (or leave) a facility without a clinical decision made by a traumatologist.

In a traditional top-down organization, executive decisions are made at the top and implemented by the lower echelons. However, in a hospital coping with a catastrophe, the situation is the exact opposite: the key decisions are made at the bedside and the role of the institutional leadership is to support, facilitate and coordinate the implementation of these decisions.

The effective response of each facility within the hospital trauma system to a sudden influx of casualties hinges on decisions made by a very small group of experienced staff members, local managers whose decisions drive the entire effort [1]. Not only the Emergency Department but every service point where casualties are treated must have such a "gatekeeper". This "gatekeeper" must be capable of making tough clinical decisions, have the authority to implement them and also to shoulder the responsibility for mistakes. A good example is the Operating Room, where an experienced surgeon acts as a "gatekeeper" who decides on priorities. These decisions cut across multiple specialties and have to be accepted by surgeons and anesthesiologists from multiple disciplines, including chiefs of service.

Understanding the role of key decision makers has profound implications on training hospital staff for disasters. Disaster drills are costly and often frustrating exercises, conducted in very unrealistic time frames and with only symbolic consumption of resources. They are often treated as a "production", put up for the sake of hospital administrators or outside visitors eager to see a "show" with their own eyes. Instead of these costly productions, the emphasis in training should be on the key decision makers. Even in a large university hospital, a group of no more than 20-30 physicians, nurses, administrators and ancillary personnel are the real engine that drives the entire hospital disaster response. These key players are often local managers, responsible for critical areas within the hospital trauma system. They must not only understand the hospital disaster plan but also be able to "think outside the box" and to improvise unconventional solutions to difficult situations. What do you do when a new severe casualty arrives while all resuscitation bays are busy? Can you rapidly improvise a resuscitation bay in the

fracture room? What if there is no available operating room for a bleeding patient in shock? Can you accommodate 2 teams operating on 2 patients simultaneously in the same operating room? The ability to improvise solutions to such problems is an acquired skill that can be developed through table-top exercises, simulations and interactive discussions. This approach to training was pioneered by Professor Sten Lennquist from Linköping University in Sweden who later developed it into the Emergo Train system [15]. This training method, using simulation and tabletop exercises to teach "key players" in the hospital disaster response to make difficult decisions has gained tremendous popularity in western Europe but remains largely unknown in the USA, where the emphasis still remains on training hospital staff where to go, not how to think when disaster strikes.

Conclusion

The central message of this brief overview is that amidst the chaos and emotional turmoil of a disaster, we must not forget our core mission as traumatologists. Instead of preparing for "nightmare mega-scenarios" that we are unlikely

to see in our professional lifetimes, we would be well advised to prepare for limited events that all of us experience from time to time. We should keep in mind that the ultimate goal of our hospital disaster response is to provide a small group of critically injured casualties with a level of trauma care that is comparable to the care given to similarly injured patients under normal circumstances. Our top priority in a disaster situation is to preserve the dedicated trauma system of the hospital, a system that is our direct responsibility and our area of expertise. The many mildly injured patients are the "noise", the casualties you see and hear in the evening news. Our job is to focus on the few casualties who are silent, those whose battle for survival unfolds away from the cameras and the microphones. We are there for them.

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