Multiple Casualty Terror Events: The Anesthesiologist's Perspective

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In a 28-mo period 14 multiple-casualty terror events occurred in Jerusalem, challenging the Department of Anesthesiology and Critical Care Medicine of the city's sole Level 1 trauma center. We performed a retrospective review of the response of the department to evaluate staff activities, resource use (emergency department, operating rooms, and intensive care unit [ICU]), and patient flow. A total of 1062 people were injured in the 14 multi-casualty terror incidents. The emergency department treated 355 victims; 108 of them were hospitalized, and 58 underwent surgery during the first 8 h. Only two surgeries were performed during the first hour, and the average time to the first surgery was 124 min. Fifty-one patients were admitted to the ICU an average of 5.5 h after the terror event. After a terrorist act, multiple, simultaneous efforts were required of the anesthesiology department, including taking part in the initial resuscitation in the emergency department, anesthetizing victims for surgery and angiographies, and caring for them in the recovery room and ICU. Therefore, anesthesiology departments are greatly impacted by such events and must plan for them to maximize the use of available personnel and to have the appropriate equipment and supplies available.

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Worldwide terror attacks over the past few years have shown that no community is immune to terrorist activity (1). During a 28-mo period there were 91 multi-casualty terrorist actions in Israel (Table 1), 31 of them in Jerusalem. Most of Jerusalem's seriously injured were cared for at the Hadassah-Hebrew University Medical Center at Ein Kerem (750 beds), the only Level 1 trauma center in Jerusalem (population 678,000).

A retrospective analysis of the activities of the Department of Anesthesiology and Critical Care Medicine (CCM) during the initial 8 h after these events was undertaken. The aim was to identify and describe the operational issues faced by department members as they cared for the victims. The importance of examining the department's response to terror events is occasioned by the significant differences between the injuries caused by terror attacks and those caused by other mechanisms of trauma (2). It is hoped that the practical lessons learned from the present experience might help other departments develop protocols for managing such events.

Methods

A retrospective review of the Department of Anesthesiology and CCM's response to multiple-casualty terror incidents occurring between October 1, 2000, and January 31, 2003, was performed. Events with fewer than 9 admissions to the Hadassah emergency department (ED) were excluded because they did not meet the hospital's criteria for a "multiple casualty event." Emphasis was on the activities during the first 8 h after a terror attack. Information was assembled from newspaper archives, the medical center's trauma registry, the operating room (OR) schedule, and the intensive care unit (ICU) patient admission and discharge database. Information collected included type of attack, number of victims at the scene, number of patients (treated in the ED/trauma admitting area, hospitalized and admitted to the ICU), ED intubations, angiographies, occupied

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Table 1. Terror casualties according to assault type (all national attacks)

	Events	Dead	Injured	Killed/event	Injured/event	Injured/dead ratio
Premeditated car accident	1	8	25	8	25	3.12
Shooting at crowd	19	46	391	2.42	20.57	8.5
Open-space explosions	53	152	1976	2.86	37.28	13
Closed-space explosions	18	177	911	9.8	50.61	5.14

ORs at the time of the attack, time from the attack to the beginning of surgery, length of surgery, type of surgery (neurosurgery, cardiothoracic/vascular, laparotomy, soft tissue, bones), time to ICU admission, ICU length of stay, and ICU mortality.

Descriptive statistics were used. The data distribution was examined for normalcy. Parametric data are reported as mean ± SD and range. Nonparametric data are reported as median and range.

Results

Fourteen multiple casualty events, killing 97 people and injuring 1062 (median, 65 victims/incident; range, 13–199), were studied.

The Hadassah ED has 24 beds plus 3 in a trauma admitting area. Three-hundred-fifty-five patients (33% of all injured; median, 25/attack; range, 10–65) were received in the ED, 108 of whom were hospitalized (30% of ED admissions; median, 6/event; range, 1–26). Only 56 patients were triaged to the trauma admitting area (3.7 ± 3.2/event; range, 1–11). Twenty-seven patients were intubated in the ED. Twelve patients underwent diagnostic angiographies (7 pelvic and lower limbs, 5 aorta and limbs, all diagnostic), and most others underwent computed tomographic (CT) scanning. In addition to the 7 on-call anesthesiologists (5 in-house, 2 at home), 9 additional anesthesiologists (range, 6–14) were required to cope with the activities of the department (OR, ICU, delivery suite) when an incident occurred after working hours. The department's staff includes 27 attending physicians and 30 residents/fellows.

The OR suite has 17 rooms. At the time the attacks occurred a median of 7 (range, 0–14) ORs were in routine use. Of the 108 patients admitted to the hospital, 58 (54%) underwent surgery within 8 h (median, 3 surgeries/event; range, 1–11). Figure 1 shows the surgeries performed. Only 2 patients needed surgery during the first hour after an event (1 cardiac and 1 exploratory laparotomy). The mean time from the incident to the beginning of the first surgery was 124 ± 81 min (range, 37–360 min). Second and third surgeries were started 179 ± 146 min (range, 75–320 min) and 205 ± 123 min (range, 85–480 min) after the event, respectively. Surgeries lasted for 172 ± 110 min (range, 40–645 min). The number of ORs used simultaneously is shown in Figure 2. The peak number of ORs used simultaneously was 7 in 1 instance and 6 in 2 others (event victims only). Figure 3 demonstrates the chronological sequence of the various types of surgeries.

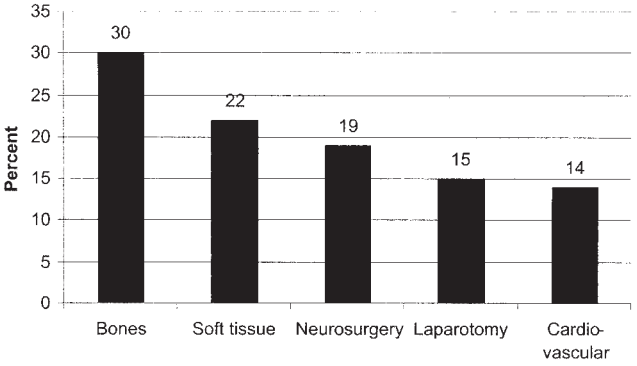

Figure 1. Types of surgeries performed in the first 8 h after an attack (percentage).

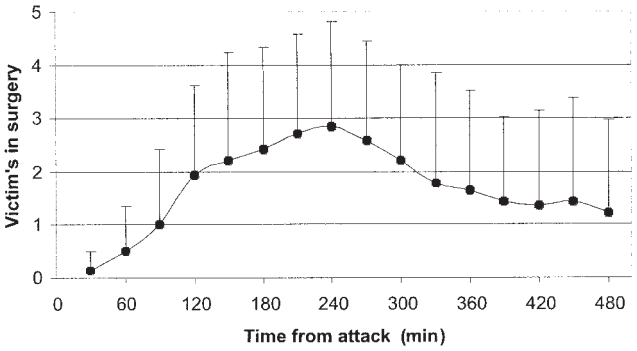

Figure 2. Number of operating rooms (mean ± SD) occupied in parallel according to time (attack victims' surgery only).

During the time that the terror victims were operated on, other patients were also undergoing surgery. For example, on February 25, 2002 a terrorist shot at a crowd. At the time of the incident three ORs were in use. During the evening four of the terror victims underwent surgery in addition to three unrelated urgent surgeries (Fig. 4).

The hospital has 28 surgical ICU beds (11 general, 6 pediatric, 5 neurosurgical, and 6 cardiothoracic). When ICUs are full, patients are treated in the 14-bed recovery room. Fifty-one patients (median, 4/event; range, 0–9) were admitted to an ICU (general ICU [GICU], 44; neurosurgical ICU, 5; pediatric ICU, 2). During the study period, 1259 patients were admitted to the GICU, of whom 44 (3.5%) were victims of these

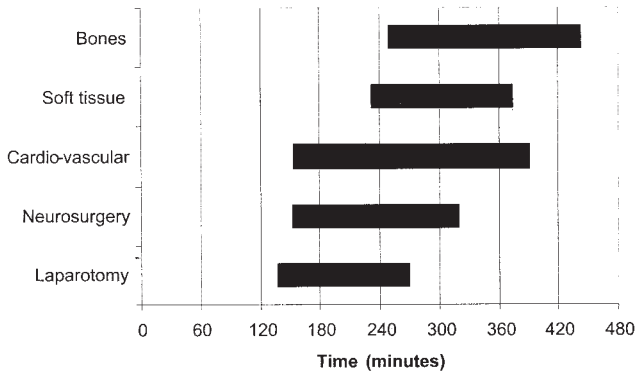

Figure 3. Mean time, from a terror attack, to the beginning and length of surgery done in the first 8 h (min).

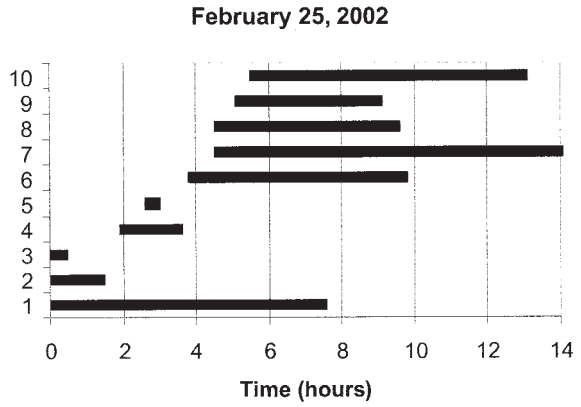

Figure 4. Operating room activity on February 25, 2002. At the time of the attack three operating rooms were in use (#1: elective neurosurgical operation; #2: liver transplant; #3: cesarean delivery). Four patients underwent operations related to the terror attack (#4: exploratory laparotomy; #8: orthopedic surgery; #9, #10: vascular repairs). Three patients underwent urgent operations unrelated to the terror attack (#5: cesarean delivery; #6: urgent mitral valve replacement; #7: liver transplant).

terrorist actions (median, 4 admissions/event; range, 0–8). Forty patients were transferred from the GICU (75% to a ward, 25% to another ICU) to provide vacant ICU beds. Twelve patients (victims from five different events, each associated with more than six admissions to the GICU) were initially admitted to the recovery room. Most of the patients were admitted from the ORs (61%), whereas the others came from the ED (32%) and the angiography suite (7%). The average time from the event to admission to the GICU was 5.5 ± 3.1 h (range, 1–13 h) (Fig. 5). Patients admitted directly from the ED or angiography suite were admitted earlier than those from the OR (mean 3.8, 3.7, and 6.3 h, respectively). The terror victims stayed in the GICU for 10.7 ± 15.1 days (median, 4.5 days; range, 1–67 days), whereas the mean length of stay for the entire GICU population was 6 days (median, 3 days). One patient died (2.2% of the victims admitted to the GICU; the overall mortality rate for the ICU was 9% in 2002) on the 10th day of ICU stay.

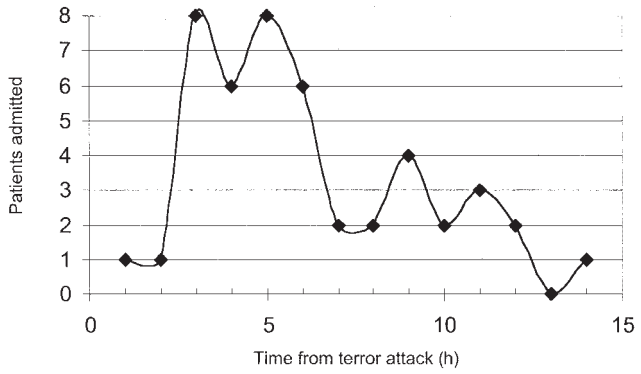

Figure 5. Patient admissions to the general intensive care unit according to time.

Discussion

Much of the published material regarding the medical aspects of terrorist actions has focused on injury patterns and ED experiences (2–4). These reports show that the care of these patients differs from that of patients with trauma from other causes because of different types of injuries (2–3). Patients hospitalized after terror events sustained more severe injuries (30% with injury severity score >16 versus 10% in other types of trauma) and had twice the mortality (6.2% versus 3%) (2). Bombing injuries are caused by a combination of mechanisms: blast (from changes in atmospheric pressure), blunt (consequence of body displacement caused by expanding gases), penetrating injuries (caused by shrapnel), and burns (2). The age distribution of terror victims included more young people and fewer children or elderly (79.6% aged 15–44 years versus 36.6% in other traumas) (2).

This report differs from previous ones in that it describes the operational and not clinical issues. We have noted two key aspects of responding to terrorist events: 1) personnel use and organization and 2) the sequence of events. The emphasis was on the initial 8 h after the event because this is the period of intense activity.

Personnel Use and Organization

Two basic personnel use elements were identified: perioperative anesthetic management ("forward deployment") and maintaining a chain of command.

"Forward deployment" of anesthesiologists is the procedure used at Hadassah for responding to all traumas. This means that an anesthesiologist continuously cares for a severely injured patient from admission to the ED, through imaging studies in the radiology department, and during surgery. This differs from many institutions where anesthesiology is confined to the OR. The advantage of forward deployment is that it permits the anesthesiologist to continuously assess, treat, and prepare the patient for either surgery or ICU

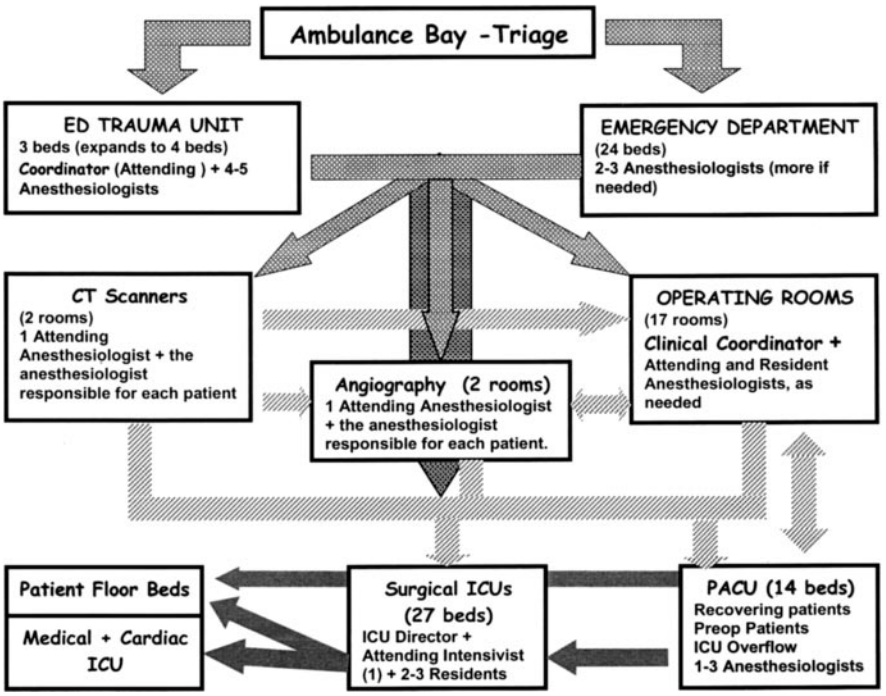

Figure 6. Severely injured patients' flow, maximal capacity of facilities, and anesthesiologists' assignments. Latent phase: evacuation of postanesthesia care unit (PACU) and surgical intensive care unit (ICU) beds. Chaotic phase: primary evaluation and resuscitation.
Definitive phase: imaging, surgeries, and intensive care unit. Bidirectional flow between facilities, no way back to the emergency department (ED).

admission while diagnostic or interventional procedures are being performed. It allows for continuity of care and avoids unnecessary transfers of vital information and responsibility for a patient. As surgical teams often change during multi-specialty surgery, it is the anesthesiologist (as the perioperative physician) who has the complete medical picture of the specific patient. Obviously, the treatment of trauma victims involves teamwork, yet it is not practical to expect the presence of a trauma surgeon all the time (during neurosurgical or orthopedic procedures, for example). Deploying all available anesthesiology personnel to the ED is essential, with anesthesiologists occupied in the OR at the time of an attack and those who live far away functioning as second-line personnel if needed (e.g., after a chemical event).

A "chain of command" (institutional and intradepartmental) is essential to control chaos. A senior general surgeon performs triage at the door of the ED. Another experienced general surgeon acts as the "surgical command officer" who guides the trauma teams. The senior triage surgeon, the senior-most anesthesiologist, the senior-most orthopedic surgeon, and a physician-administrator (hospital management) maintain a log of the most severely injured victims. They consult frequently in the ED as to the disposition of these patients (OR, radiology suite, ICU, or recovery room). They maintain contact with the ED teams and with the OR nursing and anesthesiology coordinators.

A chain of command is also established within the anesthesiology department. Figure 6 illustrates the large number of anesthesiologists working in different places and moving continuously between locations with the patients. A "clinical coordinator" located in the OR accounts for all anesthesiology personnel, dispatches them to needed areas, discharges patients from the recovery room, and provides professional advice to other anesthesiologists. He or she, along with the OR nursing supervisor, prepares an updated OR schedule. There is an anesthesiology "ED supervisor" who receives anesthesiologists from the clinical coordinator, assigns them to specific patients (according to the severity of injury and professional capability), and serves as an extra hand (e.g., during rapid sequence inductions). One of his or her most important tasks is to seek information regarding new arrivals and proposed investigational/therapeutic procedures to be passed on to the anesthesiology OR clinical coordinator. This is a backup system in case surgeons forget to alert the OR or the radiology department of an impending arrival of a patient (not an uncommon situation). The anesthesiology ED supervisor assigns anesthesiologists to identify under-triaged or deteriorating patients in lower intensity areas of the ED. Once the center of activity moves from the ED, the coordinator reviews the activities in the remote anesthesia locations (e.g., the radiology department).

Sequence of Events

The in-hospital response to a multiple casualty terror event includes a series of actions that we have dubbed the "ABCD response": **A**ssess incident size and severity, alert **B**ackup personnel, perform initial **C**asualty Care, and provide **D**efinitive treatment.

Assess Incident Size and Severity

After a terror attack there is a latent period, lasting at least 20 minutes, in which events are taking place outside the hospital. During this period, estimating the number of victims and the possible severity of their injuries is crucial for proportional "department wakeup." Estimations depend on the day of the week, time of day, location, and nature of the incident (Table 1). Therefore, in a confined space explosion the estimate should be for a large number of severely injured victims (4). Wightman and Gladish (7) suggested that a photograph brought by emergency medical service (EMS) technicians could be used as a clue to the number and severity of injuries, yet it will be available too late. Early information may best be obtained from radio, television, the Internet, or EMS radio communications. Estimates of casualties must be updated frequently because initial information changes with time.

During this latent phase, lower intensity care areas of the ED should be quickly equipped to care for major injuries. Equipment should include oxygen, airway equipment, suction, IV supplies, drugs, and physiological monitors. Mobile "multiple casualty carts" containing these supplies can save valuable time.

Backup

Data from our hospital show that a median of 7 ORs were active at the time of an event, indicating that most of the on-call anesthesiologists were busy. Recruiting additional anesthesiologists is therefore essential. We used an average of 16 anesthesiologists, attendings, and residents per event to manage all the department's activities (event victims, non-related emergencies, ICU, and delivery room). An up-to-date list of all staff members, permanently posted in a prominent place, is crucial. Anesthesiologists are called according to residential distance rather than professional status. On hearing of an event, the in-house on call anesthesiologists rapidly called the two at-home on-call anesthesiologists, the department chair, and a few senior anesthesiologists with trauma expertise. Other anesthesiologists usually did not have to be called; many arrived on their own after hearing of the event on radio or television (many were alerted by the sounds of multiple emergency vehicle sirens). Assuming that anesthesiologists will arrive voluntarily is not recommended on weekends, late at night, or early in the morning. Anesthesiologists at our hospital were not compensated monetarily or with days off.

Our hospital is equipped with cellular phones that act as an extension of the hospital telephone system (a virtual private network). However, cellular networks usually crash early after such events and cannot be relied on, mandating the use of beepers and noncellular systems (5). As a backup, the hospital has an independent institutional beeper system that reaches the entire city and its environs, capable of sending only numbers. There is also a computerized call-in system that delivers a recorded message using regular telephone lines. It was used unsuccessfully on only one occasion, when the "drill–do not come" message was mistakenly sent. Cellular networks usually resume normal function after a time and become invaluable communication tools between anesthesiologists in various locations as well as between the "surgical command officer" and all coordinators.

When using the "forward deployment" of anesthesiology personnel it is necessary to deploy all available anesthesiologists to the ED. Postponing OR preparation until enough personnel become available is rational because only a few patients are taken to the ORs within the first hour.

Casualty Care

Patients can arrive via various transportation modes (mostly, but not exclusively, by EMS ambulances); therefore adequate prehospital triage is not guaranteed (6). The arrival of the first ambulance (approximately 20 minutes after the first alert) signifies the beginning of the chaotic phase during which the center of activity is the ED (Fig. 6). There is a continual flow of ambulances from the scene for approximately 30 minutes. Patients receive the same initial evaluation as non-terror-related trauma victims. An important task of the surgical command officer is to coordinate patient evaluations according to injury severity. The victims' initial care requires the efforts of many health care professionals and support staff, creating unavoidable, but ideally controlled, chaos. Only surgeons and anesthesiologists care for major trauma victims in our institution, whereas emergency physicians treat minor injuries and medical patients. The severity of injuries was demonstrated by 27 (of 108) patients being intubated in the ED in addition to those intubated at the scene. Furthermore, over 53% of patients admitted to the hospital needed surgery within the first 8 hours after the attack, and 47% were admitted to an ICU. The most commonly performed anesthesia procedures were airway assessment and protection, assessing the location of endotracheal tubes inserted at the scene, and initiation of mechanical ventilation. Together with the surgeons, anesthesiologists established venous access, sent laboratory studies, and replaced volume deficits. Although other members of the team changed according to the stage of the patient's assessment and treatment, it was the anesthesiologists who provided continuity of care to the individual patients during the initial hours.

At times the trauma admitting area was full, and at other times patients were initially under-triaged to lower intensity care areas in the ED (8–10). A number

of these patients required intubation, mechanical ventilation, or urgent procedures (e.g., chest decompression, volume resuscitation, surgery). Timely assessment of patients admitted to such areas is important to identify deteriorating or under-triaged victims. Therefore, anesthesiologists were assigned to all areas of the ED to help assess patients and perform intubations and resuscitations.

The observation that a median of 3.7 patients were initially treated in the trauma admitting area (which has only 3 bays) meant that patients were transferred from the trauma admitting area rapidly enough to accommodate new patients. This is in line with the expectation that a Level 1 trauma center can rapidly prepare for new arrivals.

Definitive Treatment

During the definitive care phase, activities shift out of the ED (Fig. 6). The recovery room was found to be an excellent location for the care of unstable or ventilated patients awaiting surgery or an ICU bed. Therefore, early discharge of as many patients (recovering from surgeries before the attack) as is safely possible from the recovery room is important, and sufficient staff should be assigned to care for these patients.

ORs. It is necessary to evaluate what has transpired in the ED and plan for the activities of the next few hours. This includes the surgeons' plans for the OR, secondary transfers from other hospitals, emergencies not related to the event, and the need for anesthesiologists in remote locations (e.g., angiography, ICU). This information is used to revise the OR schedule to include emergency surgeries (event victims and non-related emergencies) and, if possible, elective operations. Additionally, the delivery suite continues to operate and often requires anesthesiology personnel.

Patient assessment is a detailed and lengthy process, as a combination of many injury mechanisms (blunt, penetrating, thermal, and blast injuries) should be suspected (6). Only patients who arrived in uncontrollable shock were operated on immediately (in only two events was surgery begun during the first hour.) As a result, the mean time until skin incision of the first surgery was 124 minutes. No surgery was postponed because of unavailable OR resources. The first operations performed were exploratory laparotomies, thoracotomies, and neurosurgical operations. Rooms equipped for such operations should thus be prepared first. The block of time 150 to 270 minutes after the event encompassed simultaneous neurosurgical, cardiovascular, and abdominal surgeries. These are major surgeries that often require more than one anesthesiologist per room. Although these major procedures continued, operations involving fractured bones and soft tissue injuries began and continued for many more hours. In one instance there were 7 (and in 2 others 6) ORs working concurrently, all caring for terror victims.

Performing extensive surgery on many victims in parallel while also performing surgery on other patients requires much equipment and supplies. There is large demand for patient and fluid warming devices, which our hospital overstocks. Because our hospital keeps a 1–3-month supply of disposable surgical and anesthesiology items (e.g., IV fluids, surgical sterile supplies), there were no shortages of those supplies.

In general, the hospital's ORs are each used by only one or two specialties. During the multi-casualty events, however, equipment was moved between rooms as needed. The national blood bank center automatically sent additional blood products, thus preventing shortages.

Working in the OR soon after a terror incident is difficult emotionally and physically. Therefore it is important to have additional staff to enable refreshment breaks and to provide relief after 8–12 hours of work. Like the anesthesiologists, OR nurses also came to the hospital when hearing of a terrorist incident, so that sufficient numbers were available. The activities surrounding a multiple casualty event have repercussions for the anesthesiology department for up to 24–48 hours (shortage of anesthesiologists the next day, need to provide personnel to complete operations, and a lack of recovery room beds because of the overflow from the ICU).

Angiography. Angiography was widely used for diagnoses of injured patients (12 of 108 hospitalized patients). In these events all the angiographies were diagnostic, but during several other smaller terror incidents interventional angiographies were performed. This was necessary because of the many shrapnel injuries that mandated radiological investigation and treatment of vascular injuries. At times, patients in the angiography suite were hemodynamically unstable and required continuous resuscitation and anesthesia during the procedure. It was, therefore, necessary to equip the angiography suite as a trauma OR (anesthesia machine, invasive monitoring, rapid infusers, and body surface warmers). Radiology department personnel are neither capable nor authorized to assist the anesthesiologist caring for the critically injured patient. It was, therefore, mandatory to assign more than one anesthesiologist to a patient in shock undergoing angiography. Because the angiography suite is remote, at least one anesthesiology attending was present.

ICUs. A median of 4 patients per event was admitted to the GICU, on average 5.5 $\pm$ 3.2 hours after the event. However, some patients arrived soon after the event, either because they did not require surgery or because they needed extensive stabilization before surgery. The ICU must not be a limiting factor in

clearing the acute care area of the ED in anticipation of more arrivals. Intensivists, besides continuing the routine care in the units, must identify patients who can be transferred to other ICUs or wards (Fig. 6). Finding vacant beds (ICU and ward) and negotiating with the appropriate services was done with extensive help from nursing and hospital administrators. In contrast to routine procedure, requests for patient transfer are accepted as a part of the entire hospital's response to a multiple casualty event. The transfer of a patient and preparing the now-vacant bed consumes time and therefore must begin as early as possible. The large proportion of patients needing ICU admission, together with their substantially longer ICU stays, again demonstrates the severity of injuries in terror events.

The hypothesis that response to a multi-casualty terror attack differs from response to other multi-casualty trauma is only partially true. The literature and experience demonstrate that these patients are severely injured and require extensive care and the scenario is dramatic and emotional. We compared these 14 multiple casualty events with other terror events (involving small numbers of casualties) and a dance floor collapse with over 200 victims. We found no clinically significant difference in the time to the first operation, lengths of operations, and fraction of soft/bone surgeries; however, the number of patients was not sufficient for statistical comparisons. However, if the department's response is orderly and organized, as in other traumas, it should suffice.

A debriefing as soon as possible after the event, sometimes on the same day, proves useful for changing procedures and procuring needed equipment. However, despite meticulous preparations and previous experience, no system is perfect. For example, half an hour after this manuscript was first submitted online a suicide bomber detonated himself in a crowded bus. There were many young children and infants among the victims. There was a shortage in the ED of pediatric central lines, intraosseous sets, and mechanical ventilators. As a result, it was decided that pediatricians should be alerted in cases of multiple casualty events to help with the difficult task of opening venous access in infants, and the ventilators in the ED were replaced with models able to ventilate infants, children, and adults.

There are problems that have not yet been solved. For example, overcrowding of the ED by staff from all the surgical specialties, including those not generally needed during the acute resuscitation phase. These people are motivated by a wish to offer their skills to the victims, yet they increase the chaos. Another unsolved problem is how to meet the need for quick arrival of backup without placing unequal burdens on the staff. Equal load distribution mandates calling people who live far away and will therefore arrive late.

Limitations. The experience reported here was of multi-casualty terror events. It may not be applicable to mass casualty incidents, which can overwhelm a hospital's capabilities. It is also very important to mention that none of these terror events was associated with the collapse of a building. Building collapses result in greater fatality rates and are characterized by different timetables and severity of injuries (1,6,11).

In conclusion, anesthesiologists provide essential care to patients who are injured in terror events. Their involvement begins with the initial resuscitation of severely injured patients and often continues for many more hours as the injured undergo surgery and other procedures. Anesthesiology departments are greatly impacted by such events, which must be planned for to optimize the use of available personnel and have the appropriate equipment and supplies available.

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