MEDICAL MANAGEMENT OF DISASTERS (CONVENTIONAL AND CHEMICAL TERRORISM)

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A disaster is a destructive event of natural or man-made forces that causes much causality in a short period of time, affecting the function and the social structure of a community, overwhelming the ability of a given area or community to meet the demand for health care. Disasters continue to increase in frequency and severity worldwide, and usually strike without warning.

A mass-casualty incident is defined as a situation in which there are more victims than the system is able to manage (1). The healthcare facilities should be ready and properly prepared to respond to naturally occurring disasters or terrorist attacks.

Terrorist attacks threate with conventional and non-conventional weapons of mass destruction (biologic, chemical and nuclear). Maximizing survival rates during a mass causality event implies rapid response, communication and coordination between the pre-hospital, in-hospital settings, police and fire department (2,3). Coordinated medical response requires creation of integrated disaster plans.

This lecture will focus on the medical preparedness and management of terrorist attacks (conventional bombing and chemical weapons attacks).

MEDICAL PREPAREDNESS

Planning is crucial to ensure proper functioning of a hospital in a time of crisis and helps avoiding chaos when such an event occurs. Preparations include specific policies as protocols and algorithms for both pre-hospital and in-hospital phase. Each hospital should check its ability to accommodate a very large number of patients over a short period of time. The number of causalities that a hospital should accommodate after a very short notice should be set approximately at 20% of its total bed capacity. Based on this number, the hospital should acquire medical supplies and equipment necessary for immediate emergency use (1).

Separate locations should be assigned for three different categories of patients (critical, severe and moderate). Additional emergency locations and facilities should be identified and pre-designed (1).

Medical and paramedical staff must be assigned to mission-oriented teams, to the different stations, according to the operative plans. **Every hospital employee should have a predefined role in the emergency plan and regularly participate in disaster drills** (2).

A major problem in managing a mass causality event is the lack of qualified medical and paramedical personnel.

Communication systems (e.g. cellular phone system, wireless communication) are likely to be overwhelmed in a mass casualty incident and back-up systems need to be created and tested.

Training

Medical staff responding to a disaster situation must have the knowledge, skills, abilities, and behavior needed to perform tasks

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correctly and skillfully (2-4). Appropriate training of principles of mass causalities is crucial and should include lectures, simulation exercises and **full-scale drills**. Drills are critical elements of the emergency preparedness process; they provide training exercises and identify weaknesses in the response plan so that shortcomings can be addressed. Full-scale drills should be as realistic as possible using volunteers or medical personnel to act as victims.

EVENT MANAGEMENT

Prehospital phase

Emergency medical services (EMS) crews are instructed to follow the scoop-and-run policy. Needle thoracotomy and endotracheal intubation are usually the only procedures performed in the field (5). The medical commander should be the most senior medical officer of the EMS. The immediate decision-making process involves rapid triage based on the severity of the conditions and chance for survival with medical intervention. The triage is the "art of sorting patients according to the severity of their injury" (6). In the pre-hospital setting the triage is performed by the medical commander into four categories (2):

1) immediate (need for urgent evacuation)
2) delayed (causalities that can await transfer)
3) expectant (for dying patients who should only be provided with comfort measures)
4) deceased.

Family members, bystanders and passing vehicles usually evacuate 6-10% of the injured to the nearest hospital (6).

In-hospital phase

Before the first victim arrives to the hospital a command station is opened and backup medical and paramedical staff is called in urgently. A triage officer is assigned**.** The chain of command including the senior triage surgeon, the senior-most anesthesiologist, the senior-most orthopedic surgeon, and a physician-administrator (hospital management) is established (7).

It is important to gather as many as possible data from the police and EMS crews: type of event, estimated number of causalities, location, estimated time of arrival to the hospital, severity of injuries. Operation room (OR), radiology department and blood bank are notified (2).

All medical, administrative staff and aides should be wearing identification cloths labeling the role of the staff member.

Given the large number of patients suffering from complex injuries over a short time, the patients need to be directed to the appropriate level of care, and life-threatening injuries need to be swiftly recognized and treated. The triage officer (usually a senior surgeon) is the first to assess the victims when they arrive at the hospital. The triage officer sorts the casualties into management groups according to their severity of injury:

1) critical – beyond treatment
2) severe – immediate treatment
3) moderate – postponed treatment

The patients in each of these three groups are treated in separate locations (6). Advanced Trauma Life Support (ATLS) guidelines are followed as closely as possible.

Patient flow control within the hospital has a direct influence on the outcome of the patients. Radiology department is the most common bottleneck in the flow of non-critical casualties. All "rule out" radiography is postponed. The complete radiologic evaluation of non critical patients is performed later, when casualties are no longer arriving (1, 8).

Severely injured patients are not necessarily the first to arrive and may be expected to arrive later (9).

Prioritizing of surgical procedures is crucial and should be limited in the beginning of the event to lifesaving laparotomy and thoracotomy (for bleeding and for patients in shock), as well as for major vascular injuries that endanger a limb.

To maximize personnel use and assure continuity of care, Shamir et al. (10) recommends "forward deployment" of anesthesiologists (the same anesthesiologist continuously cares for a severely injured patient from arrival to the emergency department through imaging studies in the radiology department, and during surgery.) The OR should have a "clinical coordinator" (located in the OR), which is responsible for all anesthesiology personnel and dispatches them to needed areas.

Einav et al. (9) recently reported that operative procedures were performed on 60.3% of 325 admitted patients after terrorist attacks; the report analyzed 1639 terror-related civilian casualties.

Shamir et al. (10) suggest using the classic "ABCD response" with specific highlights for the in-hospital response to a multiple casualty terror:" **A**ssess incident size and severity, alert **B**ackup personnel, perform initial **C**asualty Care, and provide **D**efinitive treatment."

Post-event phase

A debriefing meeting should be held as soon as possible following the event to identify gaps in manpower, knowledge and equipment (2).

CONVENTIONAL TERRORISM – URBAN TERRORIST BOMBING

Bombs are still the major instrument of terror, because they are simple to activate and are easily and inexpensively manufactured. Bombs and explosions usually cause more complicated injuries than other types of trauma, with higher in-hopital death rates (6.2%) as compared to other trauma victims (3%) (6). The injuries are more severe, with more body regions involved, and are a combination of blast (shock wave), penetrating, and blunt trauma, as well as burns (11). Various metal objects added to explosives increase and diversify the wounding from bombing.

Explosions produce four patterns of injury (6):

♦ **Primary injuries induced by** over-pressurization force (blast wave) spreading radically outward from an explosion an passing through the human body. Hallmark of blast injury is the appearance of air emboli that fill the pulmonary vessels and the coronary blood vessels (6). Blast lung injury (BLI) characterized by alveolar capillary disruption is a more severe form of blast injury. The radiological and pathologic signs are of lung parenchymal hemorrhage (11). Alveolar hemorrhage may develop abruptly with devastating consequences. BLI is diagnosed in up to 45% of fatalities of an explosion (13). Abdominal injuries are less frequent (11-13).

♦ **Secondary injuries induced by** projectiles (bomb fragments, metal balls, screws and bolts embedded in the explosive) are expressed by multiple penetrating injuries. Multiple penetrating injuries with unpredictable trajectories are common (9).

♦ **Tertiary injuries are a consequence of the** displacement of victim by the blast wind, and/or structural collapse, resulting in crush injuries, limb amputations. Traumatic limb amputation is frequently associated with other critical injuries and a high mortality rate (11).

♦ **Quaternary injuries produced by fire and heat resulting in burns of various degrees.**

Indoor blasts magnify the destructive power of the primary blast and tend to cause more severe primary blast injuries with increased mortality and morbidity, than open-air bombings. The blast wave is magnified, rather than dissipated, as it is reflected off walls, floors, and ceilings. Leibovici et al. (12) reported 7.8% mortality among 204 casualties involved in open-air bombings in Jerusalem and 49% mortality among 93 victims of detonation inside buses.

Recently Almogy et al. (13) demonstrated that external signs of trauma can predict the occurrence of BLI or intra - abdominal trauma. Patients with penetrating head injury and those with four body areas injured were significantly more likely to suffer from BLI. Patients with penetrating torso injury and those with four body areas injured were significantly more likely to suffer from intra-abdominal injury.

CHEMICAL WEAPONS OF MASS DESTRUCTION

Chemical agents as military weapons have been recognized for many centuries and are internationally outlawed by the 1925 Geneva

Protocol. After the nerve gas attack in Tokyo (1995) several countries implemented a number of activities to counter paramilitary and terrorist threats from nuclear, biological, and chemical agents.

"The dispersal of a chemical warfare agent (intentional or accidental) in an urban area has the potential to cause thousands of casualties" (14).

The **nerve agents** are the most dangerous of all chemical weapons. Their name has been acquired because of their effects on the nervous system. Nerve agents are gases, chemically similar to organophosphate pesticides. They are organophosphorus cholinesterase inhibitors, exerting their effects by inhibiting acetylcholinesterase enzyme (AchE), causing widespread peripheral and central neuronal paralysis, which can be rapidly fatal without timely administration of antidotes (14).

Inactivation of AChE prevents the hydrolysis of acetylcholine, which accumulates at muscarinic, nicotinic and central nervous synapses.

Symptoms develop very quickly, over minutes. At muscarinic synapses, AChE inactivation cause salivary, bronchial and lachrymal hypersecretion, miosis, sweating, vagal bradycardia (or atrioventricular block, QT prolongation), bronchoconstriction, vomiting, severe diarrhea and urinary and fecal incontinence. AChE inactivation at nicotinic receptors at the neuromuscular junction produces skeletal muscle paralysis (initial fasciculations followed by weakness and depolarization muscular paralysis). At central nervous cholinergic synapses, AChE inactivation causes irritability, giddiness, ataxia, fatigue, amnesia, hypothermia, lethargy, seizures, coma and respiratory depression (15, 16).

Death is usually related to respiratory failure caused by a combination of bronchospasm, excessive secretions, muscular paralysis, and dysfunction of the respiratory center (17).

Unlike the temporary effect of organophosphate compounds, nerve agents cause irreversible inhibition of various types of AChE through a covalent binding to the enzyme active site.

Atropine sulfate blocks the muscarinic receptor and it is the initial drug of choice in the symptomatic victim. Atropine does not reverse or prevent paralysis. It is given in doses of 2 mg i.v. with repeated dosing at 5–10 min intervals until pupillary dilatation occurs, and the heart rate rises above 80 beats/min (dosage - up to 50 mg /24 hr).

Oximes (pralidoxime chloride, obidoxime) reactivate AChE by cleavage of phosphorylated active sites, reverse nicotinic receptor dysfunction and reduce or reverse paralysis. Pralidoxime is given in doses of 15–30 mg/kg i.v./i.m. over 20 min, and may be repeated after 4 h (or 1 h if paralysis is worsening) (17, 18).

Pyridostigmine bromide is an effective preventive measure against nerve gas intoxication. It is a carbamate whose protective effects results from its ability to create a reversible rather than an irreversible chemical bond at the AChE active site. Exposure to a nerve gas immediately after administration leaves the active site of AChE largely shielded since it is already bound to pyridostigmine. Excessive administration of pyridostigmine would have similar effects to nerve agents. Pyridostigmine is prophylactically administered per os in a dose of 30 mg × 3 to a population at risk of nerve agent exposure as soon as the risk becomes a real threat (18).

INITIAL MANAGEMENT OF CAUSALITIES

Awareness toward the possibility of chemical terrorism can lead to the recognition of the involvement of a toxicant (19).

Security officers should direct the flow of causalities to prevent unauthorized vehicles to reach the decontamination and treatment areas.

Decontamination of the body by physically washing the patient, with the purpose of terminating the exposure and preventing secondary contamination of the medical staff, should be performed if possible in 2-3 min after exposure. Cloths should be removed before decontamination. Pre-constructed and assigned decontamination facilities should be activated. The Israeli model consists of showers permanently fixed to the ceiling structure of an open parking space. The decontamination process should be completed in the field or at least outside the medical center, in order to prevent secondary exposure of the medical staff. All personnel must wear full protective gear including a gas mask, chemical protective gloves, and a multilayered overgarments (15-17).

Patients can have both conventional and chemical injuries, and these two types of injuries may be synergistic making assessment and treatment more difficult, increasing the severity of the prognosis. Tissue lacerations are ports of entry for the nerve agent.

ANESTHETIC CONSIDERATIONS

- ♦ Barbiturate-induced direct myocardial depression and peripheral vasodilation may be more pronounced in the presence of pyridostigmine or nerve agents because of their vagotonic activity (18).
- ♦ Volatile anesthetics were shown to induce a false-positive reading in chemical agent-monitoring devices used by the emergency response teams (20).
- ♦ The amount of succinylcholine used to produce muscle relaxation for endotracheal intubation should be significantly reduced in patients treated with pyridostigmine or under effects of nerve agents.
- ♦ If regional anesthesia is used, amides are preferred over esters, because esters are degraded by plasma cholinesterase. These enzymes are inhibited by nerve agents or pyridostigmine.
- ♦ The use of meperidine, which also has muscarinic antagonistic properties, may aggravate an already existing nerve agent induced respiratory depression (16).

Very few physicians have any experience with true mass casualty events.

Proper management of mass-casualty incidents relies on increasing the level of preparedness (21, 22). Increased knowledge of the mechanisms of injury and the logistic problems that results can improve the diagnosis and the treatment of these patients.

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