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HOSPITAL PREPAREDNESS AND RESPONSE DURING EARTHQUAKES

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INTRODUCTION

Earthquakes pose a serious threat to the lives of people throughout the world. Hospital services have a crucial role in the initial medical response to large earthquakes, but the seismic stability of most hospital facilities remains uncertain. It is estimated that approximately 48 percent of hospital buildings are at high risk for collapse or loss of function from structural failure after a high magnitude earthquake. In addition, 91 percent of a hospital's nonstructural components, that are essential to the safety and care of patients, can be expected to fail or be seriously damaged following a strong earthquake. The most serious nonstructural damage involves leakage of water from ruptured sprinklers, rooftop tanks, and other plumbing fixtures. Other major systems that require immediate attention are the piped medical gases and vacuum units, and electrical and/or electronic systems and equipment.[1]

When a threat to the population grows to include the hospital itself, or when standards of patient care cannot be met, or the safety of the hospital infrastructure is compromised, the need to evacuate and transfer patients to other facilities will become inevitable and imminent. The evacuation of any patient population is a challenging, complex, unpredictable and difficult process that requires a carefully planned approach and robust strategy, especially for fragile infants and seriously ill patients dependent on various medical technology/devices for their survival.[2]

Seismic Events

An earthquake is the shaking or trembling of the earth, which may be natural or man-made (e.g., due to atomic explosion) in origin. Earthquakes are generated by a sudden, strong movement or slipping of the earth's crust that results in a sudden release of energy. Earthquakes occur at certain locations where the tectonic plates which form the earth's crust, coincide. Populations that live near these zones or on these plates must be prepared for earthquakes and their consequences. The direct impacts of earthquakes may be seen in several forms, such as shaking, ground ruptures, landslides, avalanches, fires, soil liquefaction, tsunamis, and/or flooding. Several related sequences can follow an earthquake such as aftershocks (an earthquake of similar or of lesser intensity following the main earthquake) and earthquake swarms (sequences of earthquakes of similar magnitude that occur within a short period of time).

Quantifying Risk During a Seismic Activity

The risk for hospital damage from an earthquake attenuates as the distance from the epicenter increases. The median epicenter-to-hospital distance for evacuated facilities is 8.1 miles {interquartile range [IQRs] 4.0 to 17.2 miles), whereas that for nonevacuated facilities is 14.1 miles (IRQ 10.5 to 17.0 miles}. Peak ground acceleration is a measure of earthquake acceleration on the ground. It is not a measure of the total energy of an earthquake, but rather of how hard the earth shakes in a given geographic area (ground motion, rather than the magnitude). On the average, this is 0.77 g (IQR 0.53 to 0.85 g) for evacuated hospitals and a median of 0.36 g (IQR 0.24 to 0.50 g) for hospitalsthat need not be evacuated. 1 g being equal the force of gravity. Peak ground acceleration is a superior indicator of risk of hospital damage and a reliable basis for initiating evacuation.

Physicians can obtain these data in real time from the Internet and should transfer patients to facilities in areas of lower recorded peak ground acceleration regardless of distance from the epicenter.[10]

The interquartile range (IQR), also called the midspread or middle fifty, is a measure of statistical dispersion, being equal to the difference between the upper and Lower quartiles,

$$IQR = Q3 - Q1.$$

It is a trimmed estimator, defined as the 25% trimmed mid-range, and is the most significant basic robust measure of scale. It is the 3rd Quartile of a box plot plot minus the first quartile.

Earthquakes are associated with significant mortality and morbidity within the community. Fatal injuries commonly occur within the first minutes to 24 h of the earthquake. The most common causes of deaths are usually head and/or chest injuries. Other causes of death include asphyxia, crush syndrome and hemorrhagic shock. Injured survivors usually have lower limb fractures. Time is precious, as every minute could mean saving or losing lives. Delays in the transport of victims to the nearest referral hospital by land ambulance due to blocked roads directly impacts the chances of survival and recovery of the injured victims. Air transportation obviously provides the best option for expeditious evacuation and reduction of fatalities.[3,4]

Hospital Preparedness

Hospitals located within or near the epicenter, or in a region close to the affected area, may serve as referral treating centers. In case of an earthquake, the referral hospital should be well-prepared to respond quickly and healthcare planners should consider following elements:

1. Geography—The location of the referral hospital should be chosen with great care. It should be away from the seaside, volcanic regions, and mountains, and should be near to and accessible by main roads.
2. Building Structure—Infrastructural developments have made available highly developed materials capable of absorbing seismic waves during earthquakes and greatly decreasing the risk of sudden collapse and giving occupants ample time to evacuate a building. This technology should be used in hospitals located in high risk zones. In addition, such hospitals should have its own well-maintained power and water resources and a helipad.
3. Medical and Paramedical Staff—The medical and paramedical staff should be qualified and well-trained in responding to different types of injuries, including burns. There should be enough staff members available 24 x 7.
4. Communication—An effective and proven network of satellite or cable communication should be available to connect locally, nationally and internationally.
5. Transportation—Air transportation is the method of choice. Therefore, special arrangements should be made to plan for helicopter and aircraft transportation.
6. Education, Training, and Drills—Education and training are key. All staff members should understand the nature and consequences of an earthquake. They should be familiar with all scientific terms used internationally. Drills should be conducted frequently, and a regional drill should occur biannually. Continuous training enables hospital staff to be prepared to respond quickly and appropriately. A ready, well-informed, and well trained hospital staff is associated with drastic reduction in fatalities during such a disaster.
7. Coordination Network: National, Regional, and International Coordination and Cooperation—Local hospitals can become overwhelmed with quake victims. Therefore, it is essential to establish a network of coordination at regional, national and even international levels between different healthcare providers or organizations. The coordinating network members must meet and interact regularly, as meeting for the first time during a disaster may cause confusion and delay in providing need-based services for victims.
8. Aftermath—Regular follow-up of the cases is important as many of the victims as well as medical and paramedical staff may experience post traumatic stress disorder (PTSD) and require psychological counseling.
9. Documentation- All details of events should be well documented for extraction of data and facts to draw lessons that can be presented at a latter day debrief and improve hospital response in future catastrophes.
10. Research - Research is vital, especially in preventing or reducing risks and injuries.[5]

Hospital Incident Command System (HICS) this must be evolved to coordinate action during a major disaster. The HICS is a standardized on-scene emergency management organization specifically designed to provide for the demands of single or multiple incidents, without being hindered by jurisdictional boundaries. It is the combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure, designed to aid in the management of resources during incidents. The system includes defined responsibilities and reporting channels and uses common language to promote internal and external communication and integration with community responders.

The core principles of an Incident Command System are as follows:

1. Establishing a clear chain of command to manage all routine and planned events of any size or type.
2. Integrating personnel from different agencies or departments into a common command structure that effectively addresses issues and delegates responsibilities
3. Providing needed logistical and administrative support to operational personnel
4. Eliminating duplication of efforts
5. Using clear language – eliminating industry codes/terms while managing an emergency situation
6. Communication with the Medical Director of a hospital the following:
   a. Type and location of incident.
   b. Number and condition of expected patients and/or expected patients for evacuation.

c. Estimated arrival time or departure time from facility.
d. Unusual or hazardous environmental exposure.

7. Requesting staffing assistance from the labour pool to determine hazard and safety information critical to treatment and evacuation of patients.
8. Ensuring that patient identification and tracking practices are being followed.
9. Communicating and coordinating with logistics department to determine medical care equipment and supply needs, transportation availability and needs (carts, cribs, wheel chairs, etc.) and ensuring that appropriate standards of care are being followed in the clinical areas as appropriate for the emergency.
10. Ensuring that all attempts have been taken to reach patient family members if not on site to notify them of the evacuation.
11. Liaising with media and public information domains to provide details of evacuation process. (6)

Hospital Evacuation

There are several critical issues that need to be considered when evacuating a hospital :

(a) Nature of threat
(b) Risk to patients
(c) Risk to staff and visitors
(d) Need for continuing acute care
(e) Demands for supplies
(f) Demands for resources

In the event of a major quake, the hospital's maintenance supervisor must assess the impact and initiate corrective action to restore any damaged system to normal operational modes expeditiously. If the building or a portion of the building is deemed unsafe a partial or total evacuation will be decided upon and the evacuation plan implemented.

Individual departments have the responsibility to report all life threatening situations to the administrative staff immediately for assessment and corrective action. In the event of a fire, personnel must sound an alert and implement the hospital's fire fighting plan immediately.

In most instances, evacuation of large numbers of patients from a hospital can be accomplished quickly and safely with the use of available resources and personnel. The success of an evacuation greatly depends on developing and evaluating alternative plans. In the absence of a standard pproach to address the issues of a hospital evacuation, it is best to view some existing models to evaluate and assess an emergency plan. This should be based on a comprehensive emergency management strategy rather than just a hospital-centric focus. For example, executing Memorandums of Understanding (MOUs) with private ambulance agencies, critical care aeromedical transportation providers, bus companies, and other transportation agencies, although not conventional, may help provide services when medical transport vehicles are unavailable or when other agencies may be competing for these same resources. The pre-planning process should also include the development of an /intra and inter-state hospital networking and a full appreciation of hospitals with ICU/NICU capabilities in the vicinity to provide a back up during an event. A ready access of their contact numbers must be available for any contingency. Despite a presumption that communities do come together and assist those who are vulnerable, the pre-planning phase must be utilized to build relationships within the community.[7]

ICU/ NICU evacuation can cause high levels of anxiety for the parents of very sick patients. Hence, processes for keeping families informed about their ward's status and relocation destinations must be maintained. An influx of inquiries from family members can create an undue burden on ICU/NICU staff who may be already overwhelmed with the mobilization process. It is essential, therefore, to pre-designate staff and physician's roles in an evacuation process and also someone exclusively for parental/guardian liaison.[8,9]

A successful evacuation requires comprehensive planning in order to maximize patient safety in a changing environment. Hospitals must include regular drills and exercises as part of the hospital emergency preparedness program.

Evacuation Modes

The intensity of the seismic activity will determine the type of evacuation required as follows:
Horizontal - to an adjacent, safer site
OR/AND
Vertical - Down ramps or stairs using cribs, stretchers, wheeled trolleys, vest pockets and physical carriage methods.

Evacuation Protocols

Moving the most severely ill patients first, offers the advantage of lessening the burden on hospital staff, since the patients who are the most seriously ill require the most resources. In addition, since resources are rapidly depleted after an earthquake, it makes sense to start by transferring the patients whose care requires the greatest resources. In the event of an immediate threat to patients' safety fearing the collapse of hospital buildings, efficient evacuation is mandatory when the healthiest patients may be preferably evacuated first, as this strategy permits the evacuation of large numbers of patients in a short time. Evacuation of the healthiest patients first is an effective strategy when speed is essential, moving all patients through the stairwells using improvised transport devices such as blankets, backboards, and mattresses. Using these low cost alternatives, it may not be necessary to purchase specialized devices as stair chairs, infant carriers, and earthquake slides. Building inspectors may be consulted to confirm the integrity of hospital structures prior to evacuation and before moving back in

A general approach to be followed in the event of an earthquake is as follows:

1. Remain calm. Do not panic or run through or outside the building. The greatest point of danger is just outside doorways and close to outer structure walls due to the hazard of falling debris.
2. If you are in the building, remain where you are. If possible, take cover under a desk, table, or bench, or in doorways, hallways, or against inside walls. These areas are the most sound structurally during an earthquake.
3. Keep visitors, patients, and other employees out of stairwells and elevators.
4. Reassure and assist patients and visitors.
5. Do not abandon your patients.
6. If you are outside, stay away from the building. Stay clear of walls, electric poles, downed wires, and trees. Check all utilities and electrical equipment and use telephones only for emergencies.
7. Above all, use good judgement.
8. Following the earthquake employees shall assess damages specific to their assigned areas and report all hazards to their supervisor. This information shall be reported to administration for revaluation and corrective action.

A specific approach for patient evacuation is as follows:

- Move the least acute, most stable first
- Apply identity tags for all those being shifted
- Bag ventilate those dependent on ventilator and administer oxygen using portable oxygen cylinders for those who need continuous oxygen administration.
- Disconnect non essential i/v fluids or hand push i/v fluids using large syringe in transit
- Improvisation during the disaster following the loss of electrical power includes patient ventilation using Ambu bags, monitoring electrocardiograms of unstable patients using defibrillator paddles, titrating IV rates using IV flow-rate devices like dial-a-drip etc, using cell phones as light sources, using piston syringes fitted with cannulae for suctioning
- Monitor by hand or auscultation or utilize battery powered monitoring devices in transit
- Wean i/v fluids where possible
- Connect chest tubes to an underwater seal drain assembly.
- Gastric decompression can be maintained by aspiration with a syringe
- Drape infants with bonnets and blankets/aluminium foil. For infants requiring additional thermoregulation, chemical warming mattresses can be used. This should be covered with a blanket prior to placing infant on it.

Patients are initially moved to safer areas of the hospital or outdoors, using available equipment such as backboards, wheelchairs, blankets or sheets, and gurneys. Since elevators may not be operating, stairways will have to be used for evacuation between floors. Medical staff may discharge some of the less serious patients home and transfer the rest to other hospitals in safer zones. When the damage is extensive, emergency generators may trip and total electrical outage may occur. Using flashlights, staff members must first escorted all ambulatory patients out of the building through the stairwells, starting on the bottom floor and working their way up. Next, patients who cannot walk but who are otherwise self-sufficient must be evacuated by wheelchairs and wheeled trolleys. Finally, patients in the intensive care unit must be shifted out of the building. Staff members must be prepared to provide manual ventilation for all intubated patients for a total of two hours - the maximum time required to transport all patients in the intensive care unit to safe open areas. Medications and medical records must accompany all patients who are transferred elsewhere. Staff members will be required to travel along with critically ill patients and vehicles containing multiple patients during their transfer. Stable patients can be transferred unescorted. Electrical personnel can provide small portable generators to supply enough power to operate the ventilators in the clearing areas. Trapped patients may not receive medical attention until all other patients have been evacuated.

The triage and movement of patients will have to be managed by senior registrars. Once power is restored, the use of elevators/lifts must not be permitted until they have been inspected by hospital utility staff and declared safe.[10]

Management of Transfers

Many regional disaster plans call for centralized direction of the evacuation process by an emergency operations center. Hospitals provide the center with information about the number of patients to be evacuated and the severity of each patient's condition. The center then contacts other facilities in the area and arranges for the patients to be transferred. This may cause a delay in shift and not suited in extreme crisis. Provision must exist for independent management of transfers when communications are completely disrupted or numbers of patients are very many. Hospital staff members may transfer stable patients in private cars, public buses, and hospital vans. Ambulances and helicopters must be reserved for more seriously ill patients, such as those receiving ventilatory support. In the immediate hours after the earthquake, television-news helicopters can be used to transport patients. Ambulances may be required to travel long distances outside the quake zone and must be topped up with enough fuel to make a one way journey to such a facility. All facilities may depend heavily on effective communication (land lines, 800 MHz satellite phones, and faxes) to coordinate transfers. All hospitals must maintain logs that match patients' names with the institutions to which they are being transferred. Family members who contact the evacuating hospitals must be referred to the facilities where the patients are being sent. Deaths must be avoided during

the evacuation process and one must anticipate problems like unintentional self extubation during evacuation and keep equipments for immediate reintubation during transit. A backup plan for providing care outside a hospital setting is imperative, in case receiving hospitals become nonfunctional or are overwhelmed.[11]

CONCLUSION

Historically, little attention has been paid to the hospital-as-victim scenario. In fact, national disaster systems are only beginning to focus on the lack of resources to deal with a sudden large increase in the volume of patients (surge capacity). Planners need to find creative solutions to this problem, such as the establishment of field hospitals and use of alternative sites of care (e.g., schools, sports facilities, or churches). All accredited hospitals must identify alternative sites of care. Hospitals must ensure that necessary medication, equipment, personnel, and medical records are provided at these sites. Creating a hospital backup system to provide acute medical care may also be prudent. The problem of surge capacity is not limited to earthquakes. Terrorist attacks targeting large populations with biologic weapons might result in thousands of victims. No hospital can absorb such a large volume of patients and maintain currently accepted standards. One solution is to use hospital facilities other than inpatient units, such as on-site clinics or offices, for the temporary provision of inpatient care. Another option is to take patients to designated facilities in the community and use of community centers to provide initial care preserves hospital resources for the most seriously ill patients. Clinicians, hospital administrators, emergency managers, and researchers must prepare for hospital evacuations after earthquakes and other sudden-impact disasters, including terrorist acts. Each hospital department must draw up its own policy and procedure which addresses earthquake preparedness and contains the appropriate course of action to be taken in the event of an earthquake. These policies must have the approval of the hospital's safety committee.

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