Strategies in Evaluation and Management of Bam Earthquake Victims

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Abbreviations
ICU = intensive care unit
IV = intravenous

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Abstract
Background: On 26 December 2003, an earthquake measuring 6.5 on the Richter scale occurred in the city of Bam in southeastern Iran. Bam was destroyed completely, >43,000 people were killed, and 30,000 were injured. The national and international responses were quick and considerable. Many field hospitals were created and large numbers of patients were evacuated from their homes and transported to hospitals throughout Iran. Nearly 700 patients were transferred to Chamran hospital in Shiraz within the first 48 hours after the earthquake.
Methods: This is a retrospective study based on the medical records of earthquake casualties dispatched to Chamran Hospital. A screening tunnel composed of multiple stations was prepared before patients entered to facilitate the large influx of patients. Each of the victims was passed through this screening tunnel and assigned into one of three groups: (1) those needing emergency surgical intervention; (2) those needing less urgent surgery; and (3) those needing elective operations, supportive care, observation, and/or rehabilitation.
Results: Among the 708 patients, 392 were male (male/female ratio: 1.24) with a mean value of their ages of 30.5 years. (range: 1.5 months–70 years). Extremity fractures (136, 19%) were more common than were axial skeleton fractures (28, 4%). Out of the total 708 patients, 152 (21.5%) patients needed emergency operations, 26 (4%) needed less urgent surgery, and 530 (74.5%) required wound care or antibiotic therapy and other forms of supportive care. Some complications occurred, such as two patients with compartment syndromes of the leg, three required below-the-knee amputation, eight suffered acute renal failure, two developed fat emboli syndrome, and one had a brain injury that resulted in death.
Conclusion: A comprehensive disaster plan is required to ensure a prompt disaster response and coordinated management of a multi-casualty incident. This can influence the outcomes of patients directly. A patient screening tunnel has advantages in rapid and effective evaluation and management of victims in any multi-casualty incident.

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Introduction
Natural disasters recurrently cause catastrophic human loss. Tragedy occurred at 05:26 hours on 26 December 2003 when an earthquake, measuring 6.5 on the Richter scale, hit the city of Bam in southeastern Iran (Figure 1).[1] At the time, most of the 100,000 inhabitants of Bam were asleep inside their brick homes.[2] Along with the chilling statistics of human loss, essential services, including water supply, electric power, telephone, health care, major roadways, and the city's only airport, were crippled.[3]

Weak earthquakes had shaken Bam during the previous 72 hours, causing many people to evacuate their homes. However, the cold weather forced many of them back inside their homes during the night, and contributed to the large number of casualties.[2] Bam was destroyed , >43,000 people were killed, and 30,000 were injured. All of the survivors were left homeless.[2–4]

The city of Bam is well-known for its long history, and especially for the historic castle of Arg-e-Bam, which is 2,000 years old. Before the earthquake, the castle was the largest mud-brick complex in the world. This historic building was devastated by the earthquake.

Soon after the earthquake, the National Red Crescent Society and other groups began rescue efforts. The international response to provide multiple rescue teams also was quick and considerable. More than 40 international teams provided search and rescue services. There also were many volunteer groups on the scene.[5] Since all of the hospital facilities in Bam had been destroyed and their physicians and nurses were injured or killed, large numbers of injured people were evacuated to hospitals throughout Iran.[6]

Among the injured patients, 12,000 were taken to various hospitals in the country.[2] In the first 48 hours after the earthquake, 700 patients were airlifted to Chamran Hospital in Shiraz, Iran. Shiraz is located about 800 km west of Bam (Figure 1), and the first group of patients reached the hospital just 12 hours after the earthquake.

Chamran Hospital is a specialized orthopedic and neurosurgery university hospital with eight operating rooms, computed tomography (CT) scanning and magnetic research imaging (MRI) facilities, and intensive care services. The evacuated patients' initial medical care was provided by a total of 30 surgeons and anesthesiologists.

Iran is at great risk for earthquakes. The destructive power and consequences of earthquakes are so great that many countries feel unable to address preparedness activities or develop effective management plans. Emergency planners recognize that effective preparedness activities should be supported with prompt disaster management strategies both within and outside of the field of disaster medicine.[7]

In each disaster, it is crucial to identify those patients who require urgent emergency care and transport them to the other core medical institutions in intact areas outside the disaster-affected area. After the Great Hanshin-Awaji Earthquake in Japan, about 500 hospitals were chosen as core medical institutions for the disaster. Each core medical institution must be capable of providing advanced medical services for the severely injured patients and of functioning as the headquarters, meaning it is equipped with a medical information system that can operate in case of disaster and emergency.[8]

This paper discusses strategies used to handle the large number of casualties entering one hospital within a short time. These strategies were designed specifically for the Bam earthquake, but are useful in other, similar situations.

Methods

This retrospective study was based on the medical records of earthquake casualties admitted to Chamran Hospital. Their arrival was documented, and a screening tunnel was prepared for quick and effective screening. This tunnel was composed of multiple stations through which the incoming patients passed in an orderly manner.

Figure 1—Map of Iran

It was reported that the patients who were transferred to Chamran Hospital were hemodynamically stable and could tolerate at least two hours of transportation time. Resuscitation equipment, intravenous (IV) lines, intubation tools, and direct-current countershock capabilities were provided in the first station where a general surgeon, with the aid of nurses, first evaluated and resuscitated the patients as needed. A neurosurgeon and an orthopedic surgeon examined the patients in the second and third stations, respectively, and then, the patients were guided to the radiology unit in the fourth station. In the fifth station, primary diagnoses were determined and admission orders were written by a group of three attending surgeons (a general surgeon, a neurosurgeon, and an orthopedic surgeon), laboratory samples were collected and sent for analysis, and the primary plan for each of the patients was determined. In the sixth station, appropriate immobilization using a slab or cast was applied, and dressing and irrigation of nonsurgical wounds were performed.

After passing through this tunnel, each of the patients was assigned into one of three groups: (1) Group A—those who required emergency surgical intervention; (2) Group B—those who required urgent surgical intervention; and (3) Group C—those needing elective operation(s) or rehabilitation, observation, and/or non-surgical and medical management, or other forms of support.

Following group assignments, the patients were transferred to an appropriate ward immediately; then, emergency surgical patients were prepared for the operating room, while others received appropriate care such as wound care, IV antibiotics, and tetanus vaccinations. After the patients were settled in the wards, they were re-examined and their radiographs were reviewed by three senior attending physicians in order to identify any missed orthopedic, general, or neurosurgerical problems.

Type of injury	Total number	Open fractures	Complex fractures
Unstable pelvic fracture	6	—	4
Hip fx-dislocations	3	—	1
Acetabular fractures	8	—	5
Femoral fractures	21	3	13
Tibial and fibular fractures	29	9	7
Humeral fractures	22	4	18
Shoulder fx-dislocations	4	—	2
Forearm fractures	8	2	3
Spine fractures	22	—	9
Hand crush	18	11	2
Foot crush	10	10	5
Large lacerations	11	—	—
Total	**162**	**39**	**69**

Table 1—Group A: Victims needing emergency operations (fx = fractures)

At this time, an internist, a gynecologist, and/or a urologist were invited to examine patients who needed their respective consultation.

Results

Among the 708 patients transported to Chamran Hospital, 392 were male (male/female ratio: 1.24). The mean value for the ages was 30.5 years (range: 1.5 months–70 years). Among the patients admitted, 28 (4%) had axial skeleton fractures and 136 (19%) had extremity fractures.

Group A consisted of 152 (21.5%) casualties who needed emergency operations due to unstable pelvic fractures, long-bone fractures, dislocations, crushed extremities, or large lacerations. Further details are listed in Table 1.

Group B consisted of 26 (4%) patients who needed less urgent operations, which are listed in Table 2. Fractures of the shoulder and upper extremities accounted for the majority of the patients in Group B.

Group C consisted of 530 (74.5%) patients, many of whom needed some form of immobilization with a cast, slab, or brace. Of these, 180 patients (34.0%) had superficial lacerations of the head, neck, back, or extremities that, after irrigation and wound closure, experienced a short period of admission for the administration of IV antibiotic therapy and observation to rule out the presence of crush syndrome. Some of the Group C patients experienced complications during their hospital stay. For example, there were two patients with compartment syndrome of leg treated with open fasciotomy, three patients that required a below-the-knee amputation due to intractable infection, and eight patients who developed acute renal failure associated with crush syndrome. All of these patients were transferred to another hospital after initial orthopedic care, and two of them required hemodialysis support. Two patients developed fat embolization syndrome; these patients were managed in the intensive care unit. One patient died due to severe, diffuse axonal injury.

Type of injury	Total number
Fracture of radius	6
Fracture of ulna	1
Hand fracture	5
Clavicular fractures	9
Ligament injuries of knee	3
Calcaneal fractures	2
Total	26

Table 2—Group B: Victims needing less urgent operations

Discussion

There are few reports on the strategies for the management of mass casualties. Most of the papers simply list victims or report treatment methods and their outcomes.

The highest number of reported earthquake casualties has been attributed to the Tang Shan earthquake, which resulted in 242,769 deaths and 164,851 patients with injuries.[9,10] In 1995, the Great Hanshin-Awaji Earthquake of the Kobe-Osaka area of Japan resulted in 6,500 deaths and 34,900 injured persons. Among 15,000 patients studied, the majority of cases had spinal, ribs, and/or pelvic fractures, but long-bone fractures were uncommon.[11] However, in the 1999 earthquake in the Marmora Sea in Turkey, among 698 hospitalized patients, the most frequent injuries encountered were crush injuries (161, 23.1%), extremity fractures (113, 16.18%), and pelvic and spinal injuries (112, 16.1%).[12]

In 1998, a total of 3,232 children continued to suffer from earthquakes in Armenia. Of these, 2,007 (62.1%) sustained damages to the locomotor apparatus. Of these, 653 (32.5%) had sustained closed fractures, and 377 (18.8%) children experienced crush syndrome.[13] After the Northridge earthquake in LosAngeles in 1994, which measured 6.8 on the Richter scale, the distribution of traumatic injuries was similar to that experienced in other earthquakes. In general, except for the total number of casualties, the distribution of patients in seismically unprepared areas are the same across different earthquakes.[14]

The difference in the number of fractures, and especially in the ratios of crush syndrome resulting from different earthquakes seems related to the rescue time.[15,16] For example, among the 60 victims of the 1988 Armenia earthquake who were referred to Moscow after six days, 48 (80%) had vast, infected wounds and six (10%) patients died because of gas gangrene, severe intoxication, and kidney failure.[17]

In another study, 245 victims of the Armenia earthquake, with a shorter rescue period and an entrappment time of ≥12 hours, 119 cases had closed, long-bone fractures, and 59 cases had open fractures, and the rate of crush syndromes was much less (2%) than did those with longer entrappment times.[18]

As most of the Chamran patients spent <10 hours under ruins and received supportive care and fluid therapy during the first 24 hours, only eight patients developed acute renal failure, two needed hemodialysis, and all of them recovered after receiving supportive care.

Hospitals located further from the site of disasters caused by natural hazards have an important role in supporting victims. The local health system almost always has been unable to respond adequately to the needs of the patients.[19]

After the Los Angeles Northridge earthquake, among the 113 nursing facilities, 23 sustained severe damage, five were closed, and 72 lost vital services.[20] Care in foreign field hospitals frequently is not immediate nor guaranteed due to the lack of efficient coordination and delay in transportation.

Nearly 20,000 persons were killed, 170,000 were injured, and 600,000 were rendered homeless in the 2001 earthquake in Gujarat, India. When the foreign field hospitals arrived five to seven days after the earthquake, most of the casualties requiring surgical intervention already had been operated upon. Nevertheless, most of the relief operation was based not on an accurate needs assessment of the medical situation, but rather on suppositions and expectations that had been developed in the donor countries prior to or immediately following the earthquake. These were based on minimal information and biases of the relief organizations.[21]

In a review article on hospital responses to sudden-onset disasters, hospitals demonstrated difficulties and failures in several major areas of operation during a disaster.[22] Due to these failures, many crisis management planners, such as the working organization designed by the French hospital and prehospital health organization (Forward Medical Post), emphasized that dispatching victims to fixed hospitals is an important part of the operation. This is an operational approach for crisis management in the field. In this strategy, relative emergency or urgent victims are placed in the category of dispatched patients.[23] Most of the patients in this category are victims with orthopedic injuries like those in this study.

In the case of the Bam earthquake, the international response was rapid and considerable; many field hospitals began their services within 24–48 hours.

Most of them were well-equipped and operated full-time. However, the role of fixed hospitals in the management of evacuated victims was significant, and having a disaster plan for each hospital can help casualties receive appropriate care in a short time.

Conclusion

True disaster readiness and preparedness cannot really be assessed until put to the test by a real disaster. The prompt disaster response and coordinated disaster management during the Bam earthquake was attributed mainly to a comprehensive disaster plan. Swift reactions by the hospital's senior decision-makers to rapidly changing situations during disasters are critical. The described screening tunnel has advantages for patient evaluation and the management of victims of a multi-casualty incident and can be used in similar situations.

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