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Original Article

The Pattern of Injuries among the Victims of the Bam Earthquake

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Abstract

Background: On December 26, 2003 an earthquake measuring 6.8 on the Richter scale, shook the city of Bam in the south east of Iran and killed more than 40000 people and nearly 30000 were injured. This is an epidemiological study performed on the victims of Bam earthquake to analyze different types of injuries of patients admitted in Kerman hospitals.

Methods: In a retrospective cross-sectional study the medical records of 1250 victims of Bam earthquake admitted in Kerman hospitals from December 26, 2003 till 21 March, 2004 were reviewed and general demographic data such as age, sex, date of admission, type and anatomical site of injuries, diagnoses and complications were recorded.

Results: More than half of the patients were male. The mean age was 29.28±11.89 years. Lower limb injuries (40.8%) and pelvic injuries (26.2%) were the most common. The least common injury was chest injury (10.9%). More than 50% of patients had fractures. There were associations between chest injuries, vertebral column injuries and abdominal injuries and between vertebral column, chest and skull fractures. The numbers of injury and fracture locations for each patient were 0.186±0.11 and 0.0886±0.098, respectively.

Conclusions: The study of individual factors and associations between different locations of injuries indicates a careful physical examinations and attention to special groups. It is important to use findings of epidemiologic studies on disasters to establish well-organized crisis registration system for the next disasters.

Keywords: *Earthquake, Injury, Iran*

Introduction

On December 26, 2003 at 5:26 am a catastrophic earthquake of magnitude 6.8 (Richter scale) occurred and caused a major disaster in ancient city of Bam; a major city of Kerman Province in southern east Iran.

Because the earthquake struck in the predawn hours and even worse in a densely populated area, the loss of life was greatly increased (1). About 40000 people died, more than 30000 were injured, and more than 25000 buildings were collapsed.

The first traumatized patients were sent to Kerman's hospitals by car or ambulance directly from the scene without first aid in field. A few times after the earthquake victims were transferred by ambulance or helicopter after giving primary care on site.

In a massive earthquake with a large number of casualties, the greatest demand for patient care occurs during the first 24 to 48 h after the disaster (2). Injured people usually seek emergency medical attention only during the first 3 to 5 d following the earthquake, from day 6 onward the need for emergency medical attention declines rapidly, so most injured people would benefit from early medical interventions (3). Previous studies have shown that one of the

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major medical problems in casualties like earthquake is from delayed medical care(4, 5).
Lack of experience and data about the precise causes of deaths and nature of injuries that occur during earthquakes is one of the most important problems in medical planning for these situations(3), the more we know about the manner in which injuries occur, the best we could plan and manage our medical sources for such tragedies.
Although studies related to earthquakes are abundant(6), a few of them have focused on the epidemiologic aspects of injured people and nature of injuries, one of the limiting factors in these studies is the number of injured patients. Better epidemiologic knowledge of types of injuries and illnesses caused by earthquake is clearly an essential requirement for more efficient services (7).
The present study of injured patients of the Bam earthquake, gives a report of epidemiologic features (demographic factors and pattern of injuries) with the aim to find a relationship between different types of injuries in the victims.

Materials and Methods

In a retrospective cross- study the medical profiles of 1250 victims of Bam earthquake admitted in five Kerman's hospitals from December 26, 2003 till March 21, 2004 were reviewed and general demographic data such as age, sex, date of admission, type and anatomical site of injuries, diagnoses and complications were recorded. This data collection was performed in this period by two nurses and five general physicians and was double checked by two specialists.
Because of logistic and medical reasons, some patients were transferred from one reference hospital to another during the hospitalization period. To avoid repetition in the census data, duplicate records were counted only in one hospital after matching the records.
Fallowing the exclusion of duplicate records 1218 sets of data were subjected to analysis.
All the data were processed and analyzed by personal computer with SPSS version 11.5. *P* values below 0.05 were considered statistically significant. The techniques applied to data analysis including descriptive statistics. The frequency tables were produced to describe the morbidity of groups according to age and sex. Age distribution for injuries were compared with the same distribution in the general population in the affected city before the earthquake reported by the Kerman government.
To check the intra-cluster correlation between different site of injuries and fractures, the hierarchical cluster method was used and the results were illustrated in the dendrogram. This graph is a simple method which illustrates how much association exists between different issues; short connection lines in this graph imply stronger association.
Statistical analyses were done by Student *t* test, ANOVA and Chi square test.

Results

Patients' characteristics

The number of the patients admitted to Kerman hospitals within the first five days following the earthquake was 796(69.3%); of whom 416 patients (52.3%) were admitted in the earthquake day (Fig. 1).
Among the hospitalized patients males were more than females (53.6%, $P< 0.008$). The mean age of admitted patients was 29.28±11.89 yr with a range of 6 months to 90 years. Most of the victims (41.7%, 508 cases) belonged to the age categories between 19 and 60 yr ($P< 0.001$). The risk of admission was the most in this age group either (0.007) (Fig. 2). In our study compared with other variables, the variable of age had the most missing data (34%).
According to the national census, 20.73% of the habitants of Bam were younger than 7 yr old, while only 5.2% of our victims were younger than 7 yr of age. A similar discordance was noted also in the age group 7 to 18 yr old; the proportion of inhabitants in this group was

34.49% but only 14.9% of the victims belonged to this age group.

Types of injuries and fractures

The most common injury was to the lower limb in 40.8% of patients (465 cases), pelvis in 26.2% (300 cases) and head 25.3% (291 cases). Only 10.9% of patients had thoracic injuries. The percents of injuries in each part of the body were significantly different ($P< 0.0001$) (Table1). 55.7% of our patients (623 cases) had fracture in one or more site. The most common fracture was in lower extremity in 261 patients (22.9%). 162 of our patients (14.1%) had pelvic fracture and 118 (10.3%) had upper extremity fracture. The most common injured bone in the lower limb was the tibia (113 cases) and the lowest number belonged to the fibula (34 cases). The most common injured bone in the upper limb was the humerus (38 cases) and the lowest number belonged to the ulna (16 cases) (Table 2).

The relation between the types of injuries and different factors

The number of places fractures in different age groups was not different. In the patients who had fractures, there was a slight predominance of males (52.7%, 328 cases), but it was not significantly different.

4.4% of our patients (54 cases) had not any injury. 44.3% (496) of patients had not any fractures in the bones. The number of injury and fracture locations in each patient was 0.186± 0.11 and 0.088±0.098, respectively and there were no difference between two sexes. The number of injury locations in the age groups was significantly different ($P<0.001$). Children under 7 yr old were less injured than adults (19 to 60 yr old) ($P<0.0001$). The number of fracture locations in each patient was not significantly different in the age groups.

The relation between sites of injuries and fractures

The correlations between injuries are illustrated in Fig. 3; strong coincidence was observed between chest vertebral column and abdominal injuries. There were considerable distances between the injuries of lower extremities and others. Fig. 4 shows strong intra-cluster correlations between vertebral column chest and skull fractures and there were a weak correlation between lower extremity fracture and other fractures. As Fig. 5 shows there were strong intra-cluster correlations between upper extremity injuries and fractures (cluster one); chest fractures, chest injuries and vertebral column fractures (cluster two); pelvic injuries and fractures (cluster three).

Considering all admissions, 17 burned patients (1.4%) and 17 pregnant traumatized patients were reported (1.4%).

Only 15 deaths were noted among the records of the hospitals.

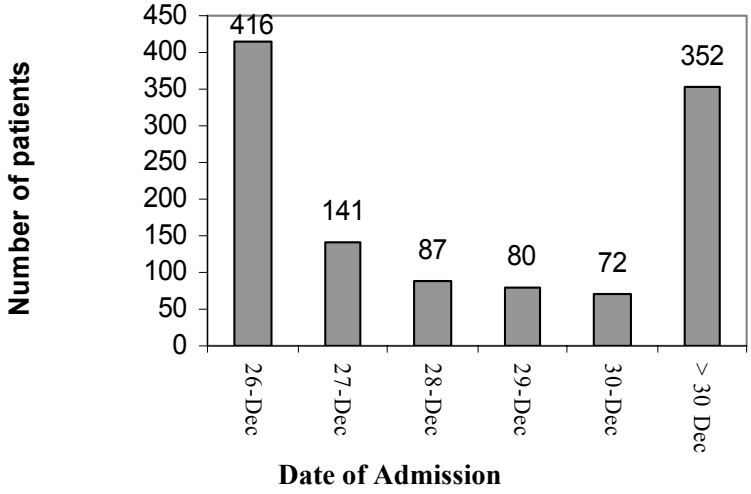

Fig. 1: Number of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals during different days after the earthquake.

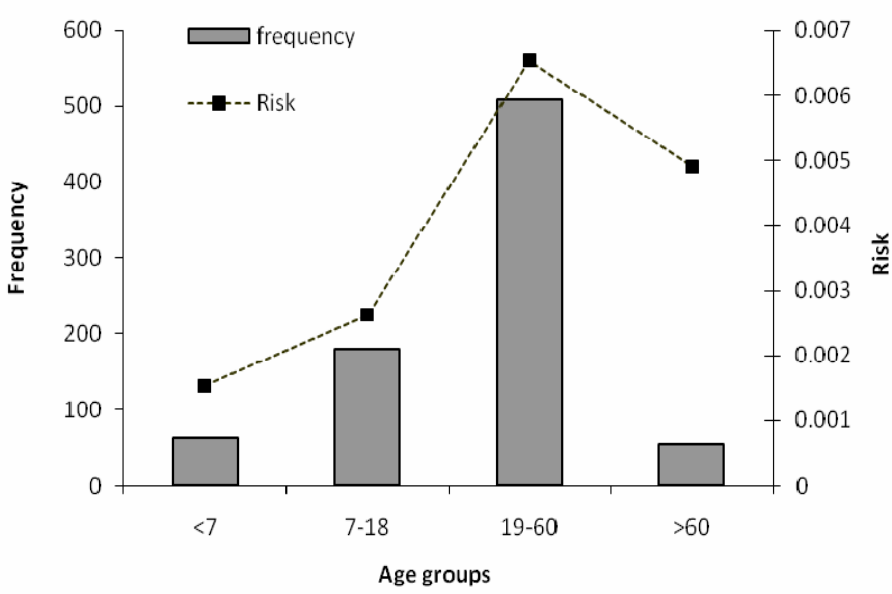

Fig. 2: Age distribution and risk of admission of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals.

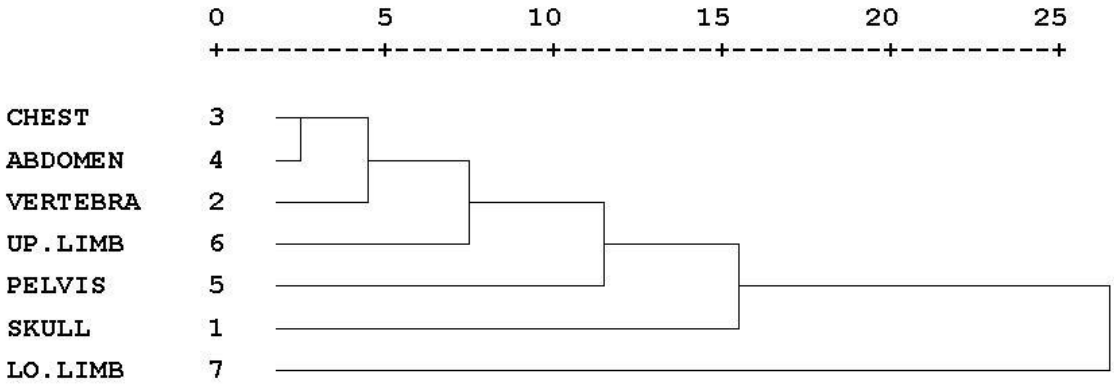

Fig. 3: The correlation between sites of ***injuries*** of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals. (Vertical lines show the strength of coincidence and short lines imply stronger association)

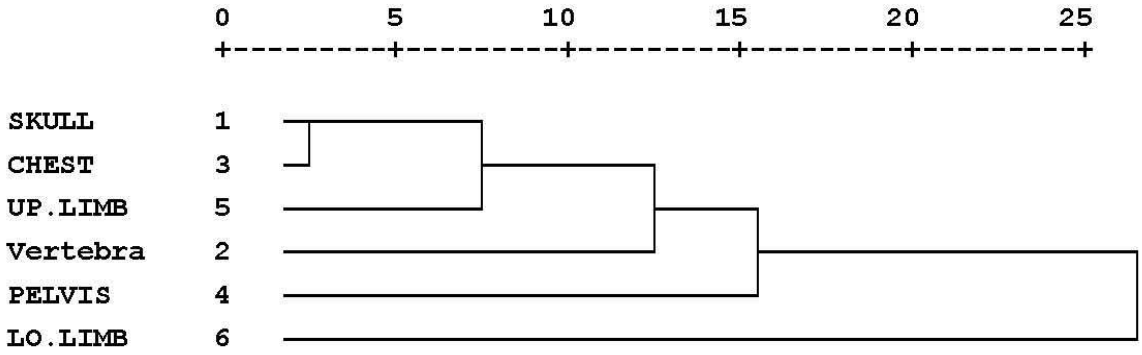

Fig. 4: The correlation between sites of ***fractures*** of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals.

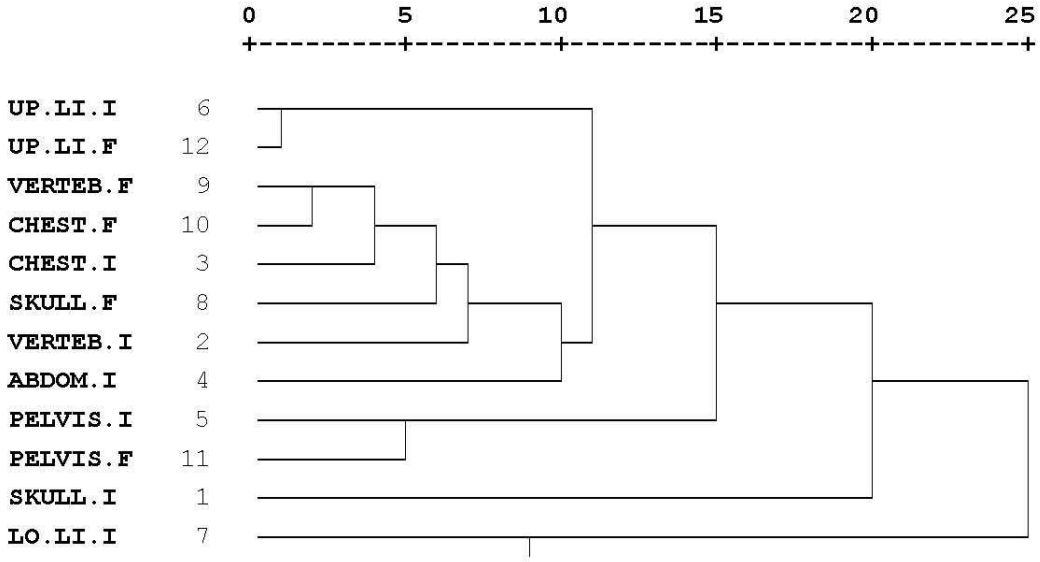

Fig. 5: The correlation between sites of ***injuries*** and ***fractures*** of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals.

Table1: The number of injuries and fractures of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals.

	Frequency of injuries (%)	Frequency of fracture (%)
Skull	291(25.3)	91(7.8)
Vertebral column	146(12.8)	44(3.8)
Chest	124(10.9)	33(2.8)
Abdomen	144(12.6)	----
Pelvis	300(26.2)	162(14.1)
Upper limb	189(16.6)	118(10.3)
Lower limb	40.8(465)	261(22.9)

Table 2: The frequencies and valid percents of fractures of traumatized patients of the Bam earthquake in 2003, 26 December; admitted in Kerman hospitals.

Fracture	Frequency (%)
Cervical vertebrae	7(0.6)
Thoracic vertebrae	8(0.7)
Lumbar vertebrae	34(2.9)
Ribs	26(2.2)
Clavicle	14(1.2)
Scapula	11(0.9)
Humerus	38(3.3)
Radius	27(2.3)
Ulna	16(1.4)
Hand	18(1.6)
Femur	94(8.1)
Tibia	113(10)
Fibula	34(3)
Foot	39(3.4)

Discussion

Following the Bam earthquake, admissions of victims were more frequent than existing medical records. For example in Afzalipour Hospital; one of the Kerman hospitals more than 5000 victims admitted during first three days after earthquake but in 5 hospitals of Kerman there were 1250 existing medical records. So this problem shows the importance and necessity of establishing a system for proper registration and organizing injury surveillance in crisis.

In 1994 Northridge earthquake injuries were 74% more frequent than usual overall and some hospitals experienced as many as five times number of injury admission seen in the days preceding the event (8).

Epidemiological studies, especially surveillance of injuries are one of the most challenging topics in crisis management of natural disasters. Although during the past 20 yr, earthquake alone have caused more than one million deaths worldwide (3, 9), but there is a little information about epidemiological features of victims. One of the most important reasons is critical situation immediately after the disaster. Also the excess work load and social and psychological aspect of subject aggravate it.

According to the results number of admitted females was lower in victims. Because of their weak body and their attempt to protect their children they may die before they could reach to medical centers. In 1999 Chi-Chi earthquake female fatalities were 1.1 times, in 1995 Hanshin earthquake 1.5 times and in 1994 Northridge 2.4 times more than males (2, 4).

There was a significant difference in the age pattern of admitted victims. The lower number of children (<7 yr) is probably because they were protected by their parents.

The possible reasons in elderly group (>60 yr) is that they were less able to react to emergencies and were physically weaker so died immediately during the earthquake. In the 1994 Northridge, California earthquake individuals over age 65 had 2.9 times more likely to be injured than younger individuals(4). In the 1999 Chi-Chi, Taiwan earthquake the mortality of the elderly (>79 yr) was approximately 12 times that of those between 20-29 yr and the mortality of children (<9 yr) was lower than expected (6, 10).

Comparing with other earthquakes, most of the lifesaving responses were needed within 24 h, and medical care for a large number of patients were needed for 3 d 7. In the Bam earthquake the large number of admissions was during the first day, too.

Trauma is the most common cause of mortality through earthquake(6). Threatening injuries like intra cranial hemorrhage, injury of intra thoracic and intra abdominal organs lead to immediate victims dead(11).

Study of injury details in this research shows the highest rate of injuries were in lower limb and the next most common were pelvis and head injuries. In fractures lower limb, pelvis and upper limb were the highest, respectively. The useful point is that inappropriate handling and traction of fractured bones like humerus while rescuing victims can lead to neural palsies (12).

There are different and same results in other earthquakes. 1999 Marmara earthquake show the most traumas in extremities in all age groups (11). In 4832 victims of 1988 Armenia earthquake, superficial trauma such as lacerations and contusions were the most (24.9%) followed by head injuries (22%) and lower extremity injuries (19%) (3). The study of department of orthopedics and trauma surgery of Shariati Hospital, Tehran, on 210 victims of Bam earthquake shows most fractures in lower limbs (46.7%), the next most common were in axial skeleton and the upper limbs were the least (12).

It has been demonstrated that the incidence of fractures and injuries in an earthquake depends on the position of the patients at the time of the incident. If the patients are standing or sitting at the time of injury the most frequent observed fractures will be those of vertebral column and if the patients are lying in supine or lateral positions, most of the fractures will be those of the pelvis and thoracic cage skeleton (12). Bam earthquake happened on 05:26 AM in the morning when huge number of people were asleep.

Each individual of Bam victims had injuries in more than one organ. In all natural disasters a lot of injured patients need care for more than one organ. There was a significant difference in the number of injury locations of each patient between the age groups. In Northridge, California, earthquake every 10 yr increase in age over age 18 led to a 30% increase in injury risk(4).

Companion of thoracic, vertebral column and abdomen injuries show the likelihood of trauma in these regions while facing with one of them. Also skull fractures have correlation with the fractures of these sites. So there is a necessity for careful management of injured patients.

One of the considerable points in an earthquake that results in 40000 deaths is the low rate of registered mortality. It states that most mortality had occurred during earthquake or through transferring wounded.

Some victims admitted in hospitals because of non-traumatic problems like burn, pneumonia, heart attack and so on. These victims were 20 percent in a hospital of Marmara earthquake (9). Among Bam victims 17 female had non trau-

matic admission like premature labor, delivery onset and abortion. These complications are predictable in every earthquake

According to our research the study of individual factors and association between different locations of injuries indicates a careful physical examinations and attention to special groups.

Reviewing our experiments reveals our defect in registering and assessing injuries. As Iran is an earthquake-prone region findings of epidemiological studies on such disasters should be used to establish well-organized crisis registration system for the next disasters. So to get this target all medical centers such as hospitals and outpatient clinics should participate (9).

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The authors declare that they have no conflict of interests.

References

1. Iskit SH, Alpay H, Tugtepe H, Ozdemir C, Ayyildiz SH, Ozel K, Bayramiçli M, Tetik C, Dağli TE (2001). Analysis of 33 pediatric trauma victims in the 1999 Marmara, Turkey earthquake. *J Pediatr Surg*.; 36(2): 368-72.
2. Schultz CH, Koenig KL, Noji EK (1996). A medical disaster response to reduce immediate mortality after an earthquake. *N Engl J Med*, 334(7): 438-44.
3. Ardalan A (2004). Disaster Epidemiology Lessons From Bam Earthquake Dec 26, 2003 Iran. University of Pittsburg. Available from: http://www.pitt.edu/
4. Peek-Asa C, Ramirez M, Seligson H, Shoaf K (2003). Seismic, structural, and individual factors associated with earthquake related injury. *Inj Prev*, 9(1): 62-6.
5. Yi-Szu W, Chung-Ping H, Tzu-Chieh L, Dar-Yu Y, Tain-Cheng W (2000). Chest injuries transferred to trauma centers after the 1999 Taiwan earthquake. *Am J Emerg Med,* 18(7):825-27.
6. Liang NJ, Shih YT, Shih FY, Wu HM, Wang HJ, Shi SF, Liu MY, Wang BB (2001). Disaster epidemiology and medical response in the Chi-Chi earthquake in Taiwan. *Ann Emerg Med*, 38(5): 549-55.
7. Ardalan A (2006). Disaster Epidemiology Lessons From Bam Earthquake Dec 26, 2003 Iran. University of Pittsburg. Available from: http://www.pitt.edu/
8. Bulut M, Fedakar R, Akkose S, Akgoz S, Ozguc H, Tokyay R (2005). Medical experience of a university hospital in Turkey after the 1999 Marmara earthquake. *Emerg Med J*, 22(7): 494-98.
9. McArthur DL, Peek-Asa C, Kraus JF (2000). Injury hospitalizations before and after the 1994 Northridge, California earthquake. *Am J Emerg Med*, 18(4): 361-66.
10. Sever MS, Erek E, Vanholder R, et al. (2002). Renal replacement therapies in the aftermath of the catastrophic Marmara earthquake. *Kidney Int*, 62(6): 2264-71.
11. Sarisozen B, Durak K (2003). Extremity injuries in children resulting from the 1999 Marmara earthquake: an epidemiologic study. *J Pediatr Orthop B*, 12(4): 288-91.
12. Tahmasebi MN, Kiani K, Mazlouman SJ, Taheri A, Kamrani RS, Panjavi B, Harandi BA (2005). Musculoskeletal injuries associated with earthquake. A report of injuries of Iran's December 26, 2003 Bam earthquake casualties managed in tertiary referral centers. *Injury*, 36(1): 27-32.