ORIGINAL RESEARCH

Pediatric Trauma at Tertiary-Level Hospitals in the Aftermath of the Bam, Iran Earthquake

Marzieh Sabzehchian, MD;[1] Hassan Abolghasemi, MD;[2] Mohammad Hadi Radfar, MD;[3] Nematollah Jonaidi-Jafari, MD;[1] Houman Ghasemzadeh, MD;[3] Frederick M. Burkle, Jr., MD, MPH, FAAP, FACEP[4]

1. Baqiyatallah Military Health Research Center, Mollasardra, Vanak, Tehran, Iran
2. Iranian Blood Transfusion Organization
3. Iranian Pediatrics Hematology and Oncology Sosciety, Tehran, Iran
4. Johns Hopkins Medical Institutions and John A. Burns School of Medicine, University of Hawaii, Honolulu, Hawaii USA

Correspondence:
Mohammad Hadi Radfar
Iranian Pediatrics Hematology and Oncology Society
No. 32
Shahed Alley
Vesal Street
Kesharvarz Boulevard
Tehran, Iran
E-mail: mhadirad@yahoo.com

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Abstract

The Bam Earthquake caused one of the most destructive disasters from naturally occurring hazards in recent years. Children are one of the most vulnerable age groups during disasters, in terms of both physical and psychological injuries. The assessment of pedatric injuries in the aftermath of the Bam Earthquake is discussed is this article. Within one week of the Earthquake, 119 patients <16 years of age were admitted to three tertiary-level referral hospitals in Tehran, Iran. Extremity, chest, and abdomen, and head and spinal column injuries were present in 83, 17, and 36 patients, respectively. Lower extremity injuries were more common than upper extremity injuries. A total of 65 operations were performed: 52 (80%) orthopedic, eight (12.3%) general, and five (7.7%) neurosurgical.

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Introduction

On the morning of 26 December 2003, a major earthquake measuring 6.5 on the Richter scale struck the city of Bam in the Province of Kerman, Iran.[1] The earthquake left >40,000 dead, 30,000 injured, and left approximately 75,000 persons homeless.[1,2] Within 48 hours of the Earthquake, >12,000 injured patients were airlifted to several hospitals throughout Iran.[1]

Few studies specifically addressed the clinical features of traumatized children during disasters caused by natural hazards.[3] Recognizing that children are one of the most vulnerable age groups during disasters, this event provided an opportunity to investigate the characteristics of earthquake-induced physical and psychological injuries among children. This study reviews clinical features and laboratory data of children admitted to three tertiary-level hospitals in Tehran, and assesses their capacity and capability to manage such injuries.

Methods

This research was conducted in three tertiary-level referral hospitals in Tehran (Imam Hossein, Milad, and Baqiyatallah hospitals). A total of 119 injured children (<16 years of age) were hospitalized within one week of the Bam Earthquake. Primary care physicians were recruited to conduct physical examinations and review medical records. Questionnaire data were collected on: (1) age; (2) sex; (3) location at the time of injury; (4) type of injury; (5) on-scene treatment; (6) initial hospital care (operative/non-operative); (7) fasciotomy performed; and (8) blood transfusion. Patients were disaggregated for age: (1) <6 years; (2) 6–10 years of age; and (3) 11–16 years of age. Injuries were classified as: (1) extremity injuries; (2) chest and/or abdomen injuries; and (3) head and/or spinal column injuries. Extremity injuries were categorized further as soft tissue and bone/joint injuries. Operative care categorization included: (1) orthopedic surgery (operations performed for fractures, dislocations, tendon injuries, and amputations); (2) general surgery (included soft tissue debridement, laceration repair, deep wound repair, wound infections, abscesses, vascular injuries, neural injuries, and repair of thoracic and abdominal injuries); and (3) neurosurgery (all head and spinal column operations). Patients with mul-

Type of injury	<5 years (n = 33) n (%)	6–10 (n = 26) n (%)	11–16 (n = 60) n (%)
Limb injury	23 (66.6)	18 (69.2)	42 (70.0)
Chest and abdomen	3 (9.0)	4 (15.0)	10 (16.0)
Head and spinal column injury	8 (24.2)	8 (30.7)	21 (35.0)

Table 1—Frequency of each type of injury in age groups

Injury Type	Upper Limb n (%)	Lower Limb n (%)
Joint Injury	10 (8.4)	50 (42.0)
Laceration/Contusion	5 (4.2)	56 (47.1)
Fracture	11 (9.2)	52 (43.7)
Echymosis	9 (7.6)	31 (26.1)
Hematoma	2 (1.7)	19 (16.0)
Deep wound	1 (0.8)	22 (18.5)
Vascular	0 (0.0)	13 (10.9)

Table 2—Frequency of different injury types in upper and lower limb

tiple injuries were counted separately for each area of injury and operation received.

Statistical analyses were performed using descriptive methods and analysis of variance (ANOVA). Correlation between the variables was evaluated using Pearson correlation test (p-values <0.05 were considered statistically significant).

Results

A total of 119 patients, <16 years of age (mean 9.4 ±4.8 years), were assessed and hospitalized in one of three Tehran hospitals within one week of the Bam earthquake. Cases included 60 (50.4%) females and 59 (49.6%) males. Sixty patients (50.4%) were 11–16-years-old, 26 (21.8%) were 5–10 years of age, and 33 (27.7%) were <5 years of age. Extremity, chest and abdomen, and head and spinal column injuries were present in 83, 17, and 36 patients, respectively.

The frequency of injury types in each age group is listed in Table 1. Injury to one or more limbs was the most common type of injury among all age groups, followed by chest and abdominal injuries. Of those with extremity injuries, six (10.8%) had only soft tissue injury, 25 (30.1%) experienced only bone/joint injury, and 49 (59.0%) had both. Eighty-five percent of extremity injuries occured in the lower extremities. The frequency of different limb injuries is shown in Table 2.

A total of 65 operations were performed: 52 (80%) orthopedic, eight (12.3%) general surgery, and five (7.7%) neurosurgical. More orthopedic operations were performed on lower limbs (88%) than on upper limbs. Operative frequencies by type and age are listed in Table 3. Orthopedic surgeries and general surgeries were distributed evenly in each age group, but neurosurgical operations had a higher frequency in the 11–16 age group.

Fifteen cases required fasciotomy: 14 lower extremity, one upper extremity. The need for fasciotomy was less likely if fixation of the injured extremity was performed at the scene ($p = 0.01$), and crush syndrome was significantly correlated with the need for blood transfusion ($p = 0.01$). Fasciotomy did not correlate significantly with the rise of serum creatinin ($p = 0.61$) and presence of multiple-traumatic injuries ($p = 0.28$). The correlation between children located beside walls for protection and a higher frequency of pelvic injuries was statistically significant ($p = 0.01$). However, a statistically significant correlation was not observed between the frequency of injuries and the location of children at the time of the event.

The longest mean value for the admission period was observed among orthopedic operations (mean = 10.7 ±4.34 days), followed by general surgeries (mean = 7.2 ±3.1 days) and neurosurgeries (mean = 4.2 ±3.2 days).

Discussion

Over the past two decades, Iran has had the second highest death toll resulting from earthquakes.[4] During the 20th Century, earthquakes have resulted in the loss of >1 million human lives worldwide.[5] Five earthquakes killed >10,000 persons in the past 10 years. Two occurred in Iran: the Guilan and Bam Earthquakes.[6] The most devastating earthquakes in Iran occur in regions with traditional architecture and deficient building codes. Mud architecture still is prevalent in the Bam area. Since it is impossible to prevent the occurrence of earthquakes, attention is focused on preparedness and prevention of the consequences. The information gathered from each disaster provides valuable lessons. Evidence-based studies in developed countries confirm that trauma is responsible for most deaths, many of which are preventable.[5]

In this study, most children who were referred to tertiary hospitals within one week of a major earthquake were 11–16-years-old. Most children suffered injuries to the extremities, followed by head and spinal column injuries.

Type of surgery	<5 years (n = 33) n (%)	6–10 (n = 26) n (%)	11–16 (n = 60) n (%)
Orthopedic operation	16 (48.4)	11 (42.3)	25 (41.6)
Soft tissue operation	1 (3.3)	4 (15.3)	3 (5.0)
Head and spinal column operation	0 (0.0)	1 (3.8)	4 (6.6)

Table 3—Frequency of operation types by age groups

This is in agreement with other studies that reported extremity injuries to the most common types of injuries.[7–9] Orthopedic operations were the most common type of operative procedure and required the longest post-operative hospitalization period. Younger children sustaining life-threatening injuries likely died at the scene or were taken to a local hospital for life-saving care. Therefore, this study mostly included children 11–16 years of age. A tertiary center, particularly one that is located far from the affected area, is more likely to receive patients with severe but not life-threatening injuries (as was the case in this study).

During a disaster, healthcare centers should maintain the healthcare facilities, personnel, and resources with regard to the injuries most likely to be referred to that facility. Accordingly, this study suggests that most of the first pediatric patients tended to in a tertiary care center after an earthquake would require orthopedic surgery of the extremities. Later, orthopedic and general surgeries in age groups with larger numbers of older children requiring neurosurgeries were distributed evenly. As time progressed after the Earthquake, extremity injuries were less commonly seen. However, hospitals should be prepared for longer periods of hospitalization after orthopedic operations. The shortest admission period was observed in neurosurgery cases because most of them required less complicated surgeries, such as drainage of hematomas.

In order to provide care, healthcare providers should consider the regional characteristics of the area, including architectural and health features. After the Bam Earthquake, suffocation was the second leading cause of death, due to the collapse of mud architecture.[10]

The lower incidence of fasciotomies associated with fixation at the scene, as well as a higher incidence after blood transfusion can be explained. It is understood that compartment syndrome occurs whenever the tissue pressure (interstitial pressure) within a closed anatomic space is greater than the perfusion pressure. Increase of tissue pressure may be caused by the decrease of the compartment size or the increase of the intracompartmental volume by edema and/or hemorrhage. Immobilization decreases edema following trauma and will prevent or limit the development of a compartment syndrome. Decreased perfusion pressure may be augmented by dehydration and volume loss. Hence, it is expected that patients with blood loss and who need a blood transfusion will be at greater risk for the development of compartment syndrome. On the other hand, compartment syndrome may develop during reperfusion following a period of ischemia. During ischemia, there is a gradual depletion of intracellular stores of high-energy phosphate bonds and glycogen stores, as well as a buildup of products of glycolysis. Instead of restoring normal muscle metabolic activity, reperfusion may cause harmful effects by washing out necessary precursors for adenine nucleotide resynthesis. Also, production of oxygen free radicals and calcium influx occurs. Interestingly, a lower frequency of fasciotomy compared to a report from the Marmara, Turkey earthquake, was observed in this study.[11] The lessons learned from the Guilan Earthquake caused many healthcare providers to consider early fluid resuscitation of the patients.

During disasters, psychiatric support is needed for all age groups, particularly children. Unfortunately, many children in this study lost their parents in the disaster, and required psychological support for a long period of time. Psychological consultation began on the first day of admission to the hospital.

Conclusion

All disasters, regardless of etiology, have some common medical and public health consequences. Disasters cause an overwhelming need for medical care, which emphasizes the importance of using healthcare resources optimally. Personnel in tertiary-level health centers that admit patients during a disaster should remember previous experiences, the special features of each event, evidence-based studies, and the lessons learned. This study confirms that characteristics of each level of hospital care can be predicted by recognizing the characteristics of the hazard involved and the injuries observed. In this regard, such information can be used to better plan, prepare, and ensure that expertise and resources are compatible with expectations.

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