

Original Article

Chest Injuries Associated with Earthquakes: An Analysis of Injuries Sustained During the 2008 Wen-Chuan Earthquake in China

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Abstract

Purpose. The goal of this study was to analyze the patterns, therapeutic modalities, and short-term outcomes of patients with chest injuries in the aftermath of the Wen-Chuan earthquake, which occurred on May 12, 2008 and registered 8.0 on the Richter scale.

Methods. Of the 1522 patients who were referred to the West China Hospital of Sichuan University from May 12 to May 27, 169 patients (11.1%) had suffered major chest injuries. The type of injury, the presence of infection, Abbreviated Injury Score (AIS 2005), New Injury Severity Score (NISS), treatment, and short-term outcome were all documented for each case.

Results. Isolated chest injuries were diagnosed in 129 patients (76.3%), while multiple injuries with a major chest trauma were diagnosed in 40 patients (23.7%). The mean AIS and the median NISS of the hospitalized patients with chest injuries were 2.5 and 13, respectively. The mortality rate was 3.0% (5 patients).

Conclusions. Most of the chest injuries were classified as minor to moderate trauma; however, coexistent multiple injuries and subsequent infection should be carefully considered in medical response strategies. Coordinated efforts among emergency medical support groups and prior training in earthquake preparedness and rescue in earthquake-prone areas are therefore necessary for efficient evacuation and treatment of catastrophic casualties.

Key words Wen-Chuan earthquake · Chest injury

Introduction

The Wen-Chuan earthquake, registering 8.0 on the Richter scale, occurred at 14:28 on May 12, 2008. This earthquake was the largest natural catastrophe to strike mainland China since the Tangshan earthquake in 1976.¹ The epicenter was located in the northwestern area of Sichuan Province, and the most severe destruction occurred in Wen-Chuan county. Official records reported that 69 181 people died, 374 171 were injured, and 18 522 were listed as missing. The widespread effects of the earthquake damaged countless cities and villages; furthermore, many hospitals and medical facilities were physically destroyed. Immediately after the earthquake, a large number of casualties were sent to the West China Hospital of Sichuan University in Chengdu by car, ambulance, and helicopter. This hospital, located about 90 km away from Wen-Chuan county, received only minor damage from the earthquake and all the medical facilities remained intact. West China Hospital served as the largest back-up hospital in the aftermath of the disaster.

There has heretofore been scant information regarding chest injuries associated with major earthquakes in developing countries due to limited data concerning the type of trauma and surgical interventions. For this reason, we conducted a descriptive analysis of 169 hospitalized patients with major chest injuries in the aftermath of the earthquake, from May 12 to May 27. Patient information was documented in order to develop a better understanding of the injury patterns, therapeutic modalities, complications, and short-term outcomes associated with chest trauma in the wake of a disaster. This information can improve all levels of medical management of this type of injury after a major catastrophic earthquake.

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Patients and Methods

From May 12 to May 27, 2244 patients were transferred to the West China Hospital of Sichuan University. Of these patients, 722 (32.2%) with minor injuries were treated in the emergency department on an outpatient basis and were excluded from this study. The other 1522 patients (77.8%) were deemed critical and required hospitalization (Fig. 1). These patients were examined by two chest surgeons (J.H., J.T.) for chest injury, and 169 were diagnosed with a major chest injury for further evaluation or surgery. Individuals with superficial trauma such as lacerations and contusions were diagnosed by physical examination, while fractured ribs or clavicle, pneumothorax, hemothorax, diaphragmatic rupture, and pulmonary contusions were diagnosed using chest radiographs or computed tomography scans. All the chest injuries were classified with respect to the Abbreviated Injury Scale 2005 (AIS2005)² and according to their severity (AIS2005 codes). The New Injury Severity Score (NISS) has demonstrated better performance in predicting postinjury complications and short-term outcomes than the Injury Severity Score (ISS) in cases of blunt and penetrating trauma;³⁻⁵ therefore, we calculated the NISS of patients with multiple injuries and analyzed its association with the survival rates. We also calculated the descriptive statistics for all numeric variables, including the mean, median, and standard deviation, in addition to the proportions of all categorical variables.

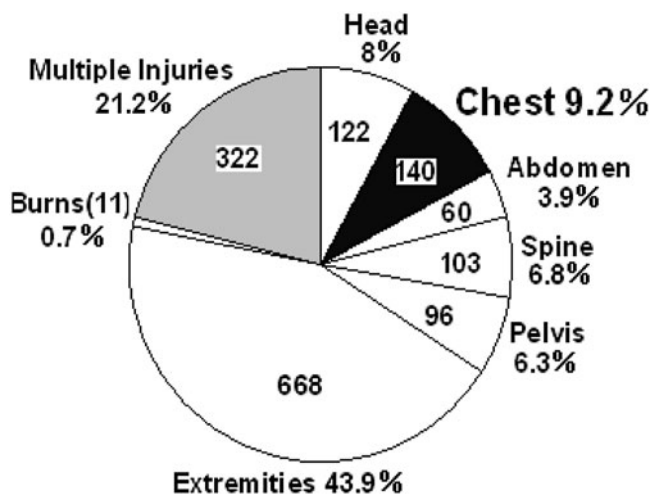


Fig. 1. Distribution of the hospitalized patients by anatomical sites. Patients who suffered multiple injuries (gray area) included 40 patients with coexistent chest trauma, and the segment Chest (black area) represents 129 patients with isolated chest injuries

Results

The 169 victims who suffered earthquake-related major chest injuries comprised 11.1% of the 1522 hospitalized patients who had injuries from all types of trauma during the earthquake. There were 80 male (47.3%) and 89 female patients (52.7%) with a mean age of 54.2 years (age range, 4–103 years). Detailed patient information is summarized in Fig. 2.

The most frequent type of chest injury was rib fracture (44.4%), followed by pneumothorax (17.2%), clavicle fracture (16.6%), and hemithorax (10.6%) (Table 1). Forty patients (23.7%) with major chest injuries suffered coexistent multiple injuries, of which vertebral injury (37.5%) and extremity fracture (31.2%) were the most common types (Table 3). The most common surgical procedure received by the hospitalized patients with chest injuries was tube thoracostomy (57 patients).

Twenty patients with severe thoracic injuries were admitted to the intensive care unit (ICU), and 16 of these patients needed intubation and mechanical ventilation for progressively worsening hypoxemia (intubation rate, 80%). The mean time (SD) on mechanical ventilation was 291.2 (117) hours. Among the 16 intubated patients, 14 developed acute respiratory distress syndrome (ARDS) (3 patients with flail chest, 10 patients with pulmonary contusion with hemopneumothorax, and 1 patient with pneumonia). The other two patients were intubated for emergency operations (one with a diaphragmatic rupture and one with a left main bronchus laceration with left lung atelectasis). Crush syndrome of the extremities was diagnosed in 3 of the 20 ICU patients, 2 of whom had developed oliguric acute renal failure with hyperkalemia and underwent emergency dialysis (one patient received hemodialysis

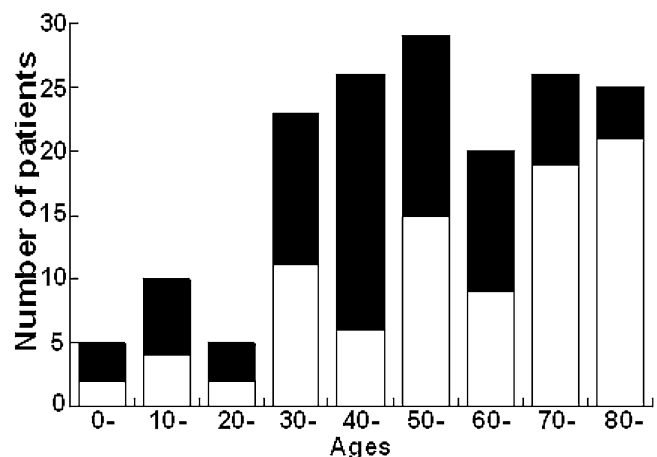


Fig. 2. Age and gender distributions of the hospitalized patients with chest injuries. Black, male; white, female

Table 1. Details of chest injury and coexistent multiple injuries/pathology

Chest injuries	No. of patients (%)	Coexistent multiple injuries/pathology (no. of patients)
Rib fracture	75 (44.4%)	Vertebral injury (8), extremity fracture (5), crush syndrome (2), pneumonia (6), ARDS (6)
Pneumothorax	29 (17.2%)	Vertebral injury (3), extremity fracture (1), scalp laceration (3), pneumonia (1), ARDS (5)
Clavicle fracture	29 (17.2%)	Vertebral injury (4), brachial plexus injury (1), scapula fracture (4), pelvis fracture (2), pneumonia (3)
Hemothorax or hemopneumothorax	18 (10.6%)	Vertebral injury (3), intracerebral hemorrhage (1), crush syndrome (1), pneumonia (4), ARDS (3)
Superficial trauma	15 (8.8%)	Subcutaneous abscess (1), extremities fracture (2), burns (1), soft tissue defect (3), pneumonia (9)
Subcutaneous emphysema	2 (1.2%)	Mandible fracture (1), traumatic asphyxia (1)
Diaphragmatic rupture	1 (0.6%)	Liver laceration (1)
Total	169	40 patients with 48 coexistent multiple injuries ^a

ARDS, acute respiratory distress syndrome

^aPneumonia and ARDS were excluded from the total coexistent multiple injuries calculation**Table 2.** Clinical characteristics of pneumonia in the hospitalized patients with chest injuries

Clinical characteristics	Group A	Group B
No. of patients	15	8
Mean age (years)	75.7 ± 27.3	56.4 ± 21.4
Interval from the earthquake to hospitalization (h)	219.2 ± 118.8	161.4 ± 147.4
Interval from admission to confirming the diagnosis of pneumonia (h)	28.1 ± 5.9	120 ± 34.5
Mean AIS/median NISS	1.2/1	3.5/21.5
Mechanical ventilation required	2 patients	8 patients
Microbiological investigation (sputum, blood, pleural effusion)	<i>Haemophilus influenzae</i> (9), <i>Streptococcus pneumoniae</i> (6), <i>Staphylococcus aureus</i> (1), <i>Pseudomonas aeruginosa</i> (1)	<i>Acinetobacter baumannii/haemolyticus</i> (7), <i>Escherichia coli</i> (3), <i>Staphylococcus aureus</i> (2), <i>Candida albicans</i> (2), invasive pulmonary aspergillosis (1)
Multiple/mono microorganism infection	2/13 patients	5/3 patients

AIS, Abbreviated Injury Score; NISS, New Injury Severity Score

and one patient received peritoneal dialysis due to unstable hemodynamics).

Among the 169 hospitalized patients with chest injuries, 23 patients (13.6%) experienced lung infection. Of these 23 individuals, 15 (Group A) had minor or superficial chest injuries and were transported from the field several days after the earthquake, while the other 8 (Group B) had severe chest injuries and contracted hospital-acquired pneumonia. There were notable differences in clinical characteristics between these two groups, and the information has been provided in Table 2. All patients received tetanus prophylaxis and there were no cases of gas gangrene or tetanus.

The mean AIS of the hospitalized patients with chest injuries was calculated as 2.6 (SD: 1), and the median NISS was 13. According to the AIS2005 classification there were 91 patients (53.8%) with minor to moderate chest injuries (AIS1, AIS2), 67 patients (39.7%) with serious but not life-threatening chest injuries (AIS3), and 11 patients (6.5%) with severe and life-threatening

or critical chest injuries (AIS4, AIS5). Five patients died, and three of these individuals were multiple injury patients with a median NISS value of 34 (mean = 36.3). The other two patients, who died due to severe lung infection, sustained isolated chest injuries with a mean AIS value of 2.5 and a median NISS value of 13 (mean = 13). The mortality rate of the patients who had suffered multiple injuries including chest trauma was 7.5% (3/40), and the mortality rate of the patients with isolated injuries was 1.6% (2/129). The median NISS value of the five mortalities was 25 (mean = 27) and the mortality rate in the patients with a NISS value > 25 was 36.4% (4/11).

Discussion

Earthquakes are extremely destructive, and have caused overwhelming casualties and material losses during the past decade.⁶ In regard of the catastrophic casualties,

property loss, and logistical scale of the relief coordination, the Wen-Chuan earthquake has been considered the largest natural disaster of the past 10 years. Furthermore, impassable roads and a breakdown in the communication systems after the earthquake made it difficult to meet an urgent need for external aid. Similar communication and transport problems were experienced in Turkey during the Marmara earthquake⁶ and in Taiwan during the Chi-Chi earthquake.⁷ Moreover, Wen-Chuan county is located in a mountainous area, and severe weather soon after the earthquake rendered helicopter landing impossible. The scope of the disaster was therefore unknown until the first Chinese relief team arrived at the site by foot 30 h after the earthquake. As can be expected, the delayed emergency medical support and the difficult transportation of victims to the nearest back-up hospitals certainly contributed to the catastrophic number of casualties. This situation was similar to that seen earlier in a Soviet earthquake.⁸

It is well known that patients with severe chest injuries suffer a disturbance in cardiovascular and respiratory functioning, and will die in a short period of time without prompt diagnosis and management (which is sometimes as simple as the insertion of a chest tube).⁸ Considering the lack of self-rescue training among the victims and the lack of emergency medical support in the early period after the earthquake, it is plausible that the small percentage of severe chest injuries (6.5%) reflects the fact that many patients did not survive to reach necessary medical treatment.

As has been the case in other natural disasters, the majority of chest injuries with coexistent multiple injuries in the Wen-Chuan earthquake were caused by the widespread collapse of buildings, which was the predominant mechanism causing the observed injuries.^{7,9-14} However, the Wen-Chuan earthquake seems to have had a surprisingly high rate of chest injuries with coexistent vertebral injuries (Table 3). Of the 18 patients with coexistent vertebral injuries, 12 were injured by jumping from the high floors of the buildings on their own initiative when the earthquake struck. These injuries are evidence of the importance of earthquake preparedness and rescue education in earthquake-prone areas, as the aforementioned injury could be minimized or even avoided.

There was a high incidence of pneumonia (13.6%) among the hospitalized patients with chest injuries. Of these 23 patients, 15 were elderly individuals (mean age, 75.7 ± 27.3 years) with minor chest injuries, who could be diagnosed with community acquired pneumonia (CAP) in light of the hospitalization duration and the isolated microorganisms (Table 2). After the earthquake, there was a significant deterioration in living conditions, and both hygiene and transportation were

Table 3. Distribution of coexistent multiple injuries in the patients with chest injuries

Coexistent multiple injuries	No. of injuries	Ratio (%)
Vertebral injury	18	37.5
Extremities injury	15	31.2
Head trauma	5	10.4
Burns and soft tissue defect	4	8.3
Pelvis injury	2	4.2
Abdominal trauma	1	2.1
Others	3	6.3
Total	48	100

Some patients had more than one system of injury

greatly affected in a negative manner. Two elderly hospitalized patients with minor chest injuries died of severe multiple-microorganism lung infection. These findings highlight the importance of transferring the elderly (> 60 years) to medical facilities in a timely manner, regardless of the severity of the injuries. The severity of the injuries and long duration of mechanical ventilation contributed to the hospital-acquired pneumonia in the other 8 patients. All three patients with flail chest were treated by internal pneumatic stabilization with ventilator support, but developed severe lung infection. Tanaka et al.¹⁵ reported that surgical stabilization shows beneficial effects due to less ventilator support, lower incidence of pneumonia, shorter trauma ICU stay, and reduced medical cost in comparison to internal fixation. Therefore, we should be more timely in the treatment of categories of injuries requiring surgery in future medical management.

Considering the fact that the mean AIS of the hospitalized patients with chest injuries was 2.6 (SD: 1) and the median NISS was 13, the chest trauma victims in this study had low injury severity. Chest injuries complicate the resuscitation of patients with multiple injuries accompanying thoracic trauma and increase the mortality rate. Therefore, the median NISS value and the mortality rate of the patients who experienced chest trauma with multiple coexistent injuries were 18% and 7.5%, respectively. In comparison, the median NISS value and the mortality rate were 13% and 1.6%, respectively, in the patients with isolated chest injuries. As can be inferred from our results, the patients with a NISS over 25 demonstrated a high incidence of mortality (36.4%), which indicates the adverse association of a high NISS with the survival rate in chest trauma victims after a major earthquake. Considering the previously published data^{4,5} and utilizing the NISS to predict post-injury complications and mortality, it is probable that some complications and even deaths might have been prevented if the victims had been transferred promptly and treated appropriately.

We were able to draw conclusions regarding the nature of chest injury patterns, challenges in emergency medical support, subsequent complications, morbidity, and mortality in the Wen-Chuan earthquake. Minor to moderate injuries were the most common type of chest injury; however, coexistent multiple injuries and subsequent infection could increase the severity of injuries and complicate the treatment strategy. A coordinated effort involving the prompt transportation of injured patients (especially the elderly) and training for earthquake preparedness and rescue in earthquake-prone areas should be implemented in order to achieve the utmost efficiency in the evacuation of catastrophic casualties. Therefore, there are many lessons to be learned from the Wen-Chuan earthquake experience that could be used to improve all levels of performance in future earthquake management.

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