Pulmonary Evaluation of Earthquake Victims Followed Up in the Intensive Care Unit After the 2023 Turkey Kahramanmaras Earthquakes

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IMV: invasive mechanical ventilation

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Abstract

Introduction and Study Objective: In Turkey, a total of 269 earthquakes took place from 1900 through 2023. The most devastating earthquakes in terms of casualties and extensive destruction occurred at 4:17AM and 1:24PM local time on February 6, 2023 with the epicenters located in Pazarcik (Kahramanmaras) and Ekinozu (Kahramanmaras) and magnitudes of 7.7Mw and 7.6Mw, respectively. The aim of this study was to define the frequency of lung complications that occurred directly and/or developed during the intensive care follow-up of individuals affected by the Kahramanmaras earthquakes.

Method: A retrospective evaluation was conducted on the files of 69 patients who were rescued from the debris of collapsed buildings after the Kahramanmaras earthquakes and followed up in the intensive care unit in terms of the time under the debris, demographic data, vital signs, and lung complications that were present at the time of admission and developed during follow-up. SPSS for Windows v. 20.0 was used for data analysis.

Results: The study included a total of 69 patients, of whom 29 (42%) were female and 40 (58%) were male. The mean age was 39.9 (SD = 16.9) years. The mean time under the debris was 53.9 (SD = 52) hours, and the mean time from rescue to the intensive care unit admission was 18.7 (SD = 12.8) hours. One or more pulmonary complications were detected in 52.2% (n = 36) of the patients at the time of admission. During the follow-up, 30.4% (n = 21) of the patients developed pulmonary congestion, 13.0% (n = 9) pneumonia, 1.5% (n = 1) alveolar hemorrhage, and 1.5% (n = 1) atelectasis, while no additional lung complications developed in the remaining 37 patients (53.6%).

Conclusion: Severe cases of individuals recovered from the debris can have a high prevalence of earthquake-related lung disorders and chest trauma, which may be associated with high mortality. The timely identification and effective intervention of pulmonary complications that may develop during follow-up can reduce mortality.

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Introduction

Turkey is situated on the Anatolian plate, an area characterized by high seismicity. Many devastating earthquakes have occurred in this region from ancient times to the present day, resulting in the deaths of thousands of people.[1] The most devastating earthquakes in terms of casualties and extensive destruction occurred at 4:17AM and 1:24PM local time on February 6, 2023 with the epicenters located in Pazarcik (Kahramanmaras) and Ekinozu (Kahramanmaras) and magnitudes of 7.7Mw and 7.6Mw, respectively. The earthquakes were strongly felt in Kahramanmaras, Hatay, Adiyaman, Gaziantep, Malatya, Kilis, Diyarbakir, Adana, Osmaniye, Sanliurfa, and Elazig. The impact was profound, resulting in the destruction of thousands of buildings, including many hospitals, and causing 50,783 deaths and more than 100,000 injuries according to official records.[2] Adana City Training and Research Hospital, the largest and most equipped hospital in the region, was not damaged in the earthquake and emerged as a primary facility for admitting thousands of cases of survivors rescued from the debris.

Pulmonary complications that occur directly under the debris during an earthquake or develop subsequently can be listed as chest traumas, inhalation of dust and particles, aspiration of water and waterborne pathogens, pulmonary thromboembolism, psychological effects caused by respiratory symptoms, and infectious respiratory diseases.[3] There is a

scarcity of research in the literature concerning pulmonary injuries associated with earthquakes and related complications. This study aimed to define the frequency of lung complications that occurred directly and/or developed during the intensive care follow-up of individuals affected by the Kahramanmaras earthquakes in order to contribute to the literature and guide future investigations in this area.

Method

Patient Selection

Survivors who were rescued from the debris of collapsed buildings after the Kahramanmaras earthquakes and patients from the earthquake-affected areas were transported to the study center by helicopter from the earthquake sites due to damaged roads, or by ambulance or helicopter from field or ship hospitals. All admitted patients were evaluated in the emergency room by pulmonologists and thoracic surgeons for possible chest injuries. Lung complications were determined by physical examination, chest radiography, computed tomography (CT), and arterial blood gas analysis. In arterial blood gas, the presence of a partial pressure of oxygen level of <60mmHg was defined as Type 1 respiratory failure and the presence of a partial pressure of carbon dioxide level of >45mmHg and a pH level of <7.35 was accepted as Type 2 respiratory failure.[4] In addition, patients with systemic symptoms resulting from injuries sustained from being crushed, leading to organ dysfunction (mostly acute kidney injury [AKI] and multi-system organ damage) or death were classified as having crush syndrome.[5]

Indications for intensive care admission were accepted as respiratory failure, hemodynamic instability, confusion, electrolyte imbalance, organ failure, isolated or multiple traumas, compartment syndrome, and crush syndrome.

The files of 79 patients, who were rescued from the debris and admitted to the Chest Diseases Intensive Care Unit of Adana City Training and Research Hospital with earthquake-related injuries and trauma from February 6, 2023 through March 6, 2023 were retrospectively examined by a researcher blinded to the study details, using the hospital's digital archives system. Patients admitted to the unit for reasons other than earthquake-related injuries were not included in the study. In addition, 10 of the 79 patients were excluded from the study because they were referred from other centers and did not have available data concerning the development of additional pulmonary complications during their follow-up or survival. As a result, the study was completed with 69 patients. The demographic data of the patients, such as age and gender, the time under the debris (hours), lung complications that were present at the time of admission or developed during the follow-up, extrapulmonary trauma, respiratory status, vital signs (body temperature, systolic and diastolic blood pressures, heart rate/minute, and respiratory rate/minute), the presence of crush syndrome, length-of-stay in the intensive care unit, and survival were recorded in standard data forms and then transferred to the SPSS database in a computerized environment.

Statistical Analysis

SPSS for Windows v. 20.0 (IBM Corp.; Armonk, New York USA) was used for statistical analysis. Incidences were presented as numbers and percentages, and continuous values as mean, median, and standard deviation (SD). Pearson's x2 test, Fisher's exact test, and the Kolmogorov–Smirnov test were used to compare the distributions of variables within groups. The Mann–Whitney and Kruskal–Wallis tests were conducted to compare the distributions of variables between groups. A P value of <.05 was considered statistically significant.

Ethical Approval

Approval was received from the ethics committee of Adana City Training and Research Hospital, with the number 3000 dated 12/7/2023.

Results

The study included a total of 69 patients, of whom 29 (42%) were female and 40 (58%) were male. The mean age was 39.9 (SD = 16.9) years. The mean time under the debris was 53.9 (SD = 52) hours, and the mean time from rescue to the intensive care unit admission was 18.7 (SD = 12.8) hours. At the time of admission to the intensive care unit, 52.2% (n = 36) of the patients had one or more pulmonary complications, while 47.8% (n = 33) did not have any pulmonary complications. Table 1 presents the comparison of the data between the patients with and without pulmonary complications at admission.

The results of physical examinations upon admission were as follows: mean body temperature 37.1 (SD = 0.9) °C; mean heart rate 111.3 (SD = 19.9) beats/minute; mean respiratory rate 28.6 (SD = 7.1) breaths/minute; mean systolic blood pressure 126.7 (SD = 11.8) mmHg; and mean diastolic blood pressure 69.4 (SD = 11.4) mmHg.

Upon admission, the blood test results indicated the following mean values: blood hematocrit 39.6% (SD = 13.4%); leukocyte count 21,562 (SD = 8,765) cells/μL; platelet count 136,775 (SD = 56,745) cells/μL; partial pressure of arterial oxygen 55.4 (SD = 12.6) mmHg; partial pressure of carbon dioxide 49.7 (SD = 13.4) mmHg; pH 7.21 (SD = 1.8); base excess -1.5 (SD = 2.1) mmol/L; serum alanine transaminase 125.5 (SD = 38.4) IU/L; serum lactate dehydrogenase 156.7 (SD = 74.9) UI/L; serum creatine kinase 1,322 (SD = 543) IU/L; serum creatinine 2.6 (SD = 1.4) mg/dl; serum urea nitrogen 154 (SD = 54.7) mg/dl; urine protein 264.6 (SD = 49.8) mg/g; and d-dimer 1.55 (SD = 0.8) g/L.

Crush syndrome was observed in 34 patients (49.3%), and the mortality rate was 82.3% in these patients.

There was one or more pulmonary complications in 12 (70.6%) of the 17 patients with a fatal course and in 24 (46.6%) of the 52 patients who survived (P = .047). Among all patients, pulmonary contusion was detected in 24.6%; pneumothorax in 17.4%; rib fractures in 10.1%; pleural effusion in 4.3%; hemothorax, hemopneumothorax, pneumonia, and atelectasis in 2.9% each; and sternal fractures in 1.4% (Table 2).

Of the 36 patients with chest complications, 31 had accompanying extrapulmonary injuries and complications (vertebral injury in 15, extremity injury in 25; head trauma in two, burns and soft tissue defects in one, pelvis injury in one, and abdominal trauma in one). Only 7.2% (n = 5) of all patients had isolated chest trauma.

The mortality rate was 24.6% (n = 17). The factors affecting mortality are summarized in Table 3.

Of the patients, 18.8% (n = 13) were followed up breathing room air, while 46.4% (n = 32) were placed on nasal/oral nasal oxygen, 2.9% (n = 2) on high-flow nasal oxygen, 5.80% (n = 4) on non-invasive mechanical ventilation, and 26.9% (n = 18) on invasive mechanical ventilation (IMV). The mean (standard deviation) time on mechanical ventilation was 173.2 (SD = 83.5) hours. All patients followed up on IMV had one or more chest traumas (rib and sternal fractures [n = 6], pneumothorax [n = 10], contusion [n = 12], and mediastinal emphysema [n = 1]). The mortality rate among the patients followed up on IMV was 78.8% (n = 14).

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Variables	Patients with Complications (n = 36)	Patients without Complications (n = 33)	Total (n = 69)	P Value
Age, mean (SD)	39.5 (SD = 13.7)	40.1 (SD = 17.5)	39.9 (SD = 16.9)	>.05[a]
Sex				
Female (n)	*38.9% (14)*	45.5 % (15)	29	>.05[b]
Male (n)	*61.1% (22)*	54.5% (18)	40	
Time (hours)[c]	*69.15 (SD = 37.11)*	35.19 (SD = 51.36)	53.9 (SD = 52)	.0415[a]
Mortality, % (n)	*27.7 (12)*	15.1 (5)	24.6 (17)	.0436[b]
Respiratory Failure	*94.4 (34)*	66.6 (22)	81.1 (56)	.0378[b]

Table 1. Comparison of the Patients with and without Pulmonary Complications
[a] Mann–Whitney test.
[b] Pearson's x2 test.
[c] Time under the debris after the earthquake.

Types of Complication n (%)	Mortality (n = 17)	Survival (n = 52)	Total (n = 69)	P Value
Pneumothorax	*3 (17.6)*	*9 (17.3)*	*12 (17.4)*	–
Hemothorax	*1 (5.8)*	*1 (1.9)*	*2 (2.9)*	–
Hemopneumothorax	*1 (5.8)*	*1 (1.9)*	*2 (2.9)*	–
Pulmonary Contusion	*6 (35.3)*	*11 (21.1)*	*17 (24.6)*	–
Fracture of Sternum	*1 (5.8)*	*0 (0)*	*1 (1.4)*	–
Rib Fracture	*4 (23.5)*	*3 (5.8)*	*7 (10.1)*	–
Pneumonia	*1 (5.8)*	*1 (1.9)*	*2 (2.9)*	–
Atelectasis	*1 (5.8)*	*1 (1.9)*	*2 (2.9)*	–
Pleural Effusion	*1 (5.8)*	*2 (3.8)*	*3 (4.3)*	–
Mediastinal Emphysema	*1 (5.8)*	*1 (1.9)*	*2 (2.9)*	–
No Chest Complication	*5 (29.4)*	*28 (53.8)*	*33 (47.8)*	*.047*

Table 2. Pulmonary Complications at Admission
Note: Some patients suffered from more than one type of pulmonary complication and therefore appear multiple times in this table. P value calculated with Likelihood-ratio chi-squared test; no value listed = P value > .05.

Variables	Mortality (n = 17)	Survival (n = 52)	P Value
Age mean, SD (range)	*37.52 (SD = 20)* *(Range: 18-72)*	40.2 (SD = 23.4) (Range: 21-84)	>.05[a]
Sex			
Female (n = 29)	*8*	21	>.05[b]
Male (n = 40)	*9*	31	>.05[b]
Time (hours)[c]	*48.35 (SD = 31.21)* *(Range: 8-138)*	68.11 (SD = 57.34) (Range: 6-78)	.0367[a]
Pulmonary Complications at Admission, % (n)	*70.58 (12)*	46.15 (24)	.0436[b]
Respiratory Failure, % (n)	*100 (17)*	75 (39)	.0231[b]
Crush Syndrome, % (n)	*82.3 (14)*	38.4 (20)	.0299[b]

Table 3. Factors Affecting Mortality
[a] Mann–Whitney test.
[b] Pearson's x2 test.
[c] Time under the debris after the earthquake.

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During the follow-up, pulmonary congestion developed in 30.4% (n = 21) of the patients, pneumonia in 13.0% (n = 9), alveolar hemorrhage in 1.5% (n = 1), and atelectasis in 1.5% (n = 1), while no additional lung complications occurred in the remaining 37 patients (53.6%). The mortality rates of the patients with and without the development of additional pulmonary complications during their follow-up were 28.1% (n = 9/32) and 21.6% (n = 8/37), respectively (P > .05).

Discussion

Earthquake-related pulmonary and extrapulmonary complications are multisystem injuries that generally require major medical and surgical interventions. Many patients who sustain blunt or penetrating trauma develop many complications that lead to concomitant morbidities and mortality.[6] During multisystemic trauma, the lungs and rib cage are greatly affected. The incidence of earthquake-related chest injuries has been reported to be 13.0% following the 1995 Japan earthquake,[7] 9.9% following the 2008 Wenchuan earthquake,[8] and 22.2% following the 2013 Lushan earthquake.[9] In the current study, the rate of earthquake-related lung complications and trauma was found to be 52.2%. The higher incidence observed in this study compared to the literature can be attributed to several factors. First, the building of Adana City Training and Education Hospital was not damaged by the Kahramanmaras earthquakes, although it was located in a city substantially affected by them. Second, the availability of a sufficient number of staff and medical equipment made this hospital one of the first centers to which severe cases with multiple injuries who were rescued from the debris were referred. Lastly, almost all the beds of the intensive care unit were allocated to the care of critical patients with trauma and complications related to the earthquake.

In the literature, the mean age of patients with earthquake-related chest trauma has been reported to be 54 years (54.2 years in a study from China, including 52.7% of female patients[10] and 53.7 years in a study from Nepal, including 61% of female patients[11]). In contrast, the mean age of the patients with earthquake-related lung complications and trauma followed up in the intensive care unit was 39.5 (SD = 13.7) years, indicating a much younger patient population than similar studies. It is considered that the lower mean age was due to younger patients with higher survival expectations being prioritized for transport from the earthquake center during the first triage.

In another study on chest injuries resulting from the 2008 China earthquake, chest injuries that caused respiratory failure were observed in 21% of patients. The authors listed the risk factors for respiratory failure as flail chest, pulmonary contusion, and crush syndrome.[8] In the current study, lung contusion was found to be the most common pulmonary complication. Furthermore, the presence of earthquake-related lung complications and trauma was identified as a significant risk factor for respiratory failure.

In studies evaluating trauma patients, the presence of chest trauma was found to be associated with a high risk of mortality (odds ratio = 3.75; P = .004).[12,13] In one study on the Marmara earthquake, the mortality rate was found to be 60% in patients with chest trauma accompanied by multiple trauma, and no mortality was observed in cases of isolated chest trauma.[14] In the current study, earthquake victims with chest trauma and associated complications had a mortality rate of 27.7%, while those without chest trauma had a mortality rate of 15.1%. It was observed that the presence of trauma and associated complications had a significant effect on mortality (P = .043). In earthquake-related injuries, isolated chest trauma cases are very rare due to the specific nature of the event. Chest trauma is usually accompanied by multiple organ injuries and crush syndrome.[14] In this study, 7.2% of the patients had isolated chest trauma and complications, which is consistent with the literature.

In this study, pulmonary congestion was identified as the most prevalent lung complication during the follow-up. It is considered that this may be due to the intense intravenous hydration used in the treatment of crush syndrome,[15] which accompanied 49.3% of the cases included in the current sample.

The incidence of pneumonia development during hospital follow-up after chest injuries is very high.[10] Hofman, et al detected pneumonia at a rate of 19.9% in post-trauma patients.[16] In a study on the development of pneumonia among polytrauma patients, Grubmüller, et al found a significant correlation between chest trauma severity and pneumonia development rates.[17] The direct effect of trauma, hypoxia, hypotension, anemia, hypo-hyperglycemia, and inflammatory processes may be held responsible for the susceptibility to pneumonia.[18] In this study, consistent with the literature, hospital-acquired pneumonia developed in 13% of the patients during the follow-up, despite the use of broad-spectrum empirical antibiotics. The presence of concomitant pulmonary and extrapulmonary injuries, follow-up under mechanical ventilation, and the presence of crush syndrome may be among the facilitating factors for pneumonia development among the patients included in this study.

Study Limitations

The limitations of this study are as follows. (1) The study had a small sample size as it was conducted in a single intensive care unit. (2) The patients received at the study site were selected for transport to the hospital by outside responders; therefore, there may have been significant selection bias, and the results do not represent all patients with potential pulmonary complications. (3) The results may not be applicable to other earthquake sites or locations. (4) The sample of the study did not consist of a homogenous set of individuals, and the patients included may or may not have had other injuries or medical problems that potentially contributed to outcomes. And (5) Due to the descriptive nature of the study, causal inferences cannot be made from the data presented. Further studies conducted in multiple centers with a larger number of patients may be beneficial in overcoming these limitations.

Conclusion

The insights gained from the patients followed up in the intensive care unit after the Kahramanmaraş earthquakes were as follows: severe cases of individuals recovered from the debris can have a high prevalence of earthquake-related lung disorders and chest trauma, which may be associated with high mortality. The timely identification and effective intervention of pulmonary complications that may develop during follow-up can reduce mortality.

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Finally, it is important to note that the findings of the study only apply to the study cohort and cannot be generalized to all earthquake victims.

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