ORIGINAL ARTICLE

Factors affecting mortality in patients undergoing surgical procedures after the 2023 Türkiye earthquake

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ABSTRACT

BACKGROUND: On February 6, 2023, two devastating earthquakes struck southeastern Türkiye and northern Syria, significantly affecting 11 provinces in Türkiye and causing widespread destruction. The aim of this study is to investigate the factors influencing mortality among patients who underwent surgical procedures at a regional tertiary care center following the earthquakes.

METHODS: A total of 4,622 earthquake victims were admitted to our hospital. Of these, 637 patients who required surgical interventions were included in the study. Patient records were retrospectively analyzed. Data collected included demographic characteristics, laboratory findings, types of injuries, surgical procedures performed, Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, length of stay (LOS) in the intensive care unit (ICU), and mortality outcomes. Extrication time and transport time to the hospital were obtained from prehospital emergency ambulance records.

RESULTS: Among the patients, 159 had been trapped under debris and later extricated. The mean APACHE II score was 29.6 and the overall mortality rate was 3.9%. Crush syndrome and burn injuries were significant predictors of mortality. Factors associated with mortality included the use of hemodynamic support drugs, direct ICU admission upon arrival, male sex, prolonged extrication and transport times, higher APACHE II scores, elevated levels of potassium, phosphorus, creatine kinase, blood urea nitrogen, aspartate aminotransferase, alanine aminotransferase, C-reactive protein, and acidosis on admission. Extrication time demonstrated strong predictive value for mortality (area under the curve [AUC]=0.895). The optimal cut-off point was identified as 21 hours, with a sensitivity of 78.9% and specificity of 86.4%.

CONCLUSION: Extrication time from entrapment under debris is one of the most important factors predicting mortality in earthquake victims. A rescue period of 21 hours is critical for survival. Early rescue from debris and rapid transport to a medical facility are essential for improving survival outcomes in earthquake victims.

Keywords: Earthquake; mortality; extrication time; transport time.

INTRODUCTION

On February 6, 2023, two catastrophic earthquakes struck southeastern Türkiye and northern Syria. The first, with a magnitude of Mw 7.7, occurred at 04:17 local time, followed by an earthquake with a magnitude of Mw 7.6 at 13:24 local time. The epicenters were located in Pazarcık and Elbistan, both in Kahramanmaraş.[1] The earthquakes affected 11 provinces in Türkiye, causing extensive devastation. According to the Disaster and Emergency Management Presidency (AFAD)

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of Türkiye, 50,783 lives were lost, and more than 115,000 individuals were injured.

More than 50,000 patients were reported to have been transferred to various hospitals across the country immediately after the earthquake.[2] Adana City Training and Research Hospital, University of Health Sciences, is one of the largest hospitals in the earthquake-affected region, with a capacity of 1,550 beds. Recently constructed and equipped with a large number of seismic isolators, the hospital remained unaffected by the earthquake and played a critical role in the treatment of earthquake victims.

The type and number of injuries following earthquakes vary significantly depending on factors such as the earthquake's seismic magnitude, geological characteristics of the region, built environment, and the demographic and behavioral characteristics of the affected population.[3] Most fatalities during the initial hours after an earthquake are primarily caused by head and neck trauma, compression injuries, and asphyxiation.[4,5] Common injuries include fractures, soft tissue injuries, crush injuries, internal organ trauma, amputations, and burns.[2,6] Extrication time from debris is also known to be a significant factor influencing the morbidity and mortality of earthquake victims (D).

The aim of this study is to investigate the factors affecting inpatient morbidity and mortality among patients who underwent surgical procedures at Adana City and Training Hospital following the February 2023 earthquakes.

MATERIALS AND METHODS

The study was approved by the Clinical Research Ethics Committee of University Health Sciences, Adana City Training and Research Hospital (Decision Number: 2416, Date:16.02.2023), and conducted in accordance with the Declaration of Helsinki. Adana City Training and Research Hospital Hospital has a capacity of 1,550 beds, including 231 intensive care beds, 50 operating rooms, 45 dialysis units, and 15 hemofiltration devices, with extracorporeal membrane oxygenation (ECMO) capability. The hospital complex contains 1,512 seismic isolators, making it the largest seismically isolated hospital in the world.[7] Following the earthquake, the hospital's post-disaster emergency plan was activated. All elective surgeries were canceled, and patients without urgent treatment needs were discharged. Additional ward and intensive care unit (ICU) beds were prepared, increasing the total ICU bed capacity to 380.

Between February 6, 2023 and February 20, 2023, a total of 4,622 patients were admitted to the hospital with the diagnosis of "Earthquake Victim" according to the International Classification of Diseases (ICD-10). Among these, 637 patients underwent at least one surgical procedure in the operating room (OR). This study included patients who required surgical interventions in the OR. Patients who underwent minor surgical procedures outside the OR without the involvement of the anesthesia team were excluded from the study.

During the study, patients' recorded data were retrospectively analyzed. Demographic characteristics, admission laboratory data, types of injuries, surgical interventions, American Society of Anesthesiologists (ASA) scores, Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, Glasgow Coma Scale (GCS) scores, length of stay (LOS) in the intensive care unit and hospital, and mortality data were collected. The duration of entrapment under debris (extrication time) and transport time to the hospital were obtained from prehospital emergency ambulance records. The diagnosis of crush syndrome was made based on established clinical criteria (E5).

Data analysis was performed using IBM SPSS Statistics 20. Categorical variables were presented as n (%), while numerical variables were expressed as mean ± standard deviation (SD) or median with interquartile ranges. Pearson's chi-square test was used to compare categorical variables. The Kolmogorov-Smirnov test was applied to assess the normal distribution of continuous numerical variables. The Mann-Whitney U test was used to compare survivor and non-survivor groups. Receiver operating characteristics (ROC) analysis was conducted to evaluate the predictive power of extrication time and transport time, with area under the curve (AUC) values

Table 1. Patient characteristics

	Mean±SD or n (%)	Median (Min-Max)
Age	27.1±17.8	25 (0-88)
Sex		
Male	307 (48.20)	
Female	330 (51.80)	
Mortality		
Non-survivors	25 (3.90)	
Survivors	612 (96.10)	
ICU Admission		
Yes	504 (78.50)	
No	138 (21.50)	
Trapped Under Debris		
Yes	159 (25.0)	
No	478 (75.0)	
GCS	14.3±1.8	15 (3-15)
APACHE II	29.6±7.5	29 (15-45)
Length of ICU Stay	6.4±5.4	5 (1-50)
Total Hospital Stay	8.2±4.5	8 (1-14)

APACHE II: Acute Physiology and Chronic Health Evaluation II; ICU: Intensive care unit; GCS: Glasgow Coma Scale; LOS: Length of stay.

Table 2. Variables affecting mortality - 1

	Non-survivors (n=25)		Survivors (n=612)		p
	n	%	n	%	
Sex					
Male	18	88.0	283	46.4	<0.001
Female	7	12.0	327	53.6	
Vasopressor/Inotropic Drug Use					
No	7	28.0	572	93.6	<0.001
Yes	18	72.0	39	6.4	
Upper Extremity Injury					
No	14	56.0	377	61.8	0.559
Yes	11	44.0	233	38.2	
Lower Extremity Injury					
No	5	20.0	204	33.4	0.162
Yes	20	80.0	407	66.6	
Crush Syndrome					
No	7	28.0	405	66.2	<0.001
Yes	18	72.0	207	33.8	
Avulsion Injury					
No	25	100.0	608	99.3	0.685
Yes	0	0.0	4	0.7	
Traumatic Brain Injury					
No	23	92.0	580	94.8	0.241
Yes	2	8.0	32	5.2	
Maxillofacial Injury					
No	25	100.0	605	98.9	0.591
Yes	0	0.0	7	1.1	
Abdominal Trauma					
No	23	92.0	592	96.7	0.841
Yes	2	8.0	20	3.3	
Pelvic Injury					
No	25	100.0	578	94.4	0.226
Yes	0	0.0	34	5.6	
Thoracic Injury					
No	19	76.0	538	87.9	0.078
Yes	6	24.0	74	12.1	
Spinal Injury					
No	25	100.0	586	95.8	0.293
Yes	0	0.0	26	4.2	
Vascular Injury					
No	25	100.0	609	99.5	0.726
Yes	0	0.0	3	0.5	
Ophthalmologic Injury					
No	25	100.0	599	97.9	0.462
Yes	0	0.0	13	2.1	
Burn Injury					
No	22	88.0	612	100.0	<0.001
Yes	3	12.0	0	0.0	
ICU Admission on Arrival					
No	5	20.0	495	80.9	<0.001
Yes	20	80.0	117	19.1	

ICU: Intensive care unit.

Table 3. Variables affecting mortality - 2

	Non-survivors			Survivors			P
	Median	25th Percentile	75th Percentile	Median	25th Percentile	75th Percentile	
Age	26.0	20.0	56.0	20.0	13.0	37.0	0.108
LOS Under Debris (Extrication Time, hours)	34.0	22.0	59.0	22.0	3.0	12.0	<0.001
Transport Time (hours)	61.0	37.0	86.0	37.0	21.0	60.0	0.005
GCS	10.0	15.0	15.0	13.0	10.0	15.0	<0.001
APACHE II Score	37.5	34.0	40.0	34.0	23.0	32.0	0.007
Hb	9.0	8.3	13.0	10.5	8.7	14	0.599
K	5.3	4.4	6.3	4.4	3.8	4.8	<0.001
Na	138.0	132.0	144.0	132.0	133.0	139.0	0.558
P	7.7	4.9	9.3	4.9	2.8	5.0	0.001
Ca	7.3	6.2	9.1	6.2	7.4	8.9	0.097
CK	31,856	4,045.0	80,200.0	4,045	693.0	30,579.0	0.013
BUN	127.0	75.5	155.0	75.5	17.0	72.0	<0.001
Cr	2.8	1.8	5.0	1.8	0.3	1.3	<0.001
AST	448.0	95.0	1,462.0	95.0	38.0	446.0	0.002
ALT	202.0	61.0	593.0	61.0	27.0	195.0	0.015
CRP	147.0	100.0	209.5	100.0	34.0	147.5	0.003
BE	-12.9	-6.0	2.3	-7.7	-12.9	-2.4	<0.001
HCO3	14.7	19.0	25.0	17.9	14.7	22.0	<0.001
Anesthesia Time (minutes)	60.0	42.5	87.5	42.5	30.0	75.0	0.141
Length of ICU Stay (days)	6.5	3.0	10.0	3.0	3.0	10.0	0.388
Length of Ward Stay (days)	7.0	3.0	12.0	3.0	4.0	13.0	0.744

APACHE II: Acute Physiology and Chronic Health Evaluation II; ICU: Intensive care unit; GCS: Glasgow Coma Scale; LOS: Length of stay.

reported. The optimal intersection point was determined using the Youden index, and sensitivity and specificity values were calculated. A p value of <0.05 was considered statistically significant.

RESULTS

The characteristics of the 637 patients included in the study are presented in Table 1. A total of 159 patients were trapped under debris and later extricated. Among all patients, 78.5% were admitted to the ICU either before or after surgical interventions. The mean APACHE II score was 29.6 (range: 15-45), indicating a high risk of morbidity and mortality upon admission. The overall mortality rate was 3.9% (n=25). The presences of crush syndrome and burn injuries were significant factors associated with increased inpatient mortality. Additionally, the need for hemodynamic drug use, direct ICU admission upon arrival, and male sex were also significantly linked to higher mortality rates (Table 2). No significant differences in mortality were found between the survivor and non-survivor groups based on injury site.

Comparison between survivor and non-survivor groups revealed that prolonged extrication time and transport time, higher GCS and APACHE II scores, elevated potassium, phosphorus, creatine kinase, blood urea nitrogen, aspartate aminotransferase, alanine aminotransferase, and C-reactive protein levels, as well as acidosis markers (increased bicarbonate and decreased base excess) on admission, were associated with mortality. There were no significant differences between survivors and non-survivors regarding ICU length of stay, overall hospital stay, or anesthesia time (Table 3). Among the surgical procedures performed, laparotomy was the only intervention significantly associated with increased mortality (Table 4).

ROC analysis of extrication time (duration under debris) and transport time showed that extrication time had a strong predictive value for mortality (AUC=0.895, p<0.001). The optimal cut-off value was identified as 21 hours, with a sensitivity of 78.9% and specificity of 86.4% (Fig. 1). While transport time was higher in patients with crush syndrome, it demonstrated low predictive value for mortality (AUC=0.672) (Fig. 2).

Table 4. Surgical procedures by groups

	Non-survivors (n=25)		Survivors (n=612)		p
	n	%	n	%	
Fasciotomy (number of procedures)					
1	11	73.3	340	83.1	0.510
2	4	26.7	65	15.9	
3	0	0.0	4	1.0	
Amputation (number of procedures)					
1	12	100.0	157	97.5	0.858
2	0	0.0	2	1.2	
3	0	0.0	2	1.2	
Spinal Surgery					
No	25	100.0	603	98.5	0.541
Yes	0	0.0	9	1.5	
Cranial Surgery					
No	25	100.0	610	99.7	0.775
Yes	0	0.0	2	0.3	
Maxillofacial Surgery					
No	25	100.0	609	99.5	0.726
Yes	0	0.0	3	0.5	
Laparotomy					
No	23	92.0	607	99.2	0.001
Yes	2	8.0	5	0.8	
Thoracic Tube Insertion					
No	23	92.0	587	95.9	0.341
Yes	2	8.0	25	4.1	
Pelvic Stabilization					
No	25	100.0	601	98.2	0.499
Yes	0	0.0	11	1.8	
Graft Surgery					
No	24	96.0	602	98.4	0.373
Yes	1	4.0	10	1.6	
Embolectomy					
No	24	96.0	608	99.3	0.063
Yes	1	4.0	4	0.7	
Ophthalmic Surgery					
No	25	100.0	611	99.8	0.840
Yes	0	0.0	1	0.2	
Femur and Lower Extremity Fixation					
No	24	100.0	583	95.3	0.265
Yes	1	0.0	30	4.7	
Upper Extremity Fixation					
No	25	100.0	600	98.0	0.480
Yes	0	0.0	12	2.0	
Coronary Surgery					
No	25	100.0	610	99.7	0.775
Yes	0	0.0	2	0.3	

ICU: Intensive care unit.

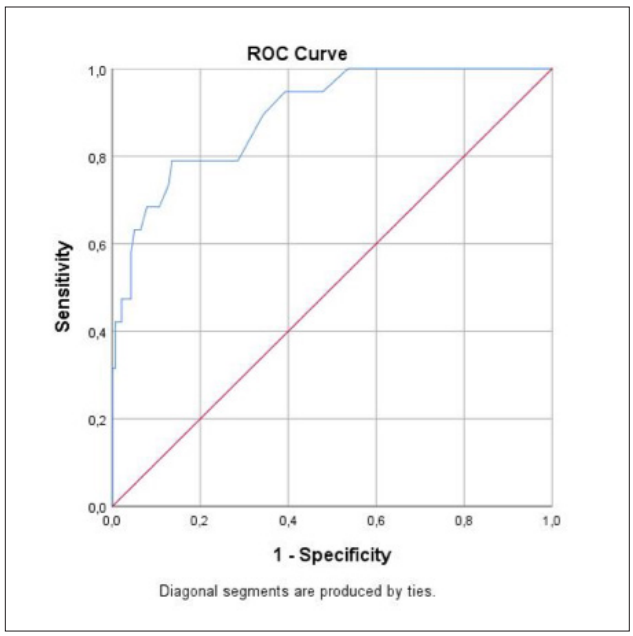


Figure 1. Receiver operating characteristic (ROC) analysis for extrication time.

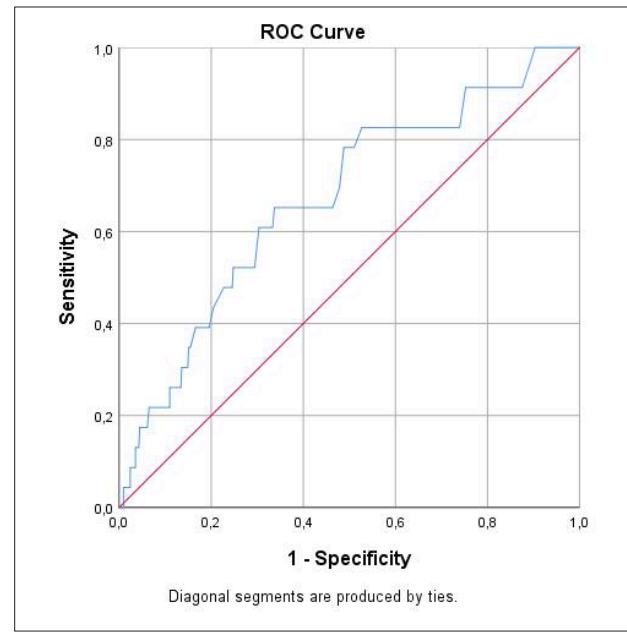


Figure 2. Receiver operating characteristic (ROC) analysis for transport time.

DISCUSSION

This study investigates the factors influencing mortality among 637 earthquake victims who required surgical intervention at a tertiary care center located near the earthquake zone.

Previous research has suggested that the impact of earthquakes on the elderly population extends beyond physical injuries, with disruptions in the supply of medications and access to healthcare services contributing to worsening chronic conditions.[8] Although older age has been reported as a significant risk factor for mortality following earthquakes,[8,9] the current study did not find a significant age difference between survivors and non-survivors.

The literature presents conflicting evidence regarding the influence of sex on post-earthquake outcomes. Some studies have reported higher injury and mortality rates among females.[8-10] On the other hand, some studies state that the rates are approximately equal between the sexes, or even higher among males.[11,12] In the present study, male sex was identified as a significant risk factor for in-hospital mortality. Males often tend to act protectively toward their families under stressful conditions, such as shielding their children and spouses. Demographic and socio-behavioral differences across cultures, as well as the timing of the earthquake (e.g., work hours, nighttime, weekends), may have contributed to the differences observed across various studies.

It was not unexpected that ICU admission was associated with an increased risk of mortality, as observed in our study. It is well known that factors linking ICU admission after earthquakes to mortality include the severity and site of injuries, as well as the availability of blood products and other resources under resource-limited conditions.[13] Despite the fact that many medical facilities in the most affected regions were destroyed and rendered non-functional during the 2023 Türkiye earthquake, several tertiary hospitals located near the earthquake's epicenter remained unaffected and operated effectively with sufficient intensive care resources. In our study, the median APACHE II score was 29.6, and higher scores were associated with increased mortality. This suggests that a high physiological severity score, indicating a severely compromised patient, rather than inadequate ICU care, was primarily responsible for the observed mortality.

Traumatic brain injury (TBI) is also a well-established predictor of in-hospital mortality. Previous studies have shown that TBI plays a significant role in determining patient outcomes.[14,15] A review of 123 earthquake studies concluded that patients with severe TBI are generally not salvageable in disaster settings.[16] In the present study, only 8% of patients in the non-survivors group had severe TBI, and none of these patients underwent cranial surgery. Given the prolonged duration under debris and transport time in our study population (61 hours for non-survivors and 37 hours for survivors), it is likely that most patients with severe TBI died at the scene and were unable to reach the hospital.

No other anatomical site of injury was found to be associated with mortality, except for burn and crush injuries. Although the burns sustained during the earthquakes were mainly minor scalds, the median time to hospital admission was 55 hours. The prolonged transfer time and the presence of additional

injuries may have contributed to the impact of these relatively minor burns on mortality. Crush syndrome is a well-known injury associated with increased inpatient mortality following earthquakes.[8,17] Previous studies have reported high mortality rates, with figures reaching up to 21% after the Marmara earthquake.[17] In our study, crush syndrome developed in 72% of non-survivors and was associated with mortality, likely due to complications such as hyperkalemia, hyperphosphatemia, and acidosis. Although the number of fasciotomies and amputations did not differ between survivor and non-survivor groups, the prolonged extrication and transport times in our patient population may have contributed to the higher mortality rate associated with crush syndrome.

In previous studies, abdominal injuries were not identified as a significant factor associated with mortality,[8] which is consistent with our findings. This may be due to the fact that major abdominal vascular or solid organ injuries typically result in death during the early "golden hours" following injury, before patients can be extricated and transported to a surgical facility. Nevertheless, we found that laparotomy was the only surgical procedure associated with mortality. This is likely due to severe abdominal injuries that were incompatible with survival after prolonged transport time.

Following major earthquakes, rescue time is a critical factor influencing patient prognosis. As extrication time increases, both mortality and complication rates rise.[2,18,19] In our study, 25% of patients (n=159) were trapped under debris. A previous study reported that the mean rescue time for 539 earthquake victims after the 1999 Marmara earthquake was 11.7±14.3 hours (A20). In our study, the median rescue times for survivors and non-survivors were 22 and 34 hours, respectively. Both extrication time and transport time were found to be associated with mortality; however, only the ROC analysis of extrication time demonstrated strong predictive power for mortality. The optimal cut-off value was identified as 21 hours, with high sensitivity and specificity.

CONCLUSION

Extrication time from entrapment under debris is one of the most important factors predicting mortality in earthquake victims. A rescue period of 21 hours is critical in determining survival. While transport time to the hospital is significant in patients at risk of crush syndrome, it has lower predictive value for overall mortality. Early rescue from debris and rapid transport to a medical facility are essential for improving survival outcomes in earthquake victims.

Ethics Committee Approval: This study was approved by the University Health Sciences, Adana City Training and Research Hospital Ethics Committee (Date: 16.02.2023, Decision No: 2416).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: H.K.Ö., M.E., M.Ö.; Design: H.K.Ö., B.A., M.Ö.; Supervision: M.E., M.Ö.; Resource: E.C.I., Ü.K., O.Ç.; Materials: E.C.I., Ü.K., O.Ç.; Data Collection and/or Processing: E.C.I., Ü.K.; Analysis and/or Interpretation: H.K.Ö., M.E., M.Ö.; Literature Review: H.K.Ö., E.C.I., Ü.K., O.Ç., M.E.; Writing: H.K.Ö., M.Ö.; Critical Review: M.E., M.Ö.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

2023 Türkiye depreminde cerrahi tedavi yapılan hastalardaki mortaliteyi etkileyen faktörler

AMAÇ: 6 Şubat 2023 tarihinde Güneydoğu Türkiye ve Kuzey Suriye'de iki büyük deprem gerçekleşti. Bu depremlerde Türkiye'de 11 il etkilendi ve büyük bir yıkım yaşandı. Bu çalışmanın amacı deprem sonrasında bölgede bulunan bir eğitim ve araştıma hastanesinde anestezi altında ameliyata alınan hastalarda mortaliteyi etkileyen faktörlerin araştırılmasıdır.
GEREÇ VE YÖNTEM: Hastanemize depremden etkilenen toplam 4622 hasta başvurdu. Bu çalışma bu hastalardan anestezi altında ameliyata alınan 637 hastayı içermektedir. Hasta kayıtları retrospektif olarak tarandı. Demografik bilgiler, laboratuvar bulguları, yaralanma tipleri, uygulanan cerrahi tipleri, APACHE II skorları, yoğun bakım yatış süreleri, mortalite bilgileri incelendi. Enkaz altında geçen süre ve hastaneye nakil süreleri acil ambulans kayıtlarından alındı.
BULGULAR: Çalışmaya alınan hastalardan 159'u enkaz altında kalıp daha sonar enkazdan çıkarılmışlardı. Ortalama APACHE II skoru 29.6 olarak belirlendi. Mortalite hızı %3.9 olarak gerçekleşti. Crush sendromu ve ek yanık hasarının mortaliteyi arttırdığı saptandı. Başvuru sırasında direk yoğun bakım yatış ve hemodinamik destek gereksinimi, erkek cinsiyet, uzamış enkaz altında kalış ve nakil süreleri, yüksek APACHE II skoru, başvuru sırasında potasyum, fosfor, keratin kinaz, kan üre nitrojen, AST, ALT, CRP seviyelerinde artış ve asidoz mortaliteyi etkileyen faktörler olarak bulundu. Enkaz altında kalış süresinin mortalite tahmininde güçlü olduğu (AUC=0.895) ve bu sürenin optimal kesim noktasının 21 saat olduğu, mortalite öngörü duyarlılığının %78.9, özgüllüğünün ise %86.4 olduğu belirlendi.
SONUÇ: Enkaz altında kalış süresi deprem mağduru travma hastalarında mortaliteyi belirlemede en önemli faktörlerden birisidir. Kurtarma süresinde 21 saat kritik noktadır. Yaralının enkazdan erken çıkartılması ve hızlı hastaneye nakil deprem sonrası sağkalım için kritik önem taşımaktadır.

Anahtar sözcükler: Deprem; mortalite; enkaz altında geçen süre; transport süresi.

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