Predictors of in-hospital mortality of trauma patients injured in vehicle accidents

Motorlu araç kazalarında yaralanan travma hastaları ile ilgili hastane mortalitesi tahminleri

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OBJECTIVES

Identification and assessment of predictive factors of in-hospital mortality of trauma patients injured in vehicle accidents.

METHODS

We reviewed the Trauma Registry data of Herakleion University Hospital, a level I trauma center in Crete, Greece. All 730 consecutive, adult motor-vehicle trauma patients admitted to our hospital from 1997 to 2000 were included in the study. Variables included in the analysis were: sex, age, mechanism of injury, injuries per anatomic region, initial vital signs, Glasgow Coma Scale (GCS), Injury Severity Score (ISS), and the final outcome. In order to better describe continuous variables, two categories were created: age ≥60 and <60; ISS ≥18 and <18.

RESULTS

Mortality rate was 4.8% (n=35). Multivariate survival analysis showed that age greater than or equal to 60 years (p=0.0002), ISS greater than or equal to 18 (p=0.003), being a pedestrian (p=0.007), craniocerebral injuries (p=0.01), thoracic (p=0.01), and abdominal injuries (p=0.01) are independent predictors of the in-hospital mortality of the patients.

CONCLUSION

Trauma patients after vehicle accidents aged ≥60, pedestrians, those with an ISS ≥18 and craniocerebral, thoracic or abdominal injuries are at higher risk of an in-hospital fatal outcome.

Key Words: In-hospital mortality; predictive factors; trauma patients; vehicle accidents.

AMAÇ

Motorlu araç kazalarında yaralanan travmalı hastalarla ilgili hastane mortalitesi tahminleri değerlendirildi.

GEREÇ VE YÖNTEM

Yunanistan'ın Girit kentinde 1. basamak travma merkezi olan Herakleion Üniversitesi Hastanesi'nin travma kayıtları değerlendirilerek, 1997 ile 2000 yılları arasında motorlu araç kazası nedeniyle yatırılan erişkin 730 travma hastası ardışık olarak çalışmaya dahil edildi. Hastaların cinsiyet, yaş, yaralanma mekanizması, beher anatomik bölge başına yaralanma, başlangıç vital bulguları, Glasgow Koma Skalası (GKS), yaralanma ciddiyet skoru (ISS) ve nihai sonuçları analiz edildi. Kesintisiz değişkenleri daha iyi tanımlamak için iki kategori oluşturuldu: ≥60 ve <60 yaş, ≥18 ve <18 ISS.

BULGULAR

Mortalite oranı %4,8 bulundu (n=35). Çok değişkenli sağkalım analizi sonuçları: yaş ≥60 (p=0,0002), ≥18 ISS (p=0,003), yaya olma durumu (p=0,007), kraniyoserebral yaralanmalarda (p=0,01), torasik (p=0,01) ve abdominal yaralanmalarda (p=0,01), hastaların hastane mortalitelerine ilişkin bağımsız tahminlerdi.

SONUÇ

Motorlu taşıt kazalarında, yaşı ≥60, yaya olan, ISS ≥18, kranyoserebral, torasik veya karın yaralanması olan travma hastaları hastanede hayatını kaybetme sonucu bakımından yüksek risk altındadırlar.

Anahtar Sözcükler: Hastanede mortalite; motorlu taşıt kazaları; tahmin faktörleri; travmalı hastalar.

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Vehicle accidents continue to be a major public health problem, with an increasing contribution to mortality, morbidity and disability. Trauma and particularly vehicular trauma is the leading cause of death in young people and one of the most common causes of death overall.[1-3] The number of the people who have died because of road traffic accidents exceeded 30 million during the past century and nowadays nearly 1 million are killed and more than 10 million injured due to traffic accidents annually worldwide.[4]

Trauma is the leading cause of death of people under the age of 40 in Greece, and the fifth most common one overall.[5] Road traffic accidents account for over a third of all deaths in the 15-39 year age group.[6] The report of the Greek Parliamentary Committee for the Study of Road Traffic Accidents entitled "For road traffic accidents and road safety in Greece" stated that every year over 2000 people are killed and 32000 injured, 4000 of whom severely; half are between 20 and 44 years old.[7] Greece has one of the highest death rates after vehicle accidents/million population in the European Union (Table 1),[7] and, in the last three decades, together with Spain and Portugal, ranked among the European Union countries where consequences of motor vehicle crashes relative to the number of registered vehicles have been highest.[1] Injuries and particularly those due to vehicle accidents are the third most common discharge diagnosis in Greece.[5]

Table 1. Deaths after road traffic accidents in the European Union and the United States, 1993[7]

Country	Deaths/million population
Belgium	165
Denmark	108
Germany	123
Greece	219
Spain	163
France	166
Ireland	122
Italy	123
Luxembourg	195
The Netherlands	81
Austria	180
Portugal	291
Finland	95
Sweden	72
United Kingdom	68
Total European Union	131
United States	156

This study examines the population of adults admitted to a University level I trauma center in Greece, who were involved in motor vehicle crashes. The objective of the study is to investigate the causes of mortality and identify predictive factors of outcome of trauma patients injured in vehicle accidents.

MATERIALS AND METHODS

This is a retrospective analysis of prospectively collected data through the Trauma Registry of the University Hospital of Herakleion, a level I trauma center in Crete, Greece. The enrollment of patients in the Trauma Registry was approved by the ethical committee of the University of Crete. All trauma patients over 14 years old admitted to our hospital after a vehicle accident from January 1997 to December 2000 were included in the study. Patients who sustained massive injuries and died either at the scene or en route to the hospital were excluded from the study.

Trauma Registry data collection (including prehospital, emergency department and in-hospital information) started immediately after patient's admission and continued on a daily basis. We collected data on demographics, mechanism of injury, physiological condition on admission (as expressed by systolic and diastolic arterial pressure, heart rate, breathing rate and Glasgow Coma Scale), diagnostic procedures, injuries per anatomic region, the severity of total injury, type of management, operating room findings, length of stay in the Intensive Care Unit (ICU) and the hospital and final outcome. Definitive anatomical injury diagnoses upon discharge or death were obtained from charts, radiology reports, or necropsies. Injury severity was determined using Injury Severity Score (ISS).[8]

We reviewed all data for all patients in the study and especially for the fatalities in order to define risk factors and predictors of in-hospital mortality after vehicle accidents in adults. Factors that were included in the analysis were: sex, age, mechanism of injury, injuries per anatomic region, initial vital signs (heart rate, systolic and diastolic arterial pres-

sure and breathing rate), Glasgow Coma Scale (GCS), and ISS.

Statistical analysis was conducted using a multivariate logistic regression model with the final outcome as a dependent variable. In order to better describe continuous variables, two categories were created: age ≥60 and <60; ISS ≥18 and <18. Univariate comparisons were performed using one-way ANOVA and chi-square test where applicable. Values are presented as means±SE (Standard error of the mean). Statistical significance was reached when $p<0.05$.

RESULTS

During the study period a total of 1280 consecutive adult trauma patients were admitted to the University Hospital of Herakleion; 730 (57%) of them had been injured in vehicle accidents, consisting our study group. Demographic and injury data of the study group are demonstrated in Table 2. The remaining 550 (43%) trauma patients were injured due to other causes; in particular, 420 cases (32.8% of the admitted patients) because of fall injuries, 79 (6.2%) occupational, 41 (3.2%) assault (stabbing, gunshot, or other), and 10 (0.8%) after sport injuries.

Mean age of the patients was 35.4±0.6 years; males accounted for the majority (76.2%) of the study group. Of the 730 injured traffic victims, 521 (71.4%) were drivers, 132 (18.1%) passengers and 77 (10.5%) pedestrians while 210 (28.8%) were car occupants and 443 (60.7%) motorcyclists. Protective devices utilization was rare; 35 (16.6%) of the injured car occupants used a seat belt and 27 (6.1%) of the motorcyclists used a helmet. One hundred and seventy-nine patients (24.5%) were admitted in the ICU. Mean length of stay in the ICU and in the hospital was 7.9±0.6 and 11.7±0.5 days, respectively.

Thirty-five motor-vehicle trauma patients died; thus, mortality rate was 4.8%. Head injury was the cause of death in 19 patients (54.4%), hemorrhagic shock in 11 (31.5%), septic shock in 2 (5.7%), ARDS in one (2.8%), pulmonary embolism in one (2.8%), and one patient (2.8%) died because of multiple organ failure. Two patients (5.7%) died in the emergency department, 4 (11.4%) in the operation room, 22 (62.9%) in the ICU, and 7 (20%) in an observation unit or a hospital ward. Finally, the overall mortality of the patients who were not injured in road traffic accidents was similar to that of motor-vehicle trauma cases (n=30, 5.4%).

Differences between vehicle accident victims that died in the hospital and those who survived are described in detail in Tables 3 and 4. Independent predictors of mortality after a vehicle accident were found to be: age, ISS, craniocerebral, thoracic and abdominal injury, and being a pedestrian. The worst outcome was present in patients with head, thoracic and abdominal injuries, who were pedestrians, older than or 60 years old, and had an ISS of 18 or more.

Mean age of dead patients was 46.5±4.2 years and of those who survived 34.9±0.6 years. Since this difference was significant ($p=0.0001$), we divided the total of the patients in two groups with reference to age: those under 60 years old (84.8%) and those older than or equal to 60 (15.2%). Patients aged 60 or more comprised 42.9% of the dead patients and 13.8% of the survivors. Patients aged 60 or more were much more likely to die (13.5%) than those under 60 years of age (3.2%). These results were found to be of strong statistical significance ($p=0.0002$).

Table 2. Demographic and injury data of the study group (total of 730 patients)

Variable	Mean±SE
Age (years)	35.4±0.6
Sex	
Male	556 (76.2%)
Female	174 (23.8%)
Heart rate (/min)	87.6±0.6
Systolic arterial pressure (mmHg)	131.7±0.8
Diastolic arterial pressure (mmHg)	73.8±0.5
Breathing rate (/min)	18.3±0.1
Glasgow Coma Scale (GCS)	14±0.8
Injury Severity Score (ISS)	13.3±0.3
Craniocerebral injury	365 (50%)
Thoracic injury	222 (30.4%)
Abdominal injury	104 (14.2%)
Spinal cord injury	70 (9.6%)
Pelvic injury	68 (9.3%)
Injury of the upper and/or lower extremity	265 (36.3%)
Mortality	4.8% (n=35)

Table 3. Epidemiology and initial vital signs of dead patients versus survivors

Variable	Dead	Survivors	*p*
Age			
≥60	42.9%	13.8%	0.0002*
<60	57.1%	86.2%	
Sex			
Male	80%	76%	0.74
Female	20%	24%	
Heart rate (/min)	85.8±2.4	87.7±0.6	0.97
Systolic arterial pressure (mmHg)	134.7±3.1	131.6±0.8	0.77
Diastolic arterial pressure (mmHg)	75.9±1.8	73.7±0.5	0.65
Breathing rate (/min)	18.2±0.7	18.3±0.1	0.67
Glasgow Coma Scale (GCS)	13.6±0.5	14.1±0.1	0.15
Car occupants	31.4%	28.5%	0.69
Motorcyclists	42.9%	61.7%	0.16
Pedestrians	25.7%	9.8%	0.007*
Vehicle drivers	51.4%	72.4%	0.76
Vehicle passengers	22.9%	17.9%	0.75
Safety belt	0%	17.5%	0.22
Helmet	0%	6.3%	0.61

* Statistical significance.

Table 4. Injury data of patients that died versus those who survived

Variable	Dead	Survivors	*p*
Injury Severity Score (ISS)			
≥18	80%	23%	0.003*
<18	20%	77%	
Craniocerebral injury	80.0%	48.5%	0.01*
Thoracic injury	40.0%	29.9%	0.01*
Abdominal injury	34.3%	13.2%	0.01*
Spinal cord injury	8.6%	9.6%	0.56
Pelvic injury	14.3%	9.1%	0.95
Upper/Lower extremity injury	31.4%	36.5%	0.89
ICU admission	74.3%	22.1%	0.01*
ICU length of stay (days)	8.8±2.8	7.8±0.6	0.73
Hospital length of stay (days)	12.1±3.9	11.7±0.5	0.84

* Statistical significance.

Mean ISS of dead patients was 16.5±2.2 and of those who survived 13.2±0.3. Since this was statistically important (p=0.0001), we divided the total of the patients in two groups with reference to ISS: those with an ISS less than 18 (74.2%) and those who had an ISS of 18 or more (25.8%). Patients with an ISS of 18 or more accounted for 80% of the dead patients in comparison to 23% of the survivors. Mortality rate for patients with an ISS greater than or equal to 18 was substantially higher (14.9%) than for patients with an ISS less than 18 (1.3%). These results were also found of strong statistical importance (p=0.003).

Patients who had sustained craniocerebral injury were significantly overrepresented in the group of deceased patients (80%) compared with survivors

(48.5%). Mortality of patients with head trauma (7.7%) was four times higher than if no head injury occurred (1.9%). These results were found to be of strong statistical significance (p=0.01).

Patients with thoracic trauma composed 40% of the dead group and 29.9% of the survivors; this was found to be statistically significant (p=0.01). Of the non-survivors group, 34.3% had abdominal injury compared to 13.2% of the survivors group. Patients that had sustained abdominal trauma were much more likely to die (11.5%) than those who had not (3.7%). These results were statistically significant (p=0.01).

Mortality rate for drivers was 3.5%, for passengers 6.5%, for car occupants 5.3%, and for motorcyclists 3.4%. On the contrary, mortality rate for pedestrians was 11.7%; pedestrians constituted 25.7% of the dead group and 9.8% of the survivors group. This was found to be statistically significant (p=0.007).

The lack of seat belt or helmet use was associated with all vehicle occupants' deaths as opposed to no deaths in patients who were protected. This result, though, was not found to be statistically significant (p>0.05).

DISCUSSION

Greece has one of the highest death rates after vehicle accidents/million population in the European Union.[7] Although several efforts have been made to reduce fatal vehicle accidents over the last years, mortality rates have remained essentially unchanged, and must continue to be considered as priority target for local prevention policies.

This retrospective study contributes to the knowledge of road users injured in motor vehicle crashes and admitted to a Greek level I trauma center, and its particular objective is to identify and assess risk factors and predictors of in-hospital mortality of these trauma patients. We report age, ISS, being a pedestrian, craniocerebral, thoracic and abdominal injuries as major predictors of vehicle accidents victims' outcome.

Mean age of dead patients was significantly higher than that of survivors. This is in accordance with other studies in the literature.[9-14] In particular, age of 60 years or more was found to be an independent predictive factor of in-hospital mortality.

In addition, mean ISS of dead patients was significantly higher than that of survivors. This is in agreement with previous reports.[10,12-14] ISS of 18 or more was found to be an independent predictor of in-hospital mortality. Mortality of patients with an ISS greater than or equal to 18 was significantly higher than of those with an ISS less than 18. This result agrees with that of another study of Tornetta et al. in which mortality rate for patients with ISS >18 was 37%, compared with only 4% in patients with ISS ≤18.[15]

Head injuries are one of the most common injuries sustained by patients of all ages after a motor vehicle crash. This has been shown in many published series for adult casualties[16,17] as well as for children.[18,19] In our study, 50% of the vehicle victims sustained craniocerebral injury. Moreover, head trauma is the most common cause of death in trauma patients of all ages after road traffic accidents.[16,17,20] Head injury was the cause of death in 54.4% of our dead patients. The actual independent impact of head injury as one of the major predictors of fatal outcome in vehicle accident victims in our study was defined in a multivariate analysis. This result is also in accordance with the literature.[14,21]

Exsanguination is the second leading cause of death in trauma patients injured in vehicle accidents.[14,20,22] Hemorrhagic shock resulted in death in 31.5% of the patients that died in our study group; the majority of them had severe thoracic or/and abdominal trauma. Thoracic as well as abdominal injuries were found to be independent predictors of fatal outcome of our patients.

Complications of injury such as sepsis, ARDS, pulmonary embolism, and multiple organ failure are important causes of death.[22] In our patients such complications were the cause of death in 14.1% of the mortality group.

Pedestrians are a highly vulnerable population group among road traffic accident victims with high mortality rates.[11,13,14,23] Our results also show that pedestrians in Greece are at higher risk of in-hospital mortality.

Multiple studies have confirmed the effectiveness of safety belts and helmets in decreasing mortality and injury severity after motor vehicle crashes.[4,24-26] However, compliance with safety restraint devices is very low in car occupants and motorcy-

clists in Greece resulting in high pre-hospital and in-hospital mortality. In our patients, protective devices utilization rate was very low and, moreover, the lack of seat belt or helmet use was associated with all vehicle occupants' deaths as opposed to no deaths in patients who were protected. Even though this difference did not reach statistical significance, our study still emphasizes the need for stricter enforcement of laws related to the use of protective devices and also for public awareness campaigns and educational programs so as to increase safety belt and helmet utilization in our country.

In the last decades, southern European countries have shown vehicle accidents rates and motor vehicle-related death rates consistently higher than the remaining European countries.[1] Vehicular trauma is the major injury mechanism in Greece, Turkey, Italy, Spain, and Portugal[1,14] while Greece, Spain, and Portugal have mortality rates 2 to 4 times higher than countries with the lowest rates.[1] Car accidents yield an important burden in traffic injuries in southern European countries as well as pedestrian- and motorcycle-related accidents although differences exist between these countries regarding the latter two road-user categories.[1,11,14] Particularly, pedestrians have been reported to comprise a higher percentage of trauma patients in a study in Turkey than in our study whereas motorcyclists a lower one.[14] Similarly to our results, such a striking contribution of motorcycle injuries has been reported in a study in Spain.[11] Furthermore, the results of this study regarding predictors of mortality of road trauma patients are in agreement with studies conducted in Turkey and Spain.[11,14] Road traffic injuries continue to be predominant in the trauma subset in south-European countries, pointing out the urgent need to implement effective strategies to reduce injury risk associated with vehicular accidents. Educational campaigns for safe traffic habits and behaviour must be promoted in order to see a reduction in the number of casualties in these countries.

Rational decision-making aimed at improving trauma care must be based on a clear and detailed understanding of the causes, treatment, and outcomes of injury. Trauma registry data analysis is of utmost importance for implementing a philosophy of continuous quality improvement regarding prevention and treatment of road traffic injuries and motor-vehicle trauma patients' mortality reduction. Mortality of our patients can be attributed to several factors that correlate with all phases of trauma care. Several efforts have consequently been made in the last years regarding injury prevention and protective devices utilization, funding of the National Ambulance Service and training of its personnel, improvement in the National Ambulance Service response and prehospital care, patients' triage system, Emergency Department care (space organisation, equipment, training of doctors, nurses, and support staff), in-hospital care of these patients and, finally, coordination of all phases of trauma management. Even though detailed analysis of more recent data has not been completed, our progress so far has been good and we believe that our results are encouraging. Though considerable improvements have been made, we still have a long way to go.

This study concludes that in-hospital mortality is associated with the patients' age as well as the severity (ISS), mechanism (pedestrian), and type (craniocerebral, thoracic or abdominal) of injury. The results obtained have allowed the identification of trauma patients injured in vehicle accidents who are at higher risk of a fatal outcome; namely, patients who are aged 60 or more, pedestrians, those with an ISS of 18 or more, and those who sustain head, thoracic or abdominal trauma. Since the consequences of road traffic accidents in Greece are so devastating, local injury prevention programs should contribute to an important reduction in accidents rates and the severity of injuries. In addition, efforts should be focused on preventive measures targeted at these groups of trauma patients at highest risk as well as the pre-hospital, emergency department, and in-hospital care of these patients.

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