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Original Article

Mortality Factors in Major Trauma Patients: Nation-wide Population-based Research in Taiwan☆

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S U M M A R Y

Background: Major trauma remains a significant medical concern, leading to about 10,000 deaths annually in Taiwan. Trauma system implementation has been shown to improve the outcomes in different countries. Using the National Health Insurance data, our study examined the influence of age and other factors on the outcomes of trauma patients.

Materials and methods: We collected the original claim data of 1 million beneficiaries who enrolled in the National Health Insurance program from 2006 to 2008. ICDMAP-90 was used for calculating the Injury Severity Score (ISS), which was required for assessing the disease severity and implementing appropriate control measures. Other variables included age, sex, triage classifications, pre-existing comorbidities, and hospital levels. The Charlson Comorbidity Index for the year of admission was used for adjusting co-morbid conditions.

Results: A total of 2497 major trauma patients (ISS >15) were identified in our database. After controlling all the variables in a logistic regression model, for all the major trauma patients, a significant difference was observed between different hospital levels. Compared with the trauma centers, the risk of mortality in nontrauma centers was 1.58 times that in trauma centers ($p = 0.004$). In the younger groups (aged <40 and 41–60 years), hospital levels had no significant effect on mortality ($p = 0.40, 0.41$). However, the risk of mortality was 1.89 times in nontrauma centers, compared to that in trauma centers, in the oldest group ($p = 0.005$).

Conclusion: Our study suggests that all major trauma patients should be sent to trauma centers, especially the older patients.

research topic

literature review

1. Introduction

Major trauma remains an important health concern, with about 10,000 trauma-related deaths occurring annually in Taiwan. In Taiwan, New Taiwan dollar (NT$)14.7 billion [about 500 million (United States dollar) USD] is spent annually on trauma patients, i.e., over NT$ 40 million (1.3 million USD) is spent per day[1]. Since Trunkey[2] described the trimodal frequency distribution of deaths after trauma and the concept of the "golden hour", outcomes for injured patients admitted to different levels of hospitals became of particular interest.

One study showed that mortality of the admitted trauma patients, especially those in the elderly group, were associated with the following factors: trauma score (less than 7), hypotension (systolic blood pressure less than 90 mmHg), hypoventilation (respiratory rate less than 10 breaths/min), or a Glasgow Coma Scale (GCS) score of 3[3]. Another study involving a chart review showed that the mortality is correlated with the Injury Severity Score (ISS), GCS coma score, systemic complications, and the need for general surgery in the elderly trauma patients[4].

Advanced age is a well-recognized risk factor for adverse outcomes following trauma. Previous studies showed that mortality increases from the age of 40 years. Morbidity and mortality increase in geriatric trauma patients compared with their younger counterparts. Morris found the mortality, defined as in-hospital

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death, begins to increase at the age of 45 years in patients with moderate and severe injuries (ISS 9–24)[5–8].

Trauma system implementation has been shown to improve the outcomes in different countries[9–11]. The Department of Health in Taiwan has suggested that all major trauma patients should be transferred to trauma centers. However, without good evidence the concept of trauma system implementation still has not been adopted widely in Taiwan. Although the field triage decision scheme in the *Advance Trauma Life Support* textbook suggests transferring all trauma patients older than 55 years to trauma centers, in Taiwan, no good evidence can be found supporting that suggestion. Thus, we need larger studies that compare mortality rates at trauma centers with those at nontrauma centers. Our study, using nationwide population-based data in Taiwan, explored the mortality rates for major trauma patients in different age groups and between trauma and nontrauma centers. Our findings may have major implications for health policies in Taiwan and other countries.

2. Materials and methods

2.1. Emergency medical services and hospital characteristics

In Taiwan, prehospital trauma care is delivered by emergency medical technicians (EMTs) of the fire departments. Except in some cities (e.g., Taipei City), in most places the EMTs are EMT-II types. Due to the limited number of EMT paramedics, prehospital advanced life support (ALS) care is available only in some urban areas. According to a research in Taipei City, around 9–16% of emergency medical services calls demanded ALS, and the average emergency response time was from 4.1 minutes to 4.9 minutes. In the rural areas, the average response time was found to be longer (more than 6.6 minutes)[12].

According to the 2005 National Health Insurance Research Database (NHIRD), there were 461 acute care hospitals in Taiwan. Based on the expertise and capability, all hospitals were categorized into three levels and certified by the Department of Health. In 2005, there were 22 medical centers and 72 regional hospitals. All the centers were level I trauma centers.

2.2. National Health Insurance dataset in Taiwan

Taiwan introduced National Health Insurance (NHI) in 1995, covering nearly all residents (about 98%). Taiwan's NHI permits patients to choose any hospital or physician, while requiring them to share some health-care costs through affordable, low, and fixed copayments. All health-care providers are geographically well dispersed. However, most of the trauma centers are located in urban areas.

The Longitudinal Health Insurance Database (LHID) 2005 contained the original claim data of 1 million beneficiaries who were randomly sampled from the 2005 registry for all beneficiaries of the NHIRD. There were approximately 25 million individuals in this registry. There was no significant difference in the sex distribution of patients between the LHID 2005 and the original NHIRD datasets ($\chi^2 = 0.008$, df = 1, $p = 0.05$). The NHIRD dataset is possibly the largest and most comprehensive population-based data source currently available in the world, and it includes one primary diagnosis and up to four secondary diagnoses that are coded by the ICD-9-CM system.

2.3. Study sample

All the patients older than 15 years who had been sent to the emergency departments with the primary diagnosis of trauma (ICD-9-CM codes 800–949) were included in our research. A total of 5912, 5611, and 5760 trauma patients were admitted to emergency departments in the years 2006, 2007, and 2008, respectively. There were 2497 major trauma patients with an ISS of more than 15.

2.4. Key variables of interest

The control variables investigated in our study included patient age, sex, triage classifications, pre-existing comorbidities, and different hospital levels. The patient age was categorized as <40 years, 40–60 years, and >60 years. Different triage classifications for patients were recognizable by different payment coding: Class I:00201A, Class II:00202A, Class III:00203A, and Class IV:00204A. The triage classifications were categorized as severe ones (Classes I and II) and others (Classes III and IV). ICDMAP-90[13] was used for calculating the ISS as the variable controlling the disease severity. Then, uses of ventilators and intensive care units (ICUs) were also included as the affecting variables.

In order to quantify the patient's pre-existing comorbidity, Charlson Comorbidity Index (CCI) for the year of admission was used for adjusting comorbid conditions. CCI was developed in 1987 for classifying comorbid conditions that may affect the risk of death from comorbid diseases. CCI has widely been used in many datasets for risk adjustment[14]. CCI is calculated from the presence of comorbid conditions (congestive heart failure, dementia, cancer, cerebral vascular disease, severe renal disease, etc.), with each condition being given a weight. The ICD codes that we used for converting CCI are given in Appendix 1.

2.5. Statistical analysis

All the statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Descriptive analyses and logistic regression analysis were then carried out to compare the mortality rates between different hospital levels, while adjusting for patient age, sex, pre-existing comorbidities, and different levels of hospitals.

3. Results

A total of 2497 major trauma patients with an ISS of more than 15 were identified in our database. Around 40% of the major trauma patients, with an average CCI of 0.78 (0.14 in the youngest group and 1.41 in the oldest group, $p < 0.01$), were cared for in the trauma centers. The total mortality rate was 12.5% (6.9% in the youngest group and 18.2% in the oldest group, $p < 0.01$). Of all the patients, 76.9% were triaged as Class I or Class II in all groups, 19.7% were intubated, and 57.2% were admitted to ICUs (Table 1).

As evident from Table 2, 968 patients were treated in the trauma centers and 1529 in nontrauma centers. The mortality rates were 11.1% in trauma centers and 13.4% in nontrauma centers ($p = 0.08$). There were significant differences in the triage classifications and the condition of intubation between both groups. However, no significant difference was observed in all other variables of nontrauma and trauma centers.

When all the major trauma patients were grouped together in a logistic regression model, there was a significant difference between trauma and nontrauma centers, as shown in Table 3. The risk of mortality in nontrauma centers was 1.58 times that in trauma centers ($p = 0.004$). In the youngest and younger groups (age <40 years and 41–60 years), hospital levels did not have any significant effect on mortality ($p = 0.402$ and 0.412, respectively). However, hospital levels did have significant effects in the oldest group (age >60 years). The relative risk of mortality in nontrauma centers was 1.89 in the oldest group ($p = 0.005$).