

# Cox Regression Analysis of 1739 Emergency Trauma Patients

**Jun Shen**

Department of Clinical Medicine, Graduate school of Soochow University

**Feng Xu**

Department of Emergency Surgery, the First Affiliated Hospital of Soochow University

**Du Chen** (✉ [sdfyycd@suda.edu.cn](mailto:sdfyycd@suda.edu.cn))

<https://orcid.org/0000-0001-6990-3310>

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## Research article

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# Abstract

**BACKGROUND:** Trauma is a damage caused by physical harm from external source. It has been one of the major causes of mortality. The purpose of this study was to explore the risk factors related to mortality among emergency trauma patients.

**METHODS:** This was a retrospective study in trauma center of the First Affiliated Hospital of Soochow University. The data were obtained from trauma database with patients registered from November 1, 2016 to November 30, 2019.

Shapiro–Wilk test, Mann-Whitney test and Likelihood-ratio Chi squared test were used to assess the survival pattern. Cox regressions were performed to calculate the hazard ratios (HRs) of variables for death.

**RESULTS:** The total 1739 emergency trauma patients, 44 (2.53%) died during the study period and 1695 (97.47%) were survival. Through univariable and multivariable Cox regression analysis, three independent risk factors for emergency death were screened out: pulse (Crude HR: 0.97, 95% Confidence Interval [CI]: 0.96-0.98; Adjusted HR: 1.04, 95% CI: 1.02-1.06), pulse oxygen saturation (Crude HR: 0.96, 95% CI: 0.95-0.97; Adjusted HR: 0.94, 95% CI: 0.91-0.97) and Revised Trauma Score (Crude HR: 0.69, 95% CI: 0.65-0.74; Adjusted HR: 0.79, 95% CI: 0.64-0.97).

**CONCLUSION:** The survival outcome of emergency trauma patients was influenced by many factors. Pulse, pulse oxygen saturation ( $SpO_2$ ) and Revised Trauma Score (RTS) were the independent risk factors for mortality. Accurate analysis and judgment of the risk factors can improve cure efficiency and long-term survival rate.

## Introduction

Trauma is a major public health problem and the leading cause of death and disability worldwide. According to the Global status report on road safety 2018, the number of annual road traffic deaths had reached 1.35 million. Road traffic injuries are now the leading killer of people aged 5 to 29 years [1]. All kinds of trauma will lead to more years of potential life lost and also contribute significantly to the nation's rising health care cost [2]. Reducing mortality and morbidity rate among patients with trauma is an extremely urgent issue, particularly in severe patients [3]. The procedure of diagnosis and treatment of injuries is a challenge for emergency physician. However, many death predictors are controllable and can be saved by timely basic life support and adequate intensive care [3, 4]. The indicators of traumatic injuries plays an important role in estimation of mortality risk [5]. So it is necessary for clinicians to correctly evaluate the relevant clinical indicators of trauma patients. In this text, we will establish a Cox regression model to analyse relevant clinical variables which may affect prognosis. Hence, the purpose of this study is to evaluate the independent risks factors as predictors of mortality in traumatic patients.

## Methods

# Study design, setting, and population

This was a single-center, retrospective study of 1739 injured trauma patients admitted to trauma center of the First Affiliated Hospital of Soochow University from November 1, 2016 to November 30, 2019. The following inclusion criteria were applied: definite damage, primary survey, complete medical data. Patients who were dead upon arrival, with insufficient medical record were excluded from the study. Overall, 1739 patients were selected in the study, including 1272 males and 467 females. Besides, data for all patients were obtained from trauma database ( all patients admitted to the emergency room were recorded ).

## Study protocol

All registered indicators of trauma patients were required for this study. Patients arriving at the ED (Emergency Department) were triaged, an assessment of pre-hospital treatment, injuries, vital signs, complications was completed to allow for a prediction of emergency death. Essential information were uploaded to the trauma database, and completed the data quality control. The following were considered related risk factors in the database: Age, Sex, MAP (mean arterial pressure), P (pulse), RR (respiratory rate), SpO<sub>2</sub> ( pulse oxygen saturation), T (body temperature) and RTS (revised trauma score). The survival outcome was tracked subsequently until discharge. Overall, the key of the study was integration and analysis of the big data. Through univariable and multivariable Cox survival analysis, we can obtain independent risk factors for emergency death.

## Data analysis

Continuous variables were tested for normality using Shapiro–Wilk test. All of the continuous variables in the current study, failing to conform to normality, were thus expressed as median (inter quartile range, IQR) and compared using Mann-Whitney test. Categorical variables were expressed as frequencies and percentages and compared using Likelihood-ratio Chi squared test. Cox regressions were performed to calculate the hazard ratios (HRs) of variables for death. Statistical analyses and graphics were completed with STATA 15.0. Two-tailed  $P < 0.05$  was considered to be statistically significant.

## Result

A total of 1739 patients were included in the trauma database during the study period. Table 1 summarized the baseline characteristics of the total cohort according to the trauma database. Overall, 1695 (97.47%) survived through effective treatment. The mortality was low (2.53%). The majority of patients were male (73.04%), with a median age of 51 (P50, 51; IQR, 25) years. The main analysis index of survival were MAP, SpO<sub>2</sub>, T and RTS, the median were 99 (IQR, 22), 98 (IQR, 4), 36.9 (IQR, 0.8), 12 (IQR, 0), respectively. Patients who died had a median age of 50 (P50, 50; IQR, 20) years and with a median MAP of 64 (IQR, 100), SpO<sub>2</sub> of 83 (IQR, 94), T of 35.8 (IQR, 2.1) and RTS of 8 (IQR, 6). However, there were no significant differences in sex ( $P = 0.532$ ), age ( $P = 0.757$ ), P ( $P = 0.074$ ), RR ( $P = 0.066$ ), between groups.

Table 1  
Baseline characteristics

| <b>Variables</b>   | <b>Survival</b><br><b>1695(97.47)</b> | <b>Non-survival</b><br><b>44(2.53)</b> | <b>P value</b> |
|--|---------------------------------------|--|----------------|
| Sex  |                                       |  | 0.532          |
| Female   | 457(26.96)                            | 10(22.73)                              |                |
| Male   | 1238(73.04)                           | 34(77.27)                              |                |
| Age (year)   | 51(25)                                | 50(20)                                 | 0.757          |
| MAP (mmHg)   | 99(22)                                | 64(100)                                | < 0.001        |
| P (n/min)  | 85(23)                                | 80(106)                                | 0.074          |
| RR (n/min)   | 20(4)                                 | 18(26)                                 | 0.066          |
| SpO <sub>2</sub> (%)   | 98(4)                                 | 83(94)                                 | < 0.001        |
| T (°C)   | 36.9(0.8)                             | 35.8(2.1)                              | < 0.001        |
| RTS  | 12(0)                                 | 8(6)                                   | < 0.001        |
| Continuous variables failing to conform to normality were thus expressed as median (inter quartile range, IQR) and compared using Mann-Whitney test. Categorical variables were expressed as frequencies and percentages and compared using Likelihood-ratio Chi squared test. |                                       |  |                |
| MAP, mean arterial pressure; P, pulse; RR, respiratory rate; T, body temperature; SpO <sub>2</sub> , pulse oxygen saturation; RTS, revised trauma score.   |                                       |  |                |

Table 2 shows the results of Cox regression analysis. Univariable Cox analysis revealed that risk factors of trauma death were significantly associated with the following aspects: MAP, P, RR, SpO<sub>2</sub>, T and RTS. In the multivariable Cox regression analysis, trauma death was independently associated with P (hazard ratio [HR], 1.04; 95% confidence interval [CI], 1.02–1.06; P=0.001), SpO<sub>2</sub> (HR, 0.94; 95% CI, 0.91–0.97; P=0.001) and RTS (HR, 0.79; 95% CI, 0.64–0.97; P = 0.023).

Table 2  
Cox regression analyses

| Variables            | Univariable     |         | Multivariable   |         |
|----------------------|-----------------|---------|-----------------|---------|
|                      | HR(95%CI)       | P value | HR(95%CI)       | P value |
| Male                 | 1.23(0.61–2.50) | 0.560   | 1.01(0.99–1.03) | 0.478   |
| Age (year)           | 0.99(0.97–1.01) | 0.573   | 2.06(0.72–5.93) | 0.180   |
| MAP (mmHg)           | 0.96(0.95–0.97) | < 0.001 | 1.00(0.99–1.02) | 0.769   |
| P (n/min)            | 0.97(0.96–0.98) | < 0.001 | 1.04(1.02–1.06) | < 0.001 |
| RR (n/min)           | 0.89(0.85–0.93) | < 0.001 | 1.02(0.96–1.08) | 0.579   |
| SpO <sub>2</sub> (%) | 0.96(0.95–0.97) | < 0.001 | 0.94(0.91–0.97) | < 0.001 |
| T (°C)               | 0.91(0.88–0.93) | < 0.001 | 0.87(0.70–1.06) | 0.170   |
| RTS                  | 0.69(0.65–0.74) | < 0.001 | 0.79(0.64–0.97) | 0.023   |

MAP, mean arterial pressure; P, pulse; RR, respiratory rate; T, body temperature; SpO<sub>2</sub>, pulse oxygen saturation; RTS, revised trauma score; HR, hazard ratio.

Forest map was used to estimate the sensitivity. In univariable analysis, the forest map visually illustrated the outcome consistent with the above analysis. Results of multivariable analysis also indicated that P, SpO<sub>2</sub> and RTS were independent risk factors. The forest map was intuitive to describe the results of analysis (Fig. 1).

## Discussion

Despite efforts in prevention and treatment, traumatic injury was still associated with a high morbidity and mortality [6]. Most of the patients with severe multiple injuries are the majority of the social labor force. The major cause of death in traumatic injury remains a major public issue [7]. Massive blood loss, reduced blood volume and tissue perfusion can easily lead to metabolic acidosis, infection and even multiple organ failure, fluid resuscitation at the appropriate time is the standard recommendation [8]. So in order to improve long-term survival and treatments outcomes, it is important to promptly and accurately determine the severity of patients with trauma in the ED [8, 9]. The study was an attempt to identify the factors that affect the survival of patients with injuries. The multivariable Cox regression analysis indicated that the P, SpO<sub>2</sub> and RTS demonstrated good sensitivity for the independent risk factors of mortality. This has been particularly true in urban environments with traffic injuries and hemodynamically unstable patients.

Pulse has been identified as an important risk factor for death in trauma patients. Pulse is closely related with heart rate, the beats and frequency are basically the same. Cardiovascular disease is more dangerous and deadly disease, the heart rate is closely related to the circulation system. Occult

hypoperfusion (OH) is associated with worse outcomes [10]. If the heart rate is increased, the oxygen supply to the myocardium is decreased and the oxygen consumption is increased, which accelerates the deterioration of the disease. Therefore, heart rate can directly reflect the severity of the emergency trauma patients. Moreover, in the case of blood volume loss, a vagal withdrawal results in activation of the sympathetic fibers to the heart and blood vessels, including increased heart rate [11]. Pulse is one of the foremost marks currently to support a clinical diagnosis of severe trauma.

Second, professional airway management can save lives when provided as early as possible [12]. Trauma patients are often associated with arterial oxygen desaturation, so we need special attention to insufficient or absent breathing. Pulse oxygen saturation (displayed on the monitor) is a good indicator to observe. Findings of decreased respiratory rate, oxygen saturation can be explained by a high number of severe head injuries [13]. Therefore, it can not only explain the etiology but also predict the survival and prognosis of the disease.

Pre-hospital triage of the seriously injured patient is fraught with challenges, and early assessment of the serious injury can improve the treatment efficiency. Revised Trauma Score (RTS) is widely used by emergency services around the world [14]. RTS is a quantitative assessment of three physiological indicators: GCS (Glasgow Coma Scale), systolic blood pressure and respiratory frequency, which are negatively correlated with the severity of the patient. The formula for calculating RTS is as follows:  $RTS = 0.7326 \times \text{systolic blood pressure} + 0.2908 \times \text{respiratory rate} + 0.9368 \times \text{GCS}$  [15]. Subsequently, some large studies have demonstrated that REMS (Rapid Emergency Medicine Score) in severe trauma is also independently correlated with mortality [16]. However, RTS is a physiologically based score that can be rapidly calculated by EMS (Emergency medical services) providers in the field (when used in an unweighted format scored from 0 to 12) [17]. RTS had an advantage over other evidence-based guidelines in terms of timeliness. Besides, RTS was a stronger predictor of in-hospital mortality in patients seen in the ED.

## Limitations

In general, the advantages of our study lay in the large sample size and reliable data sources. However, this study had certain limitations. First of all, we were primarily limited by the retrospective nature of the study, although the data from the trauma database were collected prospectively. Second, this study was conducted in a single medical center, which may limit the generalizability of the conclusions. At the same time, our data were the survival prognosis captured by trauma patients in the emergency room, and there were many uncertainties after discharged from the ED before termination of treatment. To address these limitations would require a large population with the ability to long-term follow-up.

## Conclusion

Overall, this study sought to evaluate the independent risk factors in trauma mortality. Risk factors should be well applied by every clinician in China. It can enhance trauma management processes to reduce

mortality and improve long-term survive. Therefore, we suggested that the Pulse, SpO<sub>2</sub> and RTS should be used as easy independent risk factors of mortality among patients with trauma.

## Abbreviations

HRs

Hazard Ratios

CI

Confidence Interval

SpO<sub>2</sub>

Pulse Oxygen Saturation

RTS

Revised Trauma Score

ED

Emergency Department

MAP

Mean Arterial Pressure

P

Pulse

RR

Respiratory Rate

T

Temperature

IQR

Inter Quartile Range

OH

Occult Hypoperfusion

GCS

Glasgow Coma Scale

REMS

Rapid Emergency Medicine Score

MES

Emergency Medical Services

## Declarations

### **Ethics approval and consent to participate**

Patient's data was anonymized and de-identified. Reviewed by the Ethics Committee, the design of the research scheme was scientific and in line with ethical principles. This study conformed to the principles of the Declaration of Helsinki.

## Consent for publication

Not applicable

## Availability of data and materials

The data that support the findings of this study are available from trauma database of the First Affiliated Hospital of Soochow University but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of trauma database.

## Competing interests

The authors declare that they have no competing interests.

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Not applicable

## Authors' contributions

All authors contributed equally to this work. All authors read and approved the final version of the manuscript.

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# Figures

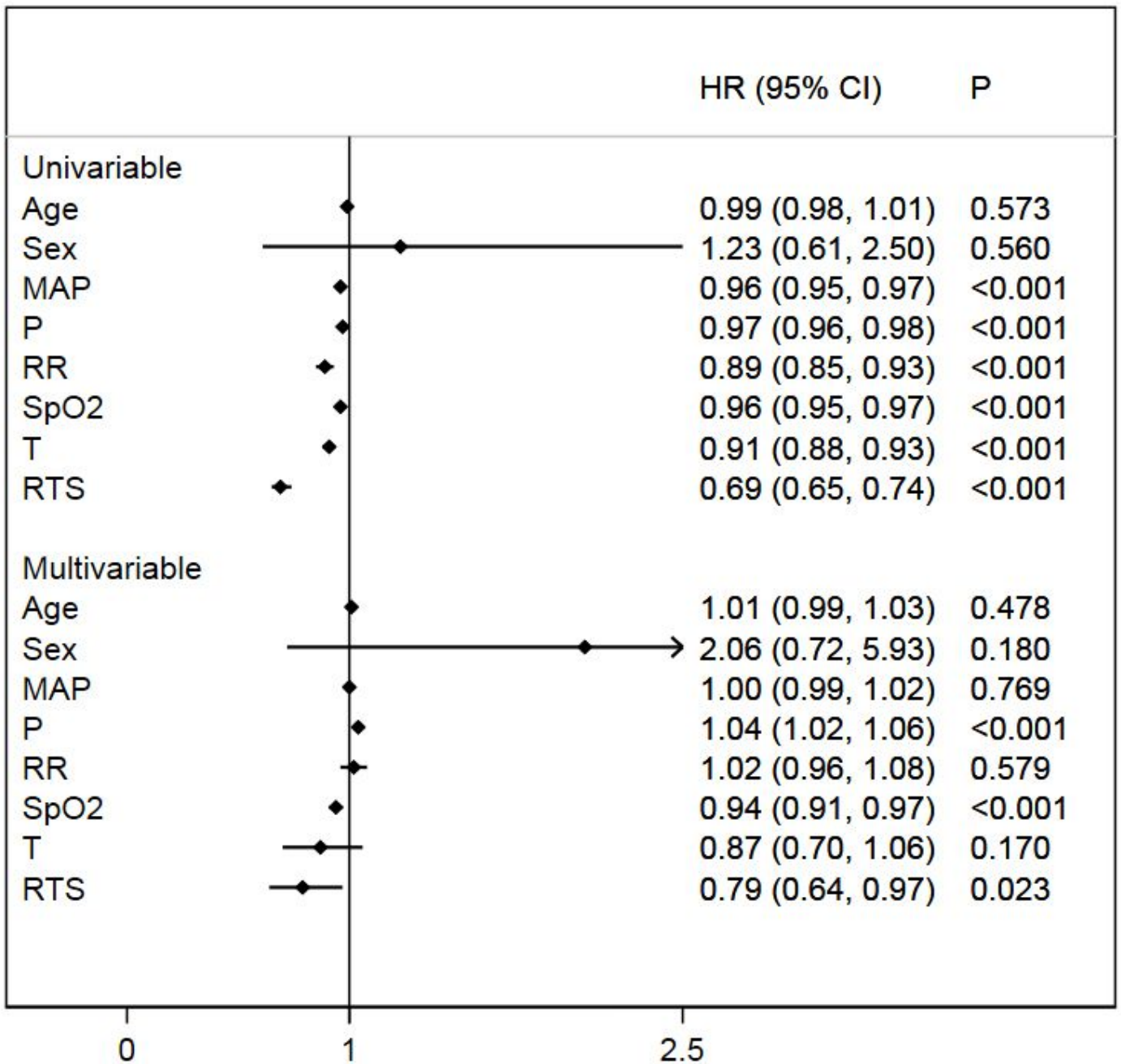


Figure 1

Forestplot of variables' hazard ratios in logistic regression models MAP, mean arterial pressure; P, pulse; RR, respiratory rate; SpO2, pulse oxygen saturation; T, body temperature; RTS, revised trauma score; HR, hazard ratio; CI, confident interval.

## Supplementary Files

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