Correlation Analysis between Pulse Oxygen Saturation and Prognosis of Emergency Trauma Patients

Cong Geng
the First Affiliated Hospital of Soochow University

Feng Xu
the First Affiliated Hospital of Soochow University

Du Chen (✉ sdfyycd@suda.edu.cn)
the First Affiliated Hospital of Soochow University

Research Article

Keywords: SpO2, trauma, prognosis, Emergency Department

Posted Date: November 8th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1006610/v1

License: ☒ This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

Background

Past studies are limited in which proposing SpO2 as mortality predictor of trauma patients. The aim of our study was to investigate the correlation between pulse oxygen saturation (SpO2) and prognosis in emergency trauma patients.

Methods

We collected 1720 trauma patients admitted to the Emergency Department of the First Affiliated Hospital of Soochow University from November 1, 2016 to November 30, 2019 to retrospective analysis. The mortality of trauma patients in the emergency department was defined as end-point of outcome. The patients were divided into six subgroups with 75%, 80%, 85%, 90% and 95% SpO2 as the bound values. SpO2>=95% subgroup was defined as basis reference, we calculated the crude HR of other subgroups and adjusted HR after the adjustment for confounders including age and sex by Cox regression model. The ROC curve was performed and the area under the curve (AUC) was calculated to evaluate the predictive value of SpO2 in emergency mortality.

Results

Compared to basis reference, the mortality of other subgroups was gradually increased with the decrease of SpO2. The crude HR and 95% CI of each subgroup calculated by univariate Cox regression were: SpO2 90%-95%, 7.62(2.65-21.95), p<0.001; SpO2 85%-90%, 12.25(2.90-51.66), p=0.001; SpO2 80%-85%,35.81(9.53-134.50), p<0.001; SpO2 75%-80%, 32.88(7.53-143.54), p<0.001; SpO2<75%, 155.07(56.41-426.29), p<0.001. The adjusted HR and 95%CI after adjustment for age and sex were respectively 6.75(2.30-19.81), p=0.001; 11.34(2.69-47.84), p=0.001; 33.26(8.83-125.38), p<0.001; 48.27(9.02-258.48), p<0.001; 162.64(57.62-459.03), p<0.001. ROC curve analysis showed that the AUC was 0.898, 95%CI (0.845-0.951), the optimal cut-off value was 94%, and the corresponding sensitivity and specificity were 79.07% and 85.84%, respectively.

Conclusion

Our study revealed that SpO2 was closely related to the prognosis of emergency trauma patients and had a good predictive value for emergency room death. The lower the SpO2, the higher the mortality.

This study was retrospectively registered in the First Affiliated Hospital of Soochow University.

Background
Trauma is a devastating medical issue with high mortality rate, imposing huge global burden[1]. In accordance to an epidemiological study[2], 52.5% of respondents in China experienced at least one lifetime traumatic event, which indicate that trauma is common and worthy of clinical attention. In emergency department (ED), it is important to quickly identify and treat patients with severe trauma. The factors that could predict trauma mortality contribute to discover severe patients to some extent. There have been some studies on the predictors of mortality in trauma patients[3–5]. Variables, including vital signs, trauma scoring systems, acute traumatic coagulopathy, ED presentation time and et al were investigated to evaluate the value of predicting trauma mortality.

As one of the vital signs, respiratory rate assessment obtained by medical personnel was unreliable and usually incorrect in the ED settings[6, 7]. Pulse oxygen saturation (SpO2), an objective, efficient and unequivocal parameter, was quick to measure and widely used in the clinical setting[8].

However, studies are scarce in which proposing SpO2 as mortality predictor of trauma patients. Though some studies reported that SpO2 was not good predictor for mortality of trauma patients, they still recommend SpO2 as a variable in a model of survival probability due to the clinical ease of obtainment and its physiological significance[4, 5]. Other studies indicated that SpO2 was independently predictive value of mortality in trauma patients[3].

This study was conducted to explore the relationship between SpO2 and prognosis of trauma patients in ED. The results of the present study will contribute to quickly identification of severe trauma and also improve the outcome of patients.

**Methods**

**Subject**

This study was retrospective and clinical data were exported from the emergency trauma registry information system of the First Affiliated Hospital of Soochow University.

We included 1720 trauma patients over 18 years of age enrolled in the database from November 1, 2016 to November 30, 2019. Information on patient characteristics was collected including sex, age, mean arterial pressure (MAP), pulse rate (P), respiratory rate (RR), SpO2, revised trauma score (RTS) and hours in emergency room (HER). SpO2>=95% was defined as basis reference. Among the rest, SpO2 was divided into five groups according to the following values, 90 to 95%; 85 to 90%; 80 to 85%; 75 to 80%; <75%.

**Outcome**

The mortality of trauma patients in ED was defined as end-point of outcome in this study. Trauma patients were divided into two groups: survival and non-survival. According to SpO2 boundary, outcomes
of five subgroups were recorded to analyze the correlation between SpO2 and prognosis.

This study was approved by the Ethics Committees of the First Affiliated Hospital of Soochow University (Approval Number: 2021-231). Personal informed consent was not required due to the retrospective nature of the data.

**Statistical analysis**

The patient characteristics involved continuous and categorical variables. Continuous variables were expressed as median (inter quartile range, IQR). Categorical variables were expressed as frequencies and percentages. \( P \) values were calculated by Mann-Whitney test or Chi squared test. The mortality of trauma patients in ED were evaluated in crude and multivariable Cox regressions. Multivariable regression analysis was adjusted for confounders including age and gender. Receiving operating characteristic curve analyses were performed to determine the cutoff values of variables for distinguishing between survival and non-survival. Statistical analyses and graphics were achieved with STATA 15. Data were presented with the standard level of significance (\( P<0.05 \)) and with 95% confidence intervals (CIs).

**Results**

Over the 3-year recruitment period, 1720 consecutive patients of trauma were enrolled in the emergency trauma registry information system of the First Affiliated Hospital of Soochow University, 97.5% of which survived in the end. Among survivals, 452 (26.95%) cases were female and 1225 (73.05%) cases were male. There was no significant sex difference between survivals and non-survivals (\( P=0.589 \)). The survivors showed on statistically significant lower HER and higher MAP, SpO2 and RTS than another group (\( P<0.05 \)), whereas age, \( P \) and RR were not different between two groups. (Table 1)

**Table 1 Baseline characteristics**
Abbreviation: Continuous variables were expressed as median (IQR); categorical variables were expressed as n/percentage; P values were calculated by Mann-Whitney test or Chi squared test. MAP, mean arterial pressure; P, pulse; RR, respiratory rate; SpO\textsubscript{2}, pulse oxygen saturation; RTS, revised trauma score; HER, hours in emergency room.

Cox regression analyses were accomplished to explore associations between different subgroups of SpO\textsubscript{2} and mortality in Table 2. Both univariable and multivariable Cox regression analyses indicated that the trauma mortality was closely associated with the level of SpO\textsubscript{2}. The crude HR and 95% CI of each subgroup were: SpO\textsubscript{2} 90%-95%, 7.62(2.65-21.95), p<0.001; SpO\textsubscript{2} 85%-90%, 12.25(2.90-51.66), p=0.001; SpO\textsubscript{2} 80%-85%,35.81(9.53-134.50), p<0.001; SpO\textsubscript{2} 75%-80%, 32.88(7.53-143.54), p<0.001; SpO\textsubscript{2}<75%, 155.07(56.41-426.29), p<0.001. The adjusted HR and 95%CI after adjustment for age and sex were respectively 6.75(2.30-19.81), p=0.001; 11.34(2.69-47.84), p=0.001; 33.26(8.83-125.38), p=0.001; 48.27(9.02-258.48), p<0.001; 162.64(57.62-459.03), p<0.001. Compared to the baseline reference, the risk of death in the other subgroups increased gradually as SpO\textsubscript{2} decreased.

Figure 1 demonstrated the ROC curve, each point on which corresponded to a sensitivity and specificity, and a high sensitivity meant a decrease in specificity. The ROC curve analysis showed that the AUC was 0.898, 95%CI (0.845-0.951), the optimal cut-off value was 94%, and the corresponding sensitivity and specificity were 79.07% and 85.84%, respectively. (Table 3)

| Variables | Survival | Non-survival | P value |
|-----------|----------|--------------|---------|
| Sex       | 1677(97.50) | 43(2.50) | 0.589 |
| Female | 452(26.95) | 10(22.26) | |
| Male | 1225(73.05) | 34(76.74) | |
| Age (year) | 51(24) | 50(20) | 0.876 |
| MAP (mmHg) | 99(22) | 64(102) | <0.001 |
| P (n/min) | 85(23) | 81(107) | 0.122 |
| RR (n/min) | 20(4) | 18(26) | 0.106 |
| SpO\textsubscript{2} (%) | 98(3) | 84(94) | <0.001 |
| RTS | 12(0) | 8(6) | <0.001 |
| HER (hour) | 4(13) | 14(33) | 0.001 |

**Table 2 Cox regression analyses**
| SpO₂ (%) | Univariate | Multivariate |
|----------|------------|--------------|
|          | Crude HR(95%CI) | P value | Adjusted HR(95%CI) | P value |
| >=95     | Reference   | Reference   |                     |         |
| 90-95    | 7.62(2.65-21.95) | <0.001 | 6.75(2.30-19.81) | 0.001   |
| 85-90    | 12.25(2.90-51.66) | 0.001 | 11.34(2.69-47.84) | 0.001   |
| 80-85    | 35.81(9.53-134.50) | <0.001 | 33.26(8.83-125.38) | <0.001  |
| 75-80    | 32.88(7.53-143.54) | <0.001 | 48.27(9.02-258.48) | <0.001  |
| <75      | 155.07(56.41-426.29) | <0.001 | 162.64(57.62-459.03) | <0.001  |

HR, odds ratio; CI, confidence interval; Adjusted for age and sex in multivariate model.

**Table 3 Analysis of receiver operating characteristic curve**

| Variable | AUC | 95% CI        |
|----------|-----|---------------|
| SpO₂     | 0.898 | 0.845-0.951  |

AUC, area under the curve; CI, confidence interval

**Discussion**

Although past studies had evaluated the potential outcome predictors of trauma patients, such studies in SpO₂ as predictive parameter are limited. SpO₂ with vital clinical significance is routinely measured and recorded in ED. The present study revealed SpO₂ was independent predictor of outcome in emergency trauma patients.

It is a key element in rapid assessment and treatment of trauma patients in ED. In order to quickly identify severe trauma patients, various severity scoring systems were explored including Injury Severity Score (ISS)[9], the Trauma and Injury Severity Score (TRISS)[10], the Revised Trauma Score (RTS)[11], the Mechanism, Glasgow coma scale, Age, and Arterial Pressure (MGAP) score[12], the Glasgow Coma Scale, Age, and Systolic Blood Pressure (GAP) score[13], the New Trauma Score (NTS)[14]. Above trauma scoring systems were dedicated to perform well in predicting outcome of trauma patients, but none played an irreplaceable role and gained easy access since of difficulties in real-time statistics.

Domingues et al.[4] proposed three new models which were equivalent to TRISS and indicated that SpO₂ as an isolated adjustment did not increase the predictive ability of this model, but also considered that the frequent lack of SpO₂ data might have underestimated its importance in the survival prediction models. It was also observed that SpO₂ did not add significant value to other variables when predicting
mortality in severe trauma patients[5]. An integrative review[15] found that an alteration to the method of age inclusion in the equation, and the insertion of gender, comorbidities and trauma mechanism, and exclusion of RTS presented a tendency towards improved performance of the TRISS, but use of SpO2 with neutralized RR in RTS did not result in improved performance.

Nevertheless, SpO2 was verified as a powerful mortality predictor across all ages by a recent study[16]. Moreover, Woodford et al discovered that mean SpO2 was a significant predictor of mortality after trauma during prehospital care[17]. According to a research from South Africa[18], SpO2 was demonstrated as an independently significant predictor of outcome in severe traumatic brain injury as well. Other studies[3, 14] also confirmed that SpO2 had significant value of predicting mortality of trauma patients.

Such results show discordance regarding performance of SpO2 and indicate that it is necessary to propose further researches to investigate the physiological component in survival probability prediction for trauma patients. Furthermore, it is important in evaluating predictor valuables of early mortality in trauma patients, especially during emergency department. This study found that SpO2 is significantly associated with the mortality of trauma patients in ED, which is consistent with previous research results[3, 14, 16-18]. We also discovered that variables including MAP, RTS and HER were independent prognostic factors for death in emergency trauma patients.

According to subgroup analysis, the lower SpO2, the higher mortality even if adjusting sex and age. This finding suggested that trauma patients with pulse hypoxia in ED deserved close attention. It is convenient to measure the level of SpO2, hereby rapid triage of trauma patients and subsequently perform intervention therapy in ED.

As far as we know, this study was the first hospital registry-based research with large sample size (1720 patients) which revealed the relationship between SpO2 and early mortality of trauma patients in ED. The complete clinical data enabled us to study the effect of SpO2 on mortality, which has not yet being well-explored in ED.

However, this study was conducted in a single-center, therefore our results may not be generalizable to the broader population of trauma patients, which may have biased our results. Moreover, it is required to carry out further subgroup studies by trauma classification in the future.

**Conclusions**

SpO2 is clearly associated with disparate outcomes following trauma. It could be applicable to both prompt triage and prognosis evaluation of trauma patients in ED. With trauma morbidity occurring at unprecedented speed and scale in China, more attention show be paid to trauma patients particularly with low SpO2, and clinical interventions that could be effective in improving SpO2 are required to reduce mortality of trauma in ED.
Abbreviations

pulse oxygen saturation, SpO2; area under the curve, AUC; emergency department, ED; mean arterial pressure, MAP; pulse rate, P; respiratory rate, RR; revised trauma score, RTS; hours in emergency room, HER; inter quartile range, IQR; confidence intervals, CIs; Injury Severity Score, ISS; the Trauma and Injury Severity Score, TRISS; the Revised Trauma Score, RTS; the Mechanism, Glasgow coma scale, Age, and Arterial Pressure, MGAP; the Glasgow Coma Scale, Age, and Systolic Blood Pressure, GAP; the New Trauma Score, NTS.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committees of the First Affiliated Hospital of Soochow University (Approval Number: 2021-231). Personal informed consent was not required due to the retrospective nature of the data.

Consent for publication

Not applicable.

Availability of data and materials

All data are included in the manuscript and Supporting Information files.

Competing interests

The authors declare that they have no competing interests.

Funding

The authors received no specific funding for this study.

Authors’ contributions

XF and CD proposed the conception, designed the work and analyzed data. GC drafted the work and substantively revised it. All authors have approved the submitted version and agreed both to be personally accountable for the author’s own contributions and to ensure that questions related to the accuracy or integrity of any part of the work.

Acknowledgements

Not applicable.
References

1. GBD 2017 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018, 392:1859–1922.

2. Benjet C, Bromet E, Karam EG, Kessler RC, McLaughlin KA, Ruscio AM, et al. The epidemiology of traumatic event exposure worldwide: results from the World Mental Health Survey Consortium. Psychol Med. 2016, 46:327–343.

3. Jin WYY, Jeong JH, Kim DH, Kim TY, Kang C, Lee SH, et al. Factors predicting the early mortality of trauma patients. Ulus Travma Acil Cerrahi Derg. 2018, 24:532–538.

4. Domingues CA, Coimbra R, Poggetti RS, Nogueira LS, de Sousa RMC. New Trauma and Injury Severity Score (TRISS) adjustments for survival prediction. World J Emerg Surg. 2018, 13:12.

5. Raux M, Thicoïpé M, Wiel E, Rancurel E, Savary D, David JS, et al. Comparison of respiratory rate and peripheral oxygen saturation to assess severity in trauma patients. Intensive Care Med. 2006, 32:405–412.

6. Lovett PB, Buchwald JM, Stürmann K, Bijur P. The vexatious vital: neither clinical measurements by nurses nor an electronic monitor provides accurate measurements of respiratory rate in triage. Ann Emerg Med. 2005, 45:68–76.

7. Philip KE, Pack E, Cambiano V, Rollmann H, Weil S, O’Beirne J. The accuracy of respiratory rate assessment by doctors in a London teaching hospital: a cross-sectional study. J Clin Monit Comput. 2015, 29:455–460.

8. Mower WR, Sachs C, Nicklin EL, Safa P, Baraff LJ. A comparison of pulse oximetry and respiratory rate in patient screening. Respir Med. 1996, 90:593–599.

9. Baker SP, O’Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma. 1974, 14:187–196.

10. Boyd CR, Tolson MA, Copes WS. Evaluating trauma care: the TRISS method. Trauma Score and the Injury Severity Score. J Trauma. 1987, 27:370–378.

11. Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the Trauma Score. J Trauma. 1989, 29:623–629.

12. Sartorius D, Le Manach Y, David JS, Rancurel E, Smail N, Thicoïpé M, et al. Mechanism, glasgow coma scale, age, and arterial pressure (MGAP): a new simple prehospital triage score to predict mortality in trauma patients. Crit Care Med. 2010, 38:831–837.

13. Kondo Y, Abe T, Kohshi K, Tokuda Y, Cook EF, Kukita I. Revised trauma scoring system to predict in-hospital mortality in the emergency department: Glasgow Coma Scale, Age, and Systolic Blood Pressure score. Crit Care. 2011, 15:R191.

14. Jeong JH, Park YJ, Kim DH, Kim TY, Kang C, Lee SH, et al. The new trauma score (NTS): a modification of the revised trauma score for better trauma mortality prediction. BMC Surg. 2017,
17:77.
15. Domingues Cde A, Nogueira Lde S, Settervall CH, Sousa RM. Performance of Trauma and Injury Severity Score (TRISS) adjustments: an integrative review. Rev Esc Enferm USP. 2015, 49:138–146.
16. Filipescu R, Powers C, Yu H, Yu J, Rothstein DH, Harmon CM, et al. Improving the performance of the Revised Trauma Score using Shock Index, Peripheral Oxygen Saturation, and Temperature-a National Trauma Database study 2011 to 2015. Surgery. 2020, 167:821–828.
17. Woodford MR, Mackenzie CF, DuBose J, Hu P, Kufera J, Hu EZ, et al. Continuously recorded oxygen saturation and heart rate during prehospital transport outperform initial measurement in prediction of mortality after trauma. J Trauma Acute Care Surg. 2012, 72:1006–1011.
18. Sobuwa S, Hartzenberg HB, Geduld H, Uys C. Predicting outcome in severe traumatic brain injury using a simple prognostic model. S Afr Med J. 2014, 104:492–494.

**Figures**

![Figure 1](image-url)

*Figure 1*

Area under ROC curve = 0.7852
Receiver operating characteristic curve