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

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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

Variables	Survival 1677(97.50)	Non-survival 43(2.50)	P value
Sex			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_2 (%)	98(3)	84(94)	<0.001
RTS	12(0)	8(6)	<0.001
HER (hour)	4(13)	14(33)	0.001

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_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 SpO2 and mortality in Table 2. Both univariable and multivariable Cox regression analyses indicated that the trauma mortality was closely associated with the level of SpO2. The crude HR and 95% CI of each subgroup 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. Compared to the baseline reference, the risk of death in the other subgroups increased gradually as SpO2 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)

Table 2 Cox regression analyses

SpO_2 (%)	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.

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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.

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Figures

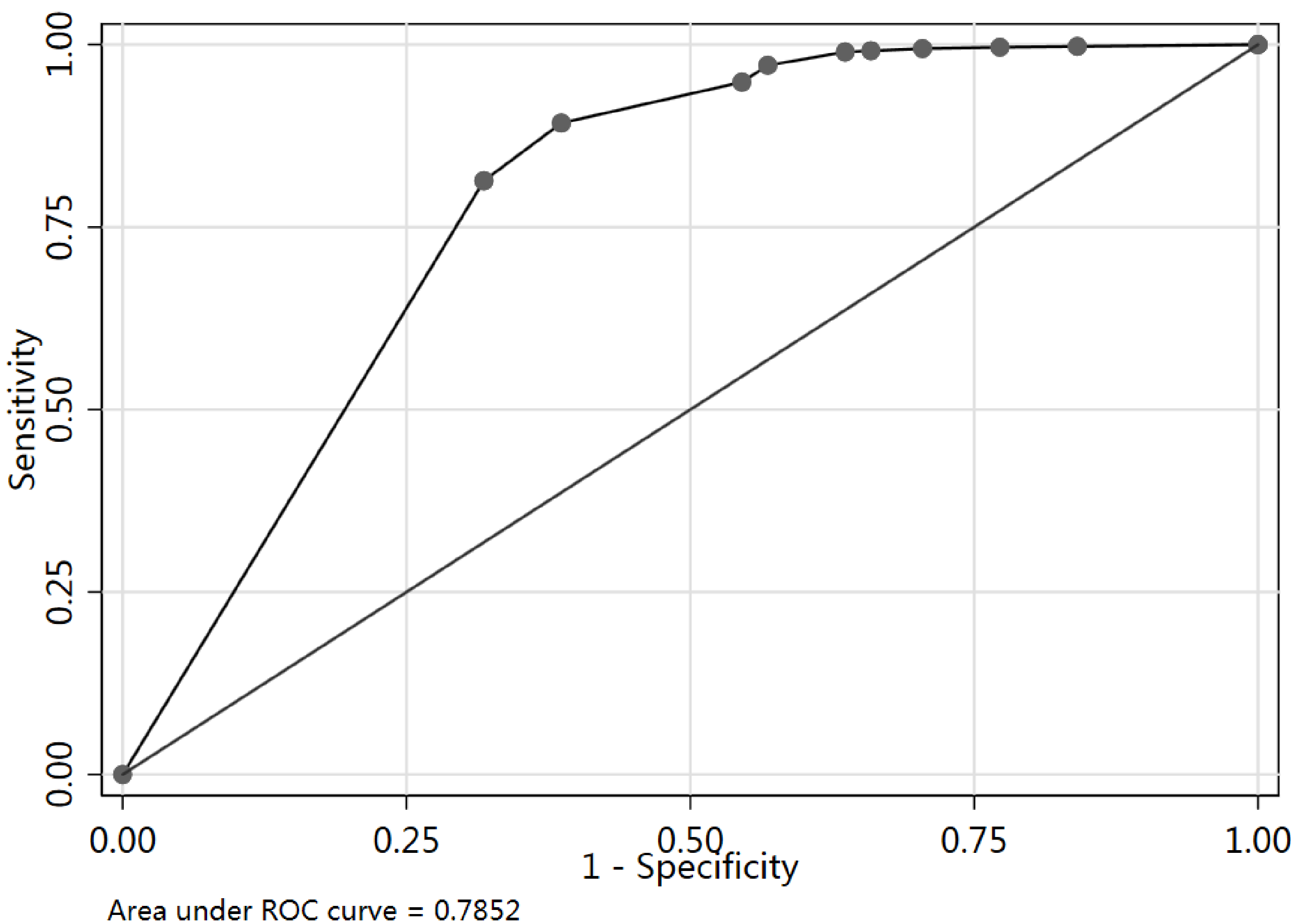

Figure 1

Receiver operating characteristic curve