Original research

The relationship of hemodynamic parameters with 6-month mortality in trauma patients; a prospective cohort study

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Abstract:

Background: Although the relationship between cardiovascular and respiratory parameters and mortality in trauma patients has been reported in studies, the findings have been contradictory in many cases. Therefore, the present study aimed to evaluate the relationship of systolic and diastolic blood pressures, heart and respiratory rates, arterial oxygen saturation and shock index with 6-month mortality of trauma patients.

Methods: In a prospective cohort study, vital signs of the trauma patients presenting to emergency department were evaluated on admission. The patients were followed for 6 months and mortalities were recorded. Finally, using stepwise multivariate logistic regression test and reporting odds ratio (OR) with 95% confidence interval (CI) and multilevel, random intercept logistic regression models, the relationship between the evaluated factors and probability of death was assessed.

Results: Data of 3158 patients with the mean age of 31.47±16.37 years (73.65% male) were evaluated. Apart from heart rate, the relationship of all the factors with probability of death was non-linear. The slope of mortality risk remained relatively constant with increase in heart rate, which means that with increase in heart rate, the probability of death also increased linearly ($R2=0.98$; $p<0.0001$). Probability of death in trauma patients is very low in respiratory rates less than 14; however, in higher rates, the probability rises significantly ($R2=0.95$; $p<0.0001$). In addition, regarding arterial oxygen saturation level, probability of death is low in saturation levels over 90% but increases significantly when it is under 90% ($R2=0.94$; $p<0.0001$). Rise of the shock index to rates higher than 1 also increases the probability of death significantly ($R2=0.93$; $p<0.000$). When diastolic blood pressure is in the 70-90 mmHg range, probability of death is very low but it significantly rises in pressures less than this ($R2=0.97$; $p<0.0001$). A similar pattern exists regarding systolic blood pressure, which indicates a low probability of death when systolic blood pressure is over 100 mmHg, yet the probability of death increases significantly when the pressure is lower than that ($R2=0.93$; $p<0.0001$).

Conclusion: Findings of the present study showed that apart from heart rate, other evaluated factors had an s-shape correlation with mortality in trauma patients. In other words, with little change in any of these factors, mortality risk of trauma patients can rise significantly. Therefore, continuous monitoring of blood pressure, heart rate, respiratory rate, and arterial oxygen saturation level in emergency departments is of great importance.

Keyword: Trauma Severity Indices; Prognosis; Physiological Parameters

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1. Introduction

Physiological evaluation of trauma patients has been considered by physicians and medical teams from a long time ago. These parameters have been used for classifying patients and identifying high risk patients. Assessment of blood pressure, heart rate, respiratory rate, body temperature, arterial oxygen saturation (SpO_2) level and other factors are all basic evaluations for trauma patients (1-7). Based on the existing guidelines, a cut-off point has been reported for each of these factors and physicians identify high risk patients based on them. However, in recent years some studies have expressed that first, some of these factors are not significantly related to the outcome of trauma patients and second, the existing cut-off points are not that accurate. For example, Fuller et al. express that the risk of mortality is 1.5 times higher in patients with systolic blood pressure less than 120 mmHg, 2 times higher in those with a blood pressure less than 100 mmHg and 6 times higher in blood pressure less than 70 mmHg (8). On the other hand, Cooke et al. express that arterial blood pressure and SpO_2 are not related to mortality in trauma patients [9]. Therefore it seems that although the relationship of cardiovascular and respiratory factors with mortality of trauma patients has been reported in previous studies, the results are contradicting in many cases (5, 8-13). Therefore, the present study aimed to evaluate the relationship of systolic and diastolic blood pressures, heart and respiratory rates, SpO_2 and shock index with 6-month mortality in trauma patients.

2. Method

2.1. Study design and setting

The present study is a cohort one with 6 months follow up in which the relationship of systolic and diastolic blood pressures, heart and respiratory rates, arterial oxygen saturation and shock index with mortality of trauma patients was evaluated from May to November 2016 in 4 educational hospitals throughout Tehran province, Iran. Data were gathered prospectively on admission by an emergency medicine specialist using convenience sampling. Protocol of the present study was approved by the ethics committee of Tehran University of Medical Sciences. Throughout the course of the study, the researchers adhered to the principles introduced in the Declaration of Helsinki. It should be noted that the patients or their relative signed the informed consent form before participation in the study.

2.2. Study participants

In this study, trauma patients 16-90 years old presenting to emergency department (ED) of the studied centers were included. Exclusion criteria consisted of death of the patient before admission to ED and not giving consent for participation. To determine the sample size, taking the 5.2% prevalence of mortality in trauma patients into account (14), and considering 95% confidence interval (CI) (α=0.05), 90% power (β=0.1) and maximum error of 1.5% (d=0.01) in estimation of mortality prevalence, the minimum required sample size was calculated to be 189 patients.

2.3. Data gathering

Before the initiation of the main study, a 1-day workshop was held for familiarizing the researchers with data gathering. After training, data gathering forms were given to the researchers and they were asked to gather data on age, sex, trauma mechanism, trauma severity based on injury severity score (ISS), level of consciousness based on Glasgow coma scale (GCS), and vital signs including heart rate, respiratory rate, systolic blood pressure, diastolic blood pressure, and SpO_2. Evaluation of blood pressure was done using a mercury manometer with a cuff for adults from the right hand in supine position. SpO_2 was also recorded via a pulse oximeter connected to the index finger of the right hand.

2.4. Studied outcomes

The patients were followed for 6 months and their living status (dead or alive) was evaluated by phone.

2.5. Statistical analyses

Data were analyzed using STATA 14.0 statistical software. The patients were divided into 2 groups of dead and alive based on their final outcome. Quantitative data were reported as mean and standard deviation (SD) and qualitative factors were shown as frequency and percentage. The relationship between the studied factors and outcome of trauma patients was evaluated using independent t-test and chi square. Each of the significant factors in these univariate tests were then entered to a stepwise multivariate logistic regression model to determine the independent factors affecting mortality of trauma patients. In this model, odds ratio (OR) was reported with 95% CI.

In this analysis, level of systolic blood pressure was divided into 3 groups: normal (blood pressure 100-140 mmHg), hypotension (blood pressure < 100 mmHg),

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and hypertension (blood pressure > 140 mmHg). Diastolic blood pressure was also divided into 3 groups: normal (60-90 mmHg), hypotension (< 60 mmHg), and hypertension (> 90 mmHg). Heart rate groups were also normal (60-100 pulses), bradycardia (< 60 pulses), tachycardia (> 100 pulses) and respiratory rate groups were normal (12-20 breaths per minute), thachypnea (> 20 breaths per minute) and bradypnea (< 12 breaths per minute). SpO_2 less than 95% was also considered as abnormal. Shock index was calculated based on dividing heart rate to systolic blood pressure and values higher than 1 were considered as abnormal.
Since based on previous studies the relationship between some vital signs and mortality of trauma patients is non-linear (8), to evaluate this subject correlation curves were drawn between probability of death and the assessed factors using multilevel, random intercept logistic regression models. In this model, mortality of the patients was entered as the dependent variable and systolic and diastolic blood pressures, heart and respiratory rates, SpO_2 and shock index were entered as exposure variables and finally, R-squared, adjusted regression coefficient was reported.

3. Result

Over the course of the study, data of 3158 patients with the mean age of 31.47±16.37 years (73.65% male) were evaluated. The most important mechanism of trauma was car accident (31.51%). Univariate analysis showed that all the studied factors including age (p=0.008), sex (p<0.0001), trauma mechanism (p<0.0001), GCS score (p<0.0001), heart rate (p<0.0001), systolic blood pressure (p<0.0001), diastolic blood pressure (p<0.0001), respiratory rate (p<0.0001), SpO_2 (p<0.0001), shock index (p<0.0001) and trauma severity (p<0.0001) significantly correlated with patient mortality (Table 1).
Multivariate logistic regression analysis showed that among the significant factors in univariate tests, decrease of SpO_2 to less than 95% (OR=8.24; p<0.0001), systolic blood pressure to less than 100 mmHg (OR=11.80; p<0.0001), diastolic blood pressure to less than 60 mmHg (OR=2.58; p<0.0001), and respiratory rate to less than 12 times per minute (OR=1.45; p=0.04) increases the odds of death in trauma patients. On the other hand, increase of heart rate to more than 100 per minute (OR=1.49; p<0.0001), diastolic blood pressure to more than 90 mmHg (OR=2.78; p=0.01), respiratory rate to more than 20 per minute (OR=2.15; p<0.0001), and shock index to more than 1 (OR=2.38; p<0.0001) are associated with increase in the odds of death in patients (Table 2).
As can be seen, it seems that the relationship between some of the evaluated factors and probability of death in trauma patients is not linear. Therefore, using multilevel, random intercept logistic regression models, curves of correlation between probability of death and these factors were drawn. As can be seen, apart from heart rate, the relationship between all the factors with probability of death was non-linear. However, the correlation was very strong. The slope of mortality risk remained relatively constant with increase in heart rate, which means that with increase in heart rate, the probability of death also increases linearly (R^2=0.98;

Table 1: Demographic and at admission characteristics of trauma patients

Variable*	Alive (n=2599)	Dead (n=559)	Total (n=3158)	P
Age (year)	31.11±16.20	33.15±17.05	31.47±16.37	0.008
Male sex	1978 (76.11)	348 (62.25)	2326 (73.65)	<0.0001
Mechanism of trauma				
Motorcycle accident	326 (12.56)	61 (10.91)	387 (12.27)	<0.0001
Car accident	767 (29.55)	227 (40.61)	994 (31.51)	
Pedestrian	1006 (38.75)	179 (32.02)	1185 (37.56)	
Fall from > 1.5 meters	96 (3.70)	49 (8.77)	145 (4.60)	
Fall from < 1.5 meter	254 (9.78)	39 (6.98)	293 (9.29)	
Other	147 (5.66)	4 (0.72)	151 (4.79)	
GCS	14.88±0.80	13.45±2.65	14.63±1.44	<0.0001
HR (beat/min)	96.84±15.16	100.93±14.59	97.56±15.14	<0.0001
SBP (mmHg)	115.41±12.27	101.38±19.94	112.92±14.93	<0.0001
DBP (mmHg)	75.85±8.29	65.91±15.32	74.10±10.60	<0.0001
RR (rate/min)	13.57±1.71	16.27±2.79	14.05±2.20	<0.0001
Spo2 (%)	97.67±1.36	95.17±3.28	97.22±2.08	<0.0001
Shock index	0.85±0.17	1.04±0.28	0.88±0.21	<0.0001
ISS	9.76±6.93	25.72±13.06	10.24±7.69	<0.0001

*, data are presented as mean±SD or n (%). DBP: diastolic blood pressure; GCS: Glasgow coma scale; HR: heart rate; ISS: injury severity score; RR: respiratory rate; SBP: systolic blood pressure; Spo2: oxygen saturation.

Table 1: Multivariate analysis for assessment of relationship between vital signs on admission and 6-month mortality of trauma patients

Variable	Odds Ratio	95% CI	P*
HR<60 beat/min	1.49	1.23 to 1.89	<0.0001
Spo2<95%	8.24	5.87 to 11.56	<0.0001
SBP<100 mmHg	11.80	7.17 to 19.14	<0.0001
DBP<60 mmHg	2.58	1.96 to 3.40	<0.0001
DBP>90 mmHg	2.78	1.31 to 5.90	0.01
Shock index >1	2.38	1.80 to 3.16	<0.0001
RR<12 rate/min	1.45	1.02 to 2.06	0.04
RR>20 rate/min	2.15	1.46 to 3.15	<0.0001

*, adjusted for age, sex, mechanism of trauma, level of conciseness and injury severity score. CI: confidence interval; HR: heart rate; Spo2: oxygen saturation; SBP: systolic blood pressure; DBP: diastolic blood pressure, RR: respiratory rate.

p<0.0001). Although probability of death in trauma patients is very low in respiratory rates less than 14, in higher rates, the probability rises significantly and reaches a plateau in about 24 breaths (R^2=0.95; p<0.0001). Additionally, regarding SpO_2 level, probability of death is low in saturation levels over 90% but increases significantly when it is under 90% (R^2=0.94; p<0.0001). Rise of the shock index to rates higher than 1 also increases the probability of death significantly (R^2=0.93; p<0.000). The relationship between mortality and systolic and diastolic blood pressures was also non-linear. In other words, when diastolic blood pressure is in the 70-90 mmHg range, probability of death is very low but it significantly rises in pressures less than this (R^2=0.97; p<0.0001). A similar pattern exists regarding systolic blood pressure, which indicates a low probability of death when systolic blood pressure is over 100 mmHg, yet the probability of death increases significantly when the pressure is lower than that (R^2=0.93; p<0.0001) (Figure 1).

4. Discussion

Findings of the present study showed that blood pressure, heart rate, respiratory rate, SpO_2, and shock index have a significant correlation with mortality of trauma patients. This emphasizes the importance of paying more attention to initial evaluations and physiological parameters in trauma patients. Apart from heart rate, other factors had an S-shape correlation with mortality of trauma patients. In other words, with little change in any of these factors, mortality risk of trauma patients can rise significantly. Therefore, continuous monitoring of blood pressure, heart rate, respiratory rate, and SpO_2 level in EDs is of great importance.

In line with the present study, Fuller et al. showed that there is a U-shape correlation between systolic blood pressure and probability of death in patients with traumatic brain injuries. These researchers expressed that the risk of death in patients is 3 times higher in systolic blood pressures less than 90 mmHg and 6 times higher in pressures less than 70 mmHg (8). The current study also showed that systolic blood pressure less than 100 mmHg increases the odds of mortality about 12 times. Other studies also show that there is a significant correlation between systolic blood pressure and mortality of trauma patients (10-12). These findings emphasize the need for change in cut-off point of systolic blood pressure for monitoring patients in trauma settings. Currently, based on the existing guidelines, drop in blood pressure to less than 90 mmHg is indicative of the patient being high risk. However, it seems that patients should also be monitored in higher cut-off points.

The present study showed that in addition to systolic blood pressure, other cardiovascular and respiratory factors including diastolic blood pressure, heart rate, SpO_2, and respiratory rate also have a significant correlation with mortality of trauma patients. These findings are also in line with other studies to some extent. For example, Cooke et al. expressed that heart rate variability can be a predictive factor of mortality in trauma patients (9). In other studies also similar findings can be observed (5, 13). However, the existing contradictions reveal the need for further studies in this field.

One of the most important findings of the current study is the non-linear correlation of blood pressure, respiratory rate, SpO_2, and shock index with mortality of the patients. This S-shape correlation indicates that with little change in any of these factors, mortality risk of trauma patients can rise significantly. Therefore in future studies, first a reliable cut-off point should be determined for each of these factors and second, the guidelines should emphasize paying more attention to vital signs.

4.1. Limitations

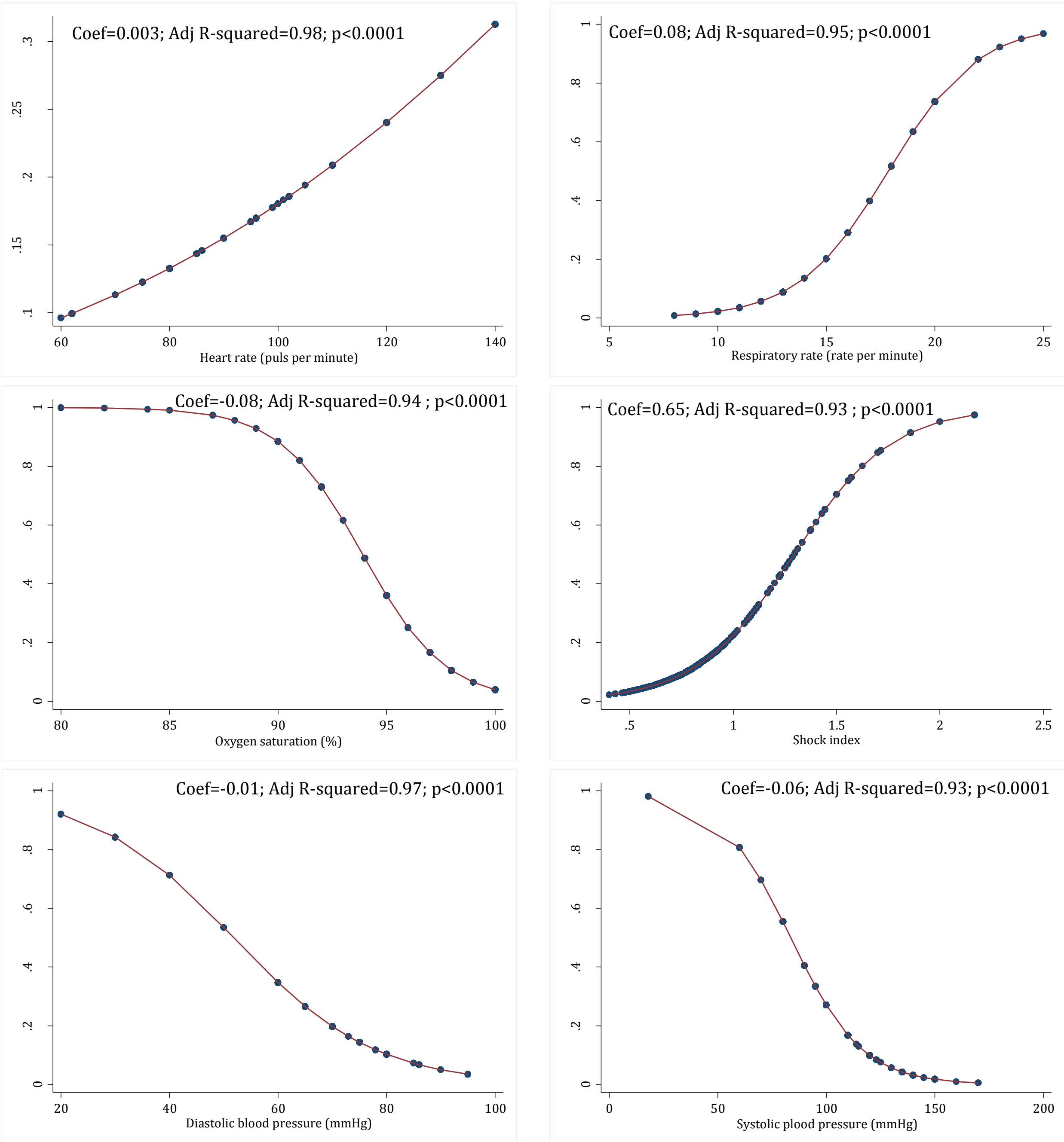

Figure 1: Figure 1: Non-linear correlation of heart rate, respiratory rate, oxygen saturation; shock index, diastolic blood pressure, and systolic blood pressure with probability of death in studied patients. Coef: regression coefficient; Adj R-squared: adjusted R-squared.

The most important limitation of the present study was possible presence of residual confounding from the factors not studied. However, in this study, effort was made to minimize this problem by evaluation of ISS and entering it to the analyses. Among other limitations of this study was convenience sampling that may lead to selection bias. Another limitation of the study was not evaluating comorbidities and coagulopathies in the final model; because the answers given to these questions by the patient or the relatives were not that accurate.

5. Conclusion:

Findings of the present study showed that blood pressure, heart rate, respiratory rate, SpO_2, and shock index have a significant correlation with mortality of trauma patients. This emphasizes the importance of paying more attention to initial evaluations and physiological parameters in trauma patients. Apart from heart rate, other factors had an S-shape correlation with mortality of trauma patients. In other words, with little change in any of these factors, mortality risk of trauma patients can rise significantly. Therefore, continuous monitoring of blood pressure, heart rate, respiratory rate, and SpO_2 level in EDs is of great importance.

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7. Conflict of interest

No conflict of interest was declared.

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None.

9. Author contribution

Conception and design of the work: MY, BN, and MH; data gathering: BA, MY, and SS; data analysis: MH; drafting the work: MH, and SS; critically revised the manuscript: All authors. All authors approved final version of the paper to be published and agreed to be accountable for all aspects of the work.

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