Original Article

Diagnostic value of intravenous oxygen saturation compared with arterial and venous base excess to predict hemorrhagic shock in multiple trauma patients

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Abstract

Introduction: In this study, with the help of peripheral vein sampling, Spvo2, and peripheral artery and vein sampling, we examined base excess (BE) in trauma patients and determined its diagnostic value for hemorrhagic shock. **Methods:** In this cross-sectional study, from 64 patients with abdominal, pelvic and chest Blunt trauma who have a score of 2 or higher trauma during treatment, blood samples were taken from peripheral vein to measure oxygen saturation and peripheral vein and artery for BE measurements and were compared in order to assess their diagnostic value in predicting the occurrence of hemorrhagic shock. **Results:** Out of 60 examined patients, 43 (71.67%) patients were diagnosed with hemorrhagic shock. The correlation for the percentage of oxygen saturation of the peripheral blood and the rate of arterial and venous BE for these $r^{2\ \text{patient}}$s were 17.0 and 09.0, respectively, with a *P* value greater than 0.005. In the case of the percentage of oxygen saturation of the peripheral blood, the sensitivity and specificity were 93.03 and 11.76%, respectively. The positive and negative likelihood ratios were 1.05 and 0.59, respectively. The positive and negative predictive values were 72.73 and 40%, respectively. **Conclusion:** In general, the results of this study showed that arterial and venous excess base levels had a proper correlation, specificity and sensitivity for diagnosing and predicting hemorrhagic shock, while the percentage of oxygen saturation of peripheral blood and BE arterial and venous levels had not proper correlation to detect and predict hemorrhagic shock.

Keywords: Arterial and venous excess base, hemorrhagic shock, oxygen saturation percentage of peripheral blood

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Introduction

Trauma is one of the most important causes of mortality and morbidity in the world, which imposes exorbitant costs on the treatment system.[1] One of the most common causes of mortality and morbidity in patients with multiple trauma is hemorrhagic shock, as bleeding reduces blood flow to tissues and tissue

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hypoxia and can lead to organ failure.[2,3] Death caused by bleeding is a major problem worldwide, with more than 60,000 deaths per year in the United States and approximately 1.9 million deaths per year worldwide, 1.5 million of which is due to trauma.[4–7] In addition, those who survive the initial hemorrhagic shock have poor performance and dramatical increase in long-term mortality.

Early detection of hemorrhagic shock and prompt action to stop bleeding is life-saving because the average time from onset to death is 2 h. Controlling the source of bleeding and restoring the patient's intravascular volume and oxygen carrying capacity should be done quickly to limit the severity and duration of the shock.[8] The signs and symptoms of hemorrhagic shock, especially from hidden sources of bleeding, are often mild. In most patients, strong compensatory mechanisms prevent the reduction of blood pressure or other symptoms of shock until the patient's blood volume is lost by more than 30%.[9] Diagnosing a hidden shock or a completely untreated shock is an important clinical problem and may indicate a hidden shock with its normal hemodynamics.

Serum factors that are available to diagnose shock, monitor resuscitation and can provide valuable information about general perfusion and oxygen delivery in patients with trauma include serum lactate and basal deficiency, which provide useful information about the anaerobic metabolism rate. Also, another method is to use oxygen saturation of the superior vena cava (ScvO2), which helps to study oxygen transfer and oxygen consumption and cardiac output.[10,11] Recent studies have shown that changes in Scvo2 and lactate, which accurately indicate the relationship between supply and demand for oxygen, reflect blood flow disorders during tissue hypoxia. On the other hand, the percentage of oxygen saturation of Spvo2 peripheral vein with Scvo2 has a strong correlation and specificity of more than 95%.[12] Therefore, due to the ease of access to blood, the peripheral vein is a better choice for measurement than the central vein. Finally, arterial base excess (BE) appears as an important indicator in the assessment of resuscitation as well as the prognosis of trauma patients.[13,14] However, intravenous blood is easily the first step in trauma management when venous access is established. Therefore, the use of intravenous BE as a symptom is under review. It also prevents the inherent dangers of performing an arterial sampling. In addition, it has been suggested that intravenous BE indicates better tissue perfusion and therefore predicts the severity of shock and mortality.[15]

In this study, using a sample of peripheral vein Spvo2 and BE, and sampling of peripheral arterial, BE was examined in trauma patients and its diagnostic value for hemorrhagic shock was measured.

Materials and Methods

The community under study

All patients of Shahid Madani Hospital in Karaj (Iran) in the age group of 18–60 years in 2018 have multiple trauma criteria that due to blunt trauma of the chest, abdomen and pelvis during the first 24 hours of hospitalization required surgical intervention. Also, they had trauma score of 3 or higher. It should be noted that in order to enter the study, it must have been possible to sample the peripheral vein and check the oxygen saturation of the peripheral vein.

Measurement

During treatment, a blood sample was taken from the peripheral vein to measure oxygen saturation, also peripheral artery and peripheral vein to measure the patient's excess base to assess their diagnostic value in predicting the occurrence of hemorrhagic shock. Finally, the results were collected and statistically analyzed. The BE was less than 2 mA/L and the peripheral oxygen saturation was less than 92% positive.

Statistical analysis

We analyze the data obtained by version 24 of SPSS software and Student's *t*-test and ANOVA statistical methods. If more statistical tests were needed, Kai Score and T-pair tests were used, and *P* value was considered smaller than 5%. The results were presented as a mean and standard range. The ethical code is: IR.ABZUMS.REC.1398.023.

Results

Demographic information

Of the 64 patients who entered the study, 60 were statistically analyzed. A total of four people dropped out of the study, two due to dissatisfaction with the study and two due to lack of follow-up and loss in the course of the study. Of the 60 patients examined, 43 (67.71%) were diagnosed with hemorrhagic shock. Demographic information of patients is shown in Table 1.

The percentage of oxygen saturation and base excess of peripheral blood and the correlation between them in all patients

The mean arterial BE in these patients was -4.03, while the mean venous BE in these patients was -3.92. Regarding the percentage of oxygen saturation of peripheral blood, an average of 72.88% was obtained. The frequency of arterial and venous BE as well as the percentage of oxygen saturation of peripheral blood is shown in Figure 1.

The correlation rate for arterial and venous BE for all patients was 0.16 ($0.01 < P$ value <0.05). This rate was 0.05 and 0.46 for the percentage of peripheral blood oxygen saturation

Table 1: Demographic information of patients

Variable	Patients (60 person)
Average age (Years)	36.14
Sexuality (male/female)	21/39
Marital status	
Single	32
Married	28

and the amount of arterial and venous BE for these patients, respectively (*P* values > 0.05).

The percentage of oxygen saturation and base excess of peripheral blood and the correlation between them in patients with hemorrhagic shock

The mean arterial BE rate for patients with hemorrhagic shock was -4.2, which was significantly different from patients without hemorrhagic shock (*P* value = 0.001). On the other hand, the mean intravenous BE of patients with hemorrhagic shock was -4.07, which was significantly different from patients without hemorrhagic shock (*P* value = 0.01). The mean percentage of peripheral blood oxygen saturation in the hemorrhagic shock group was 69.8%, which was not significantly different from patients without hemorrhagic shock (*P* value = 0.11). However, the correlation rate for arterial and venous BE for patients with hemorrhagic shock was 0.76 with a *P* value less than 0.001. The correlation for the percentage of oxygen saturation of the peripheral blood and the rate of arterial and venous BE for these patients were 0.17 and 0.09, respectively, with a larger *P* value of 0.05.

Diagnostic value of arterial and venous base excess

In the case of arterial BE, the sensitivity and specificity were 77.69 and 82.58%, respectively. The positive and negative likelihood ratios were 1.69 and 0.51, respectively. The positive and negative predictive values were 81.08 and 41.48%, respectively. In the case of venous BE, the sensitivity and specificity were 65.00 and 56.67%, respectively. The positive and negative likelihood ratios were 1.50 and 0.62, respectively. The positive and negative predictive values were 60.00 and 61.82%, respectively.

Diagnostic value of oxygen saturation of peripheral blood

In the case of the percentage of oxygen saturation of the peripheral blood, the sensitivity and specificity were 93.03 and 11.76%, respectively. The positive and negative likelihood ratios were 1.05 and 0.59, respectively. The positive and negative predictive values were 72.73 and 40.00%, respectively.

Discussion

Rapid diagnosis of hidden hemorrhagic shock due to bleeding in patients with trauma could help improve patient's outcomes.[16] Several recent studies have questioned the usefulness of vital signs in helping a physician determine the presence of shock.[17,18] Current researches have focused on the use of biomarkers to

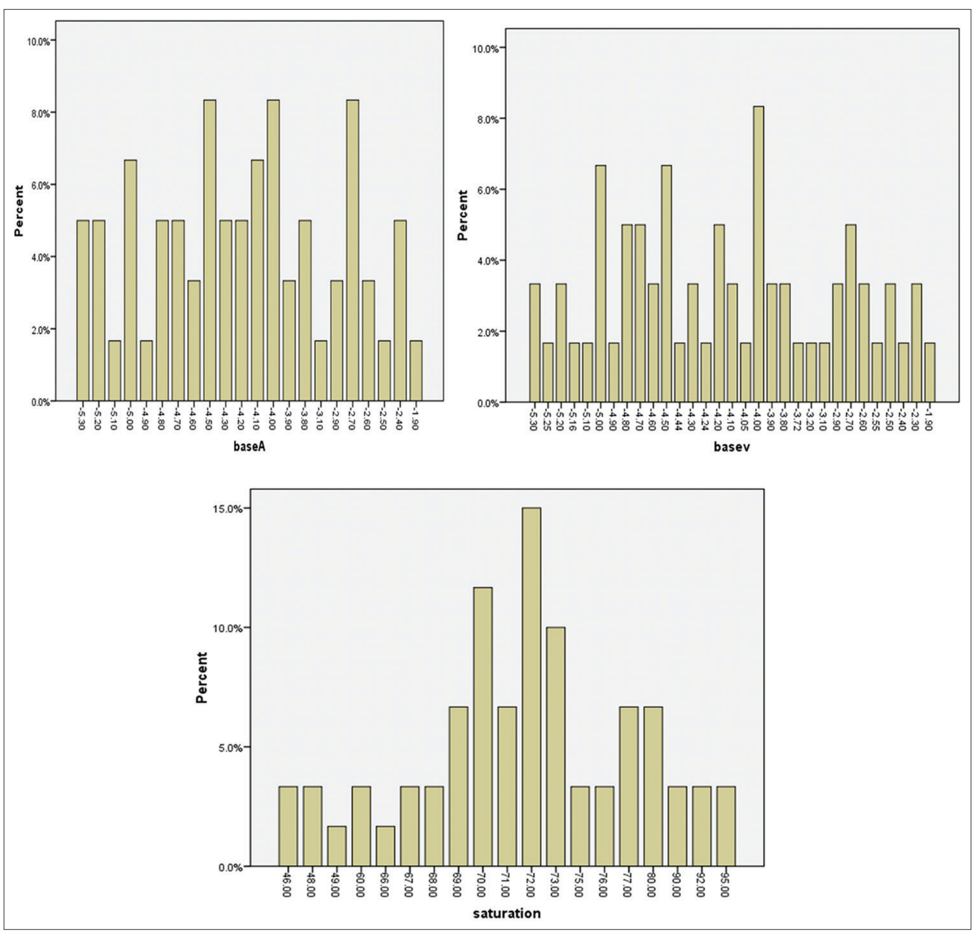

Figure 1: The frequency of arterial base excess (above left), venous base excess (above right) and the percentage of oxygen saturation of peripheral blood (bottom)

determine tissue hypoperfusion and the need for intervention to help improve outcomes. Numerous studies have shown that the use of these biomarkers such as serum lactate and BE in prehospital, hospital, emergency and ICU settings may improve survival and predict mortality.[19–21] In 2016, in a prospective study of 394 traumatic patients, Wijaya *et al*.[22] examined whether venous BE could replace arterial BE to predict shock and observed that there is no statistical difference between venous and arterial blood gas averages in time of referring. In some studies, collected data suggest venous BE could replace arterial BE in trauma patients as a means for identifying and predicting the occurrence of primary shock.[22] Another factor that has been studied in studies is the percentage of oxygen saturation in the blood.[23]

We know that the initial optimization of shock hemodynamics includes optimization of cardiac preload (reflecting the internal pressure of the central vein (CVP) or alternative), after loading (moderate arterial pressure) and contraction (cardiac output/heart rate).[24] The oxygen delivery threshold (when systemic oxygen delivery (DO2) meets consumer needs) is confirmed by the normalization of central venous oxygen saturation (ScvO2) or intravenous oxygen saturation (SvO2).[25] Saturation of peripheral venous oxygen (SpvO2) is a negative measurement of peripheral venous blood oxygen saturation and may be easily hospitalized and outpatient. By that logic, ED doctors may want to use SpvO2 or environmental lactate to manage their patients. There is information about the agreement between ScvO2 and SpvO2.[26,27] However, there is no full agreement on this yet. The results of the present study showed that the percentage of peripheral blood saturation does not have a suitable correlation for detecting hemorrhagic shock and predicting this condition. Another study also found that SpvO2 and ScvO2 have a moderate agreement and cannot be used as a reliable alternative for another in resuscitation, which is consistent with the results of this study. The limitations of this study could be noted in these cases; first, the study was performed cross-sectionally, while longitudinal studies could expand vision in determining patients' prognosis using study markers. Second, studying with a larger sample size could increase the reliability of the results. Third, measuring other markers, such as lactate, can provide additional information to determine the hemorrhagic shock. Finally, further studies are needed to investigate the correlation and specificity of peripheral and central blood lactate, BE, anion gap and the percentage of oxygen saturation of peripheral and central blood, while there is very limited available data for determining suitable biomarkers to diagnose hidden hemorrhagic shock.

As a result, arterial and venous BEs have a fine correlation, specificity and sensitivity to diagnose and predict hemorrhagic shock, and since intravenous blood sampling is a more noninvasive procedure, venous BE levels could be considered as a suitable option for diagnosing hemorrhagic shock. On the other hand, the percentage of oxygen saturation of the peripheral blood is not adequately correlated with arterial and venous BE levels and does not have acceptable results for the diagnosis and prognosis of hemorrhagic shock.

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Conflicts of interest

There are no conflicts of interest.

References

1. Hofman K, Primack A, Keusch G, Hrynkow S. Addressing the growing burden of trauma and injury in low-and middle-income countries. Am J Public Health 2005;95:13-7.
2. Radwan MM, Abu-Zidan FM. Focussed Assessment Sonograph Trauma (FAST) and CT scan in blunt abdominal trauma: Surgeon's perspective. Afr Health Sci 2006;6:187-90.
3. Heyn J, Ladurner R, Ozimek A, Bürklein D, Huber-Wagner S, Hallfeldt K, *et al*. Diagnosis and pre-operative management of multiple injured patients with explorative laparotomy because of blunt abdominal trauma. Eur J Med Res 2008;13:517-24.
4. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, *et al*. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380:2095-128.
5. Ruseckaite R, McQuilten Z, Oldroyd J, Richter T, Cameron P, Isbister J, *et al*. Descriptive characteristics and in-hospital mortality of critically bleeding patients requiring massive transfusion: Results from the Australian and New Zealand Massive Transfusion Registry. Vox Sang 2017;112:240-8.
6. Halmin M, Chiesa F, Vasan SK, Wikman A, Norda R, Rostgaard K, *et al*. Epidemiology of massive transfusion: A binational study from Sweden and Denmark. Crit Care Med 2016;44:468-77.
7. Hunt BJ. Bleeding and coagulopathies in critical care. N Engl J Med 2014;370:847-59.
8. Tisherman SA, Alam HB, Rhee PM, Scalea TM, Drabek T, Forsythe RM, *et al*. Development of the emergency preservation and resuscitation for cardiac arrest from trauma clinical trial. J Trauma Acute Care Surg 2017;83:803-9.
9. Bulger EM, May S, Kerby JD, Emerson S, Stiell IG, Schreiber MA, *et al*. Out-of-hospital hypertonic resuscitation after traumatic hypovolemic shock: A randomized, placebo controlled trial. Ann Surg 2011;253:431-41.
10. Bouglé A, Harrois A, Duranteau J. Resuscitative strategies in traumatic hemorrhagic shock. Ann Intensive Care 2013;3:1.
11. Cohn SM, Nathens AB, Moore FA, Rhee P, Puyana JC, Moore EE, *et al*. Tissue oxygen saturation predicts the development of organ dysfunction during traumatic shock resuscitation. J Trauma Acute Care Surg 2007;62:44-55; discussion 54-5.
12. Epstein CD, Haghenbeck KT. Bedside assessment of tissue oxygen saturation monitoring in critically ill adults: An integrative review of the literature. Crit Care Res Pract 2014;2014:709683.
13. Kincaid EH, Miller PR, Meredith JW, Rahman N, Chang MC. Elevated arterial base deficit in trauma patients: A marker of impaired oxygen utilization. J Am Coll Surg 1998;187:384-92.
14. Husain FA, Martin MJ, Mullenix PS, Steele SR, Elliott DC.

Serum lactate and base deficit as predictors of mortality and morbidity. Am J Surg 2003;185:485-91.

15. Oropello JM, Manasia A, Hannon E, Leibowitz A, Benjamin E. Continuous fiberoptic arterial and venous blood gas monitoring in hemorrhagic shock. Chest 1996;109:1049-55.
16. Newgard CD, Schmicker RH, Hedges JR, Trickett JP, Davis DP, Bulger EM, *et al*. Emergency medical services intervals and survival in trauma: Assessment of the "golden hour" in a North American prospective cohort. Ann Emerg Med 2010;55:235-46.e4.
17. Guly H, Bouamra O, Little R, Dark P, Coats T, Driscoll P, *et al*. Testing the validity of the ATLS classification of hypovolaemic shock. Resuscitation 2010;81:1142-7.
18. Guly H, Bouamra O, Spiers M, Dark P, Coats T, Lecky F. Vital signs and estimated blood loss in patients with major trauma: Testing the validity of the ATLS classification of hypovolaemic shock. Resuscitation 2011;82:556-9.
19. Callaway DW, Shapiro NI, Donnino MW, Baker C, Rosen CL. Serum lactate and base deficit as predictors of mortality in normotensive elderly blunt trauma patients. J Trauma Acute Care Surg 2009;66:1040-4.
20. Davis JW, Kaups KL, Parks SN. Base deficit is superior to pH in evaluating clearance of acidosis after traumatic shock. J Trauma Acute Care Surg 1998;44:114-8.
21. Moomey CB, Melton SM, Croce MA, Fabian TC, Proctor KG. Prognostic value of blood lactate, base deficit, and oxygen-derived variables in an LD50 model of penetrating trauma. Crit Care Med 1999;27:154-61.
22. Wijaya R, Ng JH, Ong L, Wong ASY. Can venous base excess replace arterial base excess as a marker of early shock and a predictor of survival in trauma? Singapore Med J 2016;57:73-6.
23. Mizock BA, Falk JL. Lactic acidosis in critical illness. Crit Care Med 1992;20:80-93.
24. Rivers E, Nguyen B, Havstad S, Ressler J, Muzzin A, Knoblich B, *et al*. Early goal-directed therapy in the treatment of severe sepsis and septic shock. N Engl J Med 2001;345:1368-77.
25. Kasnitz P, Druger GL, Yorra F, Simmons DH. Mixed venous oxygen tension and hyperlactatemia: Survival in severe cardiopulmonary disease. JAMA 1976;236:570-4.
26. Piyavechviratana K, Tangpradubkiet W. Study of the correlation between central venous oxygen saturation and venous saturation from the antecubital vein in severe sepsis/septic shock patients. Crit Care 2012;16:P255.
27. Madsen P, Olesen H, Klokker M, Secher N. Peripheral venous oxygen saturation during head-up tilt induced hypovolaemic shock in humans. Scand J Clin Lab Invest 1993;53:411-6.