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Correlation of Blood Gas Parameters with Central Venous Pressure in Patients with Septic Shock; a Pilot Study

Alireza Baratloo[1], Farhad Rahmati[1], Alaleh Rouhipour[2], Maryam Motamedi[1], Elmira Gheytanchi[3], Fariba Amini[4], Saeed Safari[1]*

[1]Department of Emergency Medicine, Shohadaye Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Department of Pediatrics, Valeeasr Hospital, Ghazvin University of Medical Sciences, Abyek, Iran
[3]Oncopathology Research Center, Iran University of Medical Sciences, Tehran, Iran
[4]Department of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

***Corresponding author:** Saeed Safari*
Address: Department of Emergency Medicine, Shohadaye Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Tel: +98-912-8251535, Fax: +98-21-22721155
e-mail: safari266@yahoo.com

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ABSTRACT

Objective: To determine the correlation between blood gas parameters and central venous pressure (CVP) in patients suffering from septic shock.
Methods: Forty adult patients with diagnosis of septic shock who were admitted to the emergency department (ED) of Shohadaye Tajrish Hospital affiliated with Shahid Beheshti University of Medical Sciences, and met inclusion and exclusion criteria were enrolled. For all patients, sampling was done for venous blood gas analysis, serum sodium and chlorine levels. At the time of sampling; blood pressure, pulse rate and CVP were recorded. Correlation between blood gas parameters and hemodynamic indices were.
Results: A significant direct correlation between CVP with anion gap (AG) and inversely with base deficit (BD) and bicarbonate. CVP also showed a relative correlation with pH, whereas it was not correlated with BD/AG ratio and serum chlorine level. There was no significant association between CVP and clinical parameters including shock index (SI) and mean arterial pressure (MAP).
Conclusion: It seems that some of non invasive blood gas parameters could be served as alternative to invasive measures such as CVP in treatment planning of patients referred to an ED with septic shock.

Keywords: Septic shock; Central venous pressure; Noninvasive monitoring.

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Introduction

The early recognition and management of shock is one of the most important clinical aspects of critical care in an emergency department (ED). The management and prognosis of shock certainly depends on rapid identification and also careful assessment corresponding with treatment of the underlying cause. The initial evaluation of patients with possible hypoperfusion are guided by some clinical and paraclinical factors. It has been reported that early stage of hypoperfusion is insufficient to make changes in vital signs in previously healthy individuals; however, quantifying the hypoperfusion

degree remains a challenging task [1]. Assessment of the possibility to replace invasive parameters with less invasive paraclinic variables and some clinical ones for the discrimination of shock has been tried in recent years. The evaluation and therapy is commonly guided by shock index (SI), base deficit (BD), lactate clearance, anion gap (AG), pH, bicarbonate and also saturation of central venous oxygen ($ScvO_2$). Improved understanding of the correlation between these variables and central venous pressure (CVP) may also reveal new strategies for assessment of septic shock in patients who need critical care at arrival to an emergency department (ED) [1-4]. The SI is normally 0.5 to 0.7 and has been almost likely be elevated in the setting of acute hypovolemia. Reviewing previous studies showed that abnormal BD can be an indicator for the increased transfusion requirement and also is related to higher incidence of shock-related complications, intensive care unit (ICU), in-hospital lengths of stay and increased mortality. Furthermore, it was suggested as an indicator and monitoring parameter for the success of resuscitation efforts [5-8]. Other studies showed that early therapy directed to relieve tissue hypoxia and repay oxygen improves clinical outcome in shock irrespective of its etiology. Mixed venous oxygen saturation obtained from pulmonary artery (SvO_2) and central venous oxygen saturation ($ScvO_2$) were shown to reflect the balance of systemic oxygen delivery (supply) to consumption (demand) [5,7-9]. Also, there are literature reviews that discussed the use of adjuncts such as blood lactate level in the initial assessment that may increase the ability to accurately recognize patients with occult hypoperfusion or early shock secondary to hemorrhage [9-11]. Base on the above mentioned, this study aimed to assess the correlation between venous blood gas parameters and CVP in the setting of septic shock, trying to develop a non invasive method for quantifying the hypoperfusion degree.

Materials and Methods

Study Design and Setting

This study was conducted from September to November 2013 in ED of Shohadaye Tajrish Hospital affiliated with Shahid Beheshti University of Medical Sciences, a major referral hospital in Tehran, Iran. The principles of the Declaration of Helsinki were applied throughout the study. The study protocol was approved by institutional review board (IRB) and ethics committee of Shahid Beheshti University of Medical Sciences. All the participants provided their informed written consents before inclusion in the study.

Participants

Forty adult patients (Age>18 years) with diagnosis of septic shock who were admitted to ED were included, regardless of sepsis source. Septic shock was defined as systemic inflammatory response syndrome (SIRS) along with evidence of infection, including positive blood culture, signs of pneumonia on chest x-ray, or other radiologic or laboratory evidence of infection; signs of end-organ dysfunction are required such as renal failure, liver dysfunction, changes in mental status, or elevated serum lactate; refractory hypotension (low blood pressure that does not respond to treatment). SIRS was also defined as presence of 2 out of these 4 criteria: tachypnea (>20 breaths per minute), or on blood gas, a PCO_2 less than 32 mmHg signifying hyperventilation; leukopenia (<4000 cells/mm^3) or leukocytosis (>12000 cells/mm^3); tachycardia (>90 beats per minute); Fever (>38.0°C) or hypothermia (<36.0°C). Each patient that had at least four criteria of six, as mentioned below was enrolled as candidate for central venous catheterization: Ill appearance or altered mental status, heart rate >100 beats/minute, respiratory rate >20 breaths/minute or $PaCO_2$ <32 mmHg, base deficit <–4 mEq/Liter or lactate >4 mmol/Liter, urine output <0.5 mL/kg/hour, and arterial hypotension more than 30 minutes continuous duration. Exclusion criteria were defined as CVP catheterization contraindication, ΔCVP more than 4 cmH_2O with impression of obstructive shock.

Data Collection

After diagnosis of circulatory shock, a central venous catheter was inserted by emergency physicians. For all these patients, venous blood sampling was requested for gas analysis, sodium (Na) and chlorine (Cl) levels. At the time of sampling, non-invasive blood pressure, pulse rate and also CVP were recorded.

Statistical Analysis

The collected data were analyzed using the SPSS statistical software package (Version 21, SPSS Inc, Chicago, IL, USA). Correlation coefficient (r) was calculated with Pearson's correlation test to analyze the significance of relation between CVP with blood gas, Cl, mean arterial pressure (MAP), and SI. A *p*-value of <0.05 was considered to be statistically significant.

Results

A total of 40 patients who were diagnosed with septic shock included 15 (37.5%) females and 25 (62.5%) males, ranging in age from 34 to 94 (mean age=70.45±16.0) years were enrolled. The mean SI was 1.16±0.4 and ranged from 0.23 to 2.2 (normal range=0.5-0.7). Pearson's correlation tests showed a direct correlation between CVP and AG (r=0.388, *p*=0.013,) (Figure 1) and inverse relation with HCO_3 (r=-0.465, *p*=0.002,) and BE (r=-0.391, *p*=0.013,) (Figure 2 and 3). Association between CVP and paraclinical and clinical parameters in patients were summarized in Table 1.

Discussion

The results of the present study showed indirect

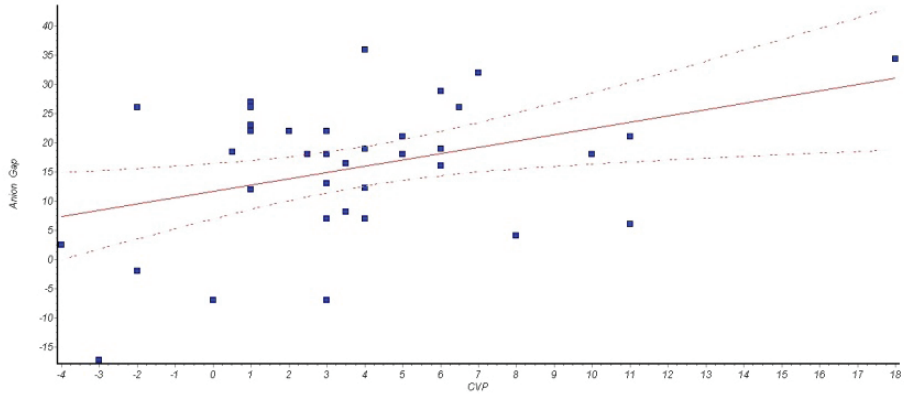

Fig. 1. Central venous pressure–Anion Gap correlation in patients with septic shock.

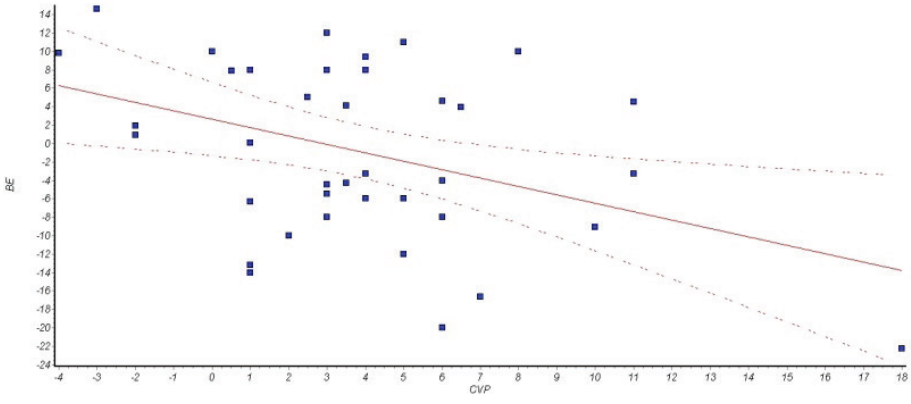

Fig. 2. Central venous pressure–base deficit correlation in patients with septic shock.

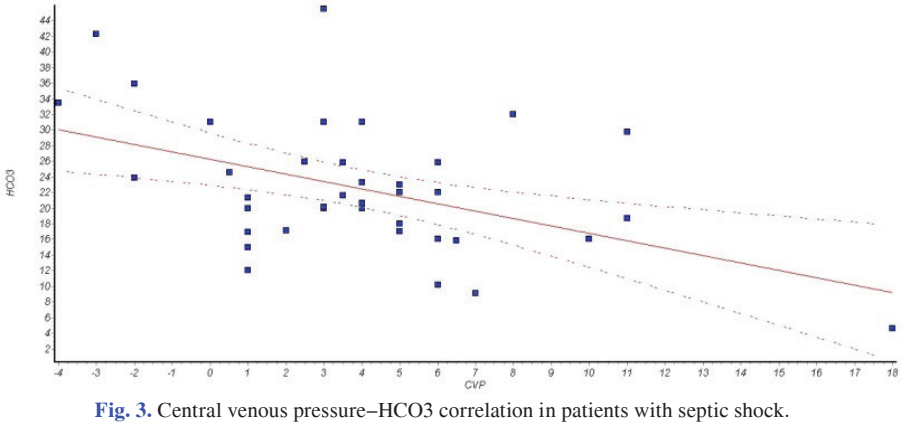

Fig. 3. Central venous pressure–HCO3 correlation in patients with septic shock.

Table 1. Central venous pressure and paraclinical and clinical parameters association in patients with septic shock

	AG	BD	BD[b]/AG[c]	pH	HCO_3[d]	Cl[e]	MAP[f]	SI[g]
Correlation Coefficient	0.388[a]	-0.391[a]	-0.139	-0.273	-0.465[a]	-0.177	-0.041	-0.095
***P*-value**	0.013	0.013	0.391	0.088	0.002	0.300	0.804	0.561

[a] Significant correlation; [b]BD: Base Deficit; [c]AG: Anion Gap; [d]HCO_3: Bicarbonate; [e]Cl: Cholaride; [f]MAP: Mean Arterial Pressure; [g]SI: Shock Index

correlation between BE and HCO3, and direct correlation between anion gap with CVP in the setting of septic shock. However, there was not any significant correlation between CVP and other studied parameters. There are few reports regarding the assessment of relation among the physiologic and blood gas variables in treatment of septic shock. The increased rate of SI was observed in 94% of patients even after normalization of heart rate (HR), MAP and CVP. There are several evidences regarding the morbidity or mortality after normalization of physiologic variables including MAP, CVP and HR, so it seems that these physiologic variables cannot serve as consistent indexes in shock state [12-14]. It has been reported that SI could be served as adjunct monitoring tools in identifying systemic oxygenation, cardiac function,

hypoperfusion during initial therapy of shock [15]. In contrast to, the closely relation of base deficit with SI has been observed in several studies and it has also been suggested as predicting factor in multi organ damage death and hemorrhage [16-19]. In our study, we found a good correlation between CVP and blood gas variables. Our results were consistent with the findings of Kaplan study in traumatic patients [2,20]. This suggests that non-invasive monitoring and prompt intervention are necessary to identify and control of shock using several paraclinical factors such as AG, BD, pH and HCO3. In a study recently performed by Drakhshanfar *et al*., [5] among Iranian pediatric patients, BD caused by metabolic acidosis was introduced as a predicting factor in blunt abdominal trauma. As we mentioned, there are still some controversies regarding the correlation between SI, pH and MAP with CVP in the current study. The prospective and retrospective studies should be required to validate and expand these findings. We proposed that these indices can be tightly linked to septic shock patients and can be applied in a routine clinical practice for rapid critical treatment.

Currently there is no consensus on the accurate markers of hemodynamic instability in hypovolemia and septic shock. There is also controversy regarding the endpoints for optimal fluid therapy in hypovolemic or septic shock [21,22]. However recent lines of evidence suggest that fluid therapy should be based on dynamic (such as cardiac output, pulse pressure variation and stroke volume variation) rather than static hemodynamic variables (such as CVP, pulmonary artery occlusion pressure). This is because the dynamic markers are better predictors of fluid resuscitation especially in critically ill patients [23,24]. In the same way several studies have revealed the role of O_2 saturation monitoring in predicting the outcome of patients with septic shock [25,26]. It has been observed that septic patients have lower O_2 saturation values when compared to healthy individuals or less severe septic patients [25]. In a study by Georger *et al*. [27] it was shown that O_2 saturation can be increased by administration of norepinephrine in septic shock patients. In these patients the O_2 saturation has been shown to be correlated with MAP [28]. Taking all these findings together it can be postulated that O_2 saturation is an indicator of both endothelial function [29] and regional tissue perfusion pressure; the latter is affected by MAP. Capillary recruitment secondary to local vasodilatation, as well as perfusion pressure of the tissue bed is effective factors in reoxygenation of the tissue in response to an ischemic challenge especially in septic shock. Thus reoxygenation happens in the interaction between the macrohemodynamics (perfusion pressure) and microcirculation (endothelial function). The present lines of evidence suggest that there is a correlation between the O_2 saturation slope and the prognosis [30]. Taking all these together, it could be concluded that the oxygenation of the tissues in septic shock determined by O_2 saturation is a valuable indicator and predictor of response to therapy [27]. However the fact that improvement of O_2 saturation may alleviate the prognosis of patients with septic shock remains the matter of debate.

We note some limitations to our study. We measured the baseline blood gas parameters in septic shock patients and we did not follow that changes of these variables. We also did not correlate these parameters with patients' clinic and outcome. The main limitation of the study is the lack of power to analyze mortality prediction. As we have not measured the blood gas parameters in different stages of the shock, we cannot comment on their role and correlation with the clinical entity. Future studies with continuous measurement of blood gas parameters and correlation with clinical parameters is recommended.

Another potential limitation derives from the fact that VOT-derived variables were obtained once

In conclusion, it seems that some of non-invasive blood gas parameters could be served as alternative to invasive measures such as CVP in treatment planning of patients referred to an ED with septic shock.

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Conflict of Interest: None declared.

References

1. Birkhahn RH, Gaeta TJ, Terry D, Bove JJ, Tloczkowski J. Shock index in diagnosing early acute hypovolemia. *Am J Emerg Med*. 2005;**23**(3):323-6.
2. Kaplan LJ, Kellum JA. Initial pH, base deficit, lactate, anion gap, strong ion difference, and strong ion gap predict outcome from major vascular injury. *Crit Care Med*. 2004;**32**(5):1120-4.
3. Mutschler M, Nienaber U, Brockamp T, Wafaisade A, Fabian T, Paffrath T, et al. Renaissance of base deficit for the initial assessment of trauma patients: a base deficit-based classification for hypovolemic shock developed on data from 16,305 patients derived from the TraumaRegister DGU(R). *Crit Care*. 2013;**17**(2):R42.
4. Mutschler M, Nienaber U, Munzberg M, Wolfl C, Schoechl H, Paffrath T, et al. The Shock Index revisited - a fast guide to transfusion requirement? A retrospective analysis on 21,853 patients derived from the TraumaRegister DGU(R). *Crit Care*. 2013;**17**(4):R172.
5. Drakhshanfar H, Rafsanjani MS, Shojaee M, Reza H. Accuracy of base deficit in diagnosis of intra-abdominal injury in pediatrics with

blunt abdominal trauma. *Blood Transfusion*. 2013;**8**:6.3.

6. Rixen D, Raum M, Bouillon B, Lefering R, Neugebauer E. Base deficit development and its prognostic significance in posttrauma critical illness: an analysis by the trauma registry of the Deutsche Gesellschaft fur unfallchirurgie. *Shock*. 2001;**15**(2):83-9.

7. Rixen D, Siegel JH. Metabolic correlates of oxygen debt predict posttrauma early acute respiratory distress syndrome and the related cytokine response. *J Trauma*. 2000;**49**(3):392-403.

8. Rixen D, Siegel JH. Bench-to-bedside review: oxygen debt and its metabolic correlates as quantifiers of the severity of hemorrhagic and post-traumatic shock. *Crit Care*. 2005;**9**(5):441-53.

9. Paladino L, Sinert R, Wallace D, Anderson T, Yadav K, Zehtabchi S. The utility of base deficit and arterial lactate in differentiating major from minor injury in trauma patients with normal vital signs. *Resuscitation*. 2008;**77**(3):363-8.

10. Eastridge BJ, Salinas J, McManus JG, Blackburn L, Bugler EM, Cooke WH, et al. Hypotension begins at 110 mm Hg: redefining "hypotension" with data. *J Trauma*. 2007;**63**(2):291-7; discussion 7-9.

11. Jansen TC, van Bommel J, Mulder PG, Rommes JH, Schieveld SJ, Bakker J. The prognostic value of blood lactate levels relative to that of vital signs in the pre-hospital setting: a pilot study. *Crit Care*. 2008;**12**(6):R160.

12. Rady MY, Rivers EP, Martin GB, Smithline H, Appelton T, Nowak RM. Continuous central venous oximetry and shock index in the emergency department: use in the evaluation of clinical shock. *Am J Emerg Med*. 1992;**10**(6):538-41.

13. Baek SM, Makabali GG, Bryan-Brown CW, Kusek JM, Shoemaker WC. Plasma expansion in surgical patients with high central venous pressure (CVP); the relationship of blood volume to hematocrit, CVP, pulmonary wedge pressure, and cardiorespiratory changes. *Surgery*. 1975;**78**(3):304-15.

14. Shoemaker WC, Appel PL, Bland R, Hopkins JA, Chang P. Clinical trial of an algorithm for outcome prediction in acute circulatory failure. *Crit Care Med*. 1982;**10**(6):390-7.

15. Bland RD, Shoemaker WC, Abraham E, Cobo JC. Hemodynamic and oxygen transport patterns in surviving and nonsurviving postoperative patients. *Crit Care Med*. 1985;**13**(2):85-90.

16. Bilello JF, Davis JW, Lemaster D, Townsend RN, Parks SN, Sue LP, et al. Prehospital hypotension in blunt trauma: identifying the "crump factor". *J Trauma*. 2011;**70**(5):1038-42.

17. Jung J, Eo E, Ahn K, Noh H, Cheon Y. Initial base deficit as predictors for mortality and transfusion requirement in the severe pediatric trauma except brain injury. *Pediatr Emerg Care*. 2009;**25**(9):579-81.

18. Verbeek DO, Zijlstra IA, van der Leij C, Ponsen KJ, van Delden OM, Goslings JC. Management of pelvic ring fracture patients with a pelvic "blush" on early computed tomography. *J Trauma Acute Care Surg*. 2014;**76**(2):374-9.

19. Vandromme MJ, Griffin RL, Kerby JD, McGwin G, Jr., Rue LW, 3rd, Weinberg JA. Identifying risk for massive transfusion in the relatively normotensive patient: utility of the prehospital shock index. *J Trauma*. 2011;**70**(2):384-8; discussion 8-90.

20. Vandromme MJ, Griffin RL, Weinberg JA, Rue LW, 3rd, Kerby JD. Lactate is a better predictor than systolic blood pressure for determining blood requirement and mortality: could prehospital measures improve trauma triage? *J Am Coll Surg*. 2010;**210**(5):861-7, 7-9.

21. Barros JM, do Nascimento P, Jr., Marinello JL, Braz LG, Carvalho LR, Vane LA, et al. The effects of 6% hydroxyethyl starch-hypertonic saline in resuscitation of dogs with hemorrhagic shock. *Anesth Analg*. 2011;**112**(2):395-404.

22. Vallet B. Intravascular volume expansion: which surrogate markers could help the clinician to assess improved tissue perfusion? *Anesth Analg*. 2011;**112**(2):258-9.

23. Michard F, Teboul JL. Predicting fluid responsiveness in ICU patients: a critical analysis of the evidence. *Chest*. 2002;**121**(6):2000-8.

24. Monnet X, Osman D, Ridel C, Lamia B, Richard C, Teboul JL. Predicting volume responsiveness by using the end-expiratory occlusion in mechanically ventilated intensive care unit patients. *Crit Care Med*. 2009;**37**(3):951-6.

25. Creteur J, Carollo T, Soldati G, Buchele G, De Backer D, Vincent JL. The prognostic value of muscle StO2 in septic patients. *Intensive Care Med*. 2007;**33**(9):1549-56

26. Payen D, Luengo C, Heyer L, Resche-Rigon M, Kerever S, Damoisel C, et al. Is thenar tissue hemoglobin oxygen saturation in septic shock related to macrohemodynamic variables and outcome? *Crit Care*. 2009;**13** Suppl 5:S6

27. Georger JF, Hamzaoui O, Chaari A, Maizel J, Richard C, Teboul JL. Restoring arterial pressure with norepinephrine improves muscle tissue oxygenation assessed by near-infrared spectroscopy in severely hypotensive septic patients. *Intensive Care Med*. 2010;**36**(11):1882-9

28. Mesquida J, Gruartmoner G, Martinez ML, Masip J, Sabatier C, Espinal C, et al. Thenar oxygen saturation and invasive oxygen delivery measurements in critically ill patients in early septic shock. *Shock*. 2011;**35**(5):456-9

29. Creteur J. Muscle StO2 in critically ill patients. *Curr Opin Crit Care*. 2008;**14**(3):361-6.

30. Mesquida J, Espinal C, Gruartmoner G, Masip J, Sabatier C, Baigorri F, et al. Prognostic implications of tissue oxygen saturation in human septic shock. *Intensive Care Med*. 2012;**38**(4):592-7.