# Only SIRS Criteria Temperature Correlates With Elevated Oxygen Debt In Critically Ill Patients

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**Citation**

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**Abstract**

Background

Central venous oxygen saturation (ScvO2) is a useful marker of tissue oxygenation in the resuscitation of critically ill patients. Systemic inflammatory response syndrome (SIRS) is frequently present in the critically ill. Other authors have described temperature dysregulation as an early and independent predictor of outcomes in SIRS and have begun using temperature to develop predictive equations for outcomes in SIRS.

Methods

We retrospectively reviewed all critically ill patients consecutively admitted or consulted to the general surgical service of 350-bed urban community hospital over a 6-month period. We included 80 critically ill patients who had venous blood gases performed during admission for analysis and performed one-way analysis of variance (ANOVA) and regression analyses, comparing data sets from patients meeting individual SIRS criteria and patients meeting the criteria for SIRS versus ScvO2.

Results

Only SIRS criteria for temperature significantly correlated with ScvO2. ScvO2 was significantly lower in the presence of temperature dysregulation versus ScvO2 when temperature criteria were not met (66.49 ± 3.69% [95% CI 3.07-5.05] versus 73.23 ± 1.20% [95% CI 1.07-1.36], p=0.032). R-squared value for temperature and ScvO2 was more than 10-times higher than white blood cell count, respiratory rate or heart rate and ScvO2.

Conclusions

Temperature dysregulation significantly correlates with elevated oxygen debt and may be considered with greater concern than other individual SIRS criteria. These data add a new dimension to the study of temperature dysregulation in the critically ill population.

## BACKGROUND

Elevated oxygen debt is associated with increased mortality in critically ill patients.1-3 Since elevated oxygen debt may exist despite the presence of normal hemodynamic parameters, central venous oxygen saturation (ScvO2) has proved a useful marker of tissue oxygenation during the resuscitation of critically ill patients.1

Systemic inflammatory response syndrome (SIRS) is frequently present in the critically ill, and the presence or absence of the syndrome is used for risk-stratification. Studies implicate elevated oxygen debt with increased mortality among critically ill patients with SIRS.4,5 However, there is insufficient literature evaluating the relationship between the individual SIRS criteria (Table 1)

and elevated oxygen debt.

**Table 1**

ScvO2 is lower when SIRS criteria for temperature are met compared to when they are not met.

_____ *66.49 ▯ 3.69% [95% CI 3.07-5.05] ‡73.23 ▯ 1.20% [95% CI 1.07-1.36]

| | p-value | $r^2$ |
|---|---|---|
| WBC count <4,000/µL or >12,000/µL | 0.52 | 0.006 |
| Respiratory rate >20 rpm | 0.18 | 0.011 |
| Heart rate >90 bpm | 0.14 | 0.004 |
| ***Temperature <36 C or >38 C*** | ***0.032*** | ***0.14*** |
| Multiple SIRS criteria | 0.56 | - |

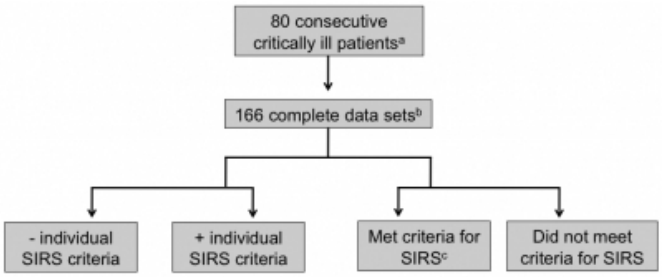
The purpose of this study is to help clarify the relationship of individual SIRS criteria and elevated oxygen debt.

## METHODS

In light of the non-interventional nature of and retrospective analysis performed during our study, the authors obtained institutional review board exemption. All human data were deidentified. We retrospectively reviewed all critically ill patients consecutively admitted or consulted to the general surgical service of 350-bed urban community hospital from July 1, 2011 to January 1, 2012. For analysis, we included all patients (n = 80) who had venous blood gases performed during admission (Figure 1).

**Figure 1**

Individual and multiple SIRS criteria versus ScvO2. Only SIRS criteria temperature correlates with ScvO2. R2 values show correlation of SIRS criteria temperature is at least 10-fold higher than correlation of any other individual SIRS criteria.




One-way analysis of variance (ANOVA) was performed, comparing data sets from patients meeting individual and multiple SIRS criteria with oxygen debt. By convention, elevated oxygen debt was defined as ScvO2<70%. Since tachycardia can be tempered by the presence of beta-blocker therapy and ventilator support can be a surrogate for tachypnea or hypocarbia, categories of heart rate and respirations were further divided into two groups and compared with regard to the presence/absence of beta-blocker therapy and presence/absence of ventilator support, respectively. We also performed regression analyses to determine r-squared values for the individual SIRS criteria and ScvO2.

We used StatPlus software (Mac version 4.8.0; AnalystSoft Inc, Vancouver, British Columbia, Canada) and software available at www.vassarstats.com to perform all statistical analyses. We used a p-value of .05 as a standard cutoff for statistical significance.

## RESULTS

During the study period, 80 critically ill patients had at least one VBG completed during their hospital admission. These patients consisted of primarily postoperative patients but also several patients whose primary illness was medical.

Our institution uses central lines and VBGs liberally during the management of SIRS/sepsis, resulting in a large pool of VBG results, 166 data sets for analysis. All VBGs were confirmed drawn from subclavian or internal jugular veins by reviewing procedure notes and laboratory reports.

Data analysis failed to reveal a significant correlation between oxygen debt and SIRS criteria for white blood cell (WBC) count, heart rate (regardless of presence or absence of beta-blockade), and respiratory rate (regardless of the presence or absence of mechanical ventilation) (all p=NS). Additionally, there was no difference between the ScvO2 data of patients who met multiple criteria for SIRS and those who did not (71.2 ± 1.51% versus 72.5 ± 2.09%, p=NS).

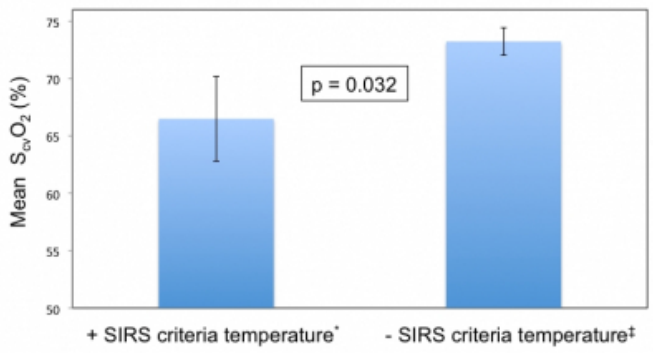
A group of 33 data sets met SIRS criteria for temperature; all of these met multiple criteria for SIRS. A group of 133 data sets did meet SIRS criteria for temperature; 103 of these (77%) met multiple criteria for SIRS. The range of values that met SIRS criteria temperature was 32.9C to 35.9C and 38.0C to 39.7C. The range of ScvO2 values that were associated with SIRS criteria temperature was 10% to 92% compared to a range of 5% to 99% for the remaining data.

Among all data, only SIRS criteria for temperature was significantly correlated with ScvO2 (Table 1); ScvO2 was significantly lower in the presence of temperature dysregulation meeting SIRS criteria versus ScvO2 when the temperature criteria were not met (66.49 ± 3.69% versus

73.23 ± 1.20%, p=0.032) (Figure 2).

**Figure 2**

Study design _____ aAdult critically ill patients consulted to or admitted to a general surgical service at an urban community hospital from July 1, 2011 to January 1, 2012 with at least one venous blood gas completed. bHad complete records from the same hour of a venous blood gas result. cPresence of two or more individual SIRS criteria.




## DISCUSSION

Correction of elevated oxygen debt has been shown to be an important therapeutic endpoint in the resuscitation of critically ill patients.6-9 Oxygen debt is most accurately measured by placement of a pulmonary artery catheter to obtain mixed venous oxygen saturation (SvO2). At our institution, ScvO2 is frequently used to estimate tissue oxygen extraction in lieu of SvO2 as most critically ill patients already have a central venous catheter in place, and measurement of ScvO2 does not require an additional invasive procedure.

SIRS leads to diffuse cytokine release resulting in disruption of homeostatic processes including circulation, cellular metabolism, and thermoregulation and may result in organ hypoperfusion and elevated oxygen debt. We found that hypo- or hyperthermic states are associated with hypoperfusion tied to systemic inflammation while other individual SIRS criteria (WBC, heart rate, respiratory rate) were not. (Table 1, Figure 2).

To our knowledge, ours is the first data to demonstrate a significant correlation between increased oxygen debt and thermal dysregulation meeting the temperature criteria for SIRS. Other authors have analyzed temperature derangements as they relate to SIRS/sepsis, yielding conflicting results about the association of temperature derangements and mortality.10-12 Our data add a clinically-relevant dimension to the discussion of temperature derangements and the treatment of these derangements in the critically ill population; if our findings are accurate, treatment of temperature derangements may be worthwhile.

One recent case-control study determined that even slight derangements of temperature below the threshold of fever can predict the onset of sepsis.13 Even in an increasingly digital environment, simple observations such as vital signs are used to guide triage and treatment; more precise application of temperature data may guide resource utilization. Future research will focus on the development of a predictive equation in order to prospectively analyze the accuracy of temperature as a predictor of elevated oxygen debt among the critically ill; other researchers have begun similar work, particularly among the neonatal population.13-16 If successful, temperature derangement may become a simple, clinically useful tool to estimate the adequacy of tissue oxygenation and guide resuscitative efforts.

According to its accompanying editorial, the Protocolized Care for Early Septic Shock (ProCESS) trial suggested that work on “early recognition of sepsis…and clinical assessment of the adequacy of circulation [are] the elements we should focus on to save lives.”17 The Surviving Sepsis Campaign is awaiting the outcome of other trials and other technologies for measurement of organ dysfunction to alter its recommendations, including its recommended use of ScvO2.18 Our work adds to the refinement of the early recognition of SIRS, allows those with limited medical education some insight, based on temperature dysregulation, that a patient’s circulation may be suboptimal and offers a fresh perspective for the concept of organ malperfusion. Our findings may be beneficial both in the early resuscitation of the critically ill in the emergency department and during ongoing treatment in the intensive care unit.

There are some limitations to our study. The ranges of the ScvO2 data are wide and may be related to variations in laboratory technique. However, the ranges for data sets were similar, suggesting that if laboratory variation was present, it was applied across all data. Because all patients with temperature derangements also had SIRS, SIRS could have been driving the differences in ScvO2. However, we found that meeting multiple criteria for SIRS did not significantly affect ScvO2.

Other unmeasured factors (e.g. number of comorbidities, underlying diagnoses, postoperative versus medical admission) could have influenced our ScvO2 data. However, we believe the narrow and empirical nature of our study

limits the influence of both confounding unmeasured factors and selection bias. Additional data sets from a more broad set of patients could be analyzed to strengthen the power and generalizability of our study.

## CONCLUSIONS

Temperature dysregulation significantly correlates with elevated oxygen debt and may be considered with greater concern than other individual SIRS criteria. These data add a new dimension to the study of temperature dysregulation in the critically ill population.

LIST OF ABBREVIATIONS

ScvO2 – central venous oxygen saturation

SIRS – systemic inflammatory response syndrome

VBG – venous blood gas

ANOVA – one-way analysis of variance

WBC – white blood cell

SvO2 – mixed venous oxygen saturation

ETHICS

GB obtained institutional review board exemption for this study from the Wyckoff Heights Medical Center institutional review board for retrospective analysis. All human data were deidentified.

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