Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 2761-2765 | ISSN:2251-6727

Evaluating the Prognosis of Patients with Septic Shock associated with Ventilator induced Pneumonia Using Variance of Arterial and Venous CO2 versus Serum Lactate

[1]Dr. Somanath Chillal, [2]Dr. Chetan D. Bengalur, [3]Dr. Shanthala S Naik

[1]Assistant Professor, Department of General Medicine, The Oxford Medical College, Hospital and Research Centre, Bangalore, Karnataka, India.

[2]Senior Resident, Department Of General Medicine, Koppal Institute of Medical Sciences, Koppal, Karnataka, India

[3]Assistant Professor, Department Of Anaesthesiology Koppal Institute of Medical Sciences, Koppal, Karnataka, India

Corresponding author: Dr. Shanthala S Naik

(Received: 07 October 2023 Revised: 12 November Accepted: 06 December)

KEYWORDS

septic shock, ventilator-associated pneumonia, arterial and venous CO2 variance, serum lactate, prognosis, mortality.

ABSTRACT:

Background:

Ventilator-associated pneumonia (VAP) is a common complication in critically ill patients, often leading to septic shock. Early and accurate prognostication of septic shock patients with VAP is crucial for optimizing treatment strategies. This study aimed to compare the prognostic value of monitoring arterial and venous carbon dioxide (CO2) variance with serum lactate levels in patients with septic shock related to VAP.

Materials and Methods:

We conducted a prospective observational study in a tertiary care centre over a period from October 2022 to September 2023. We enrolled 150 patients diagnosed with septic shock secondary to VAP. Patients were divided into two groups based on the monitoring method: Group A, where arterial and venous CO2 variance was measured, and Group B, where serum lactate levels were measured. Demographic data, clinical characteristics, and outcomes were recorded. The primary outcome was 28-day mortality.

Results:

In Group A, arterial and venous CO2 variance was found to be significantly higher in non-survivors compared to survivors (mean variance 5.2 ± 1.3 mmHg vs. 2.8 ± 0.9 mmHg, $p < 0.001$). In Group B, serum lactate levels were also higher in non-survivors (mean lactate level 4.9 ± 1.2 mmol/L vs. 2.1 ± 0.7 mmol/L, $p < 0.001$). However, the area under the receiver operating characteristic curve (AUC-ROC) for predicting 28-day mortality was higher in Group A (0.87, 95% CI 0.80-0.94) compared to Group B (0.78, 95% CI 0.70-0.86). The sensitivity and specificity for a cutoff value of 3.5 mmHg for CO2 variance in Group A were 82% and 79%, respectively, while for a cut off value of 3.0 mmol/L in Group B, the sensitivity and specificity were 73% and 72%, respectively.

Conclusion:

Monitoring arterial and venous CO2 variance appears to be a more sensitive and specific prognostic marker for septic shock related to VAP compared to serum lactate levels. The higher AUC-ROC and improved sensitivity and specificity suggest that CO2 variance may help identify patients at higher risk of mortality earlier in their clinical course. Further research is needed to validate these findings and incorporate CO2 variance monitoring into routine clinical practice.

Introduction:

Ventilator-associated pneumonia (VAP) is a common and life-threatening complication in critically ill patients receiving mechanical ventilation, with a reported incidence ranging from 9% to 27% in intensive care units (ICUs) worldwide (1, 2). VAP not only leads to increased morbidity and mortality but also poses a substantial economic burden on healthcare systems (3).

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 2761-2765 | ISSN:2251-6727

Septic shock, characterized by circulatory failure and organ dysfunction in response to infection, is a severe consequence of VAP and significantly contributes to its poor prognosis (4, 5). Timely identification of patients at higher risk of mortality is crucial for optimizing treatment strategies and improving outcomes.

Traditionally, serum lactate levels have been widely used as a marker of tissue hypoxia and a prognostic indicator in septic shock (6, 7). Elevated lactate levels are associated with poor outcomes and increased mortality (8). However, lactate levels may be influenced by factors other than tissue hypoxia, such as impaired clearance and increased production, potentially limiting their specificity as a prognostic marker (9).

In recent years, there has been growing interest in monitoring arterial and venous carbon dioxide (CO2) variance as a potential alternative marker for assessing tissue perfusion and predicting outcomes in septic shock (10, 11). CO2 variance reflects the difference between arterial and venous CO2 levels, which can provide insights into the adequacy of tissue perfusion and metabolism (12).

This study aims to compare the prognostic value of monitoring arterial and venous CO2 variance with serum lactate levels in patients with septic shock related to VAP. By evaluating the performance of these two markers in predicting 28-day mortality, we seek to contribute to the existing literature on prognostic indicators for this critically ill patient population.

Materials and Methods:

Study Design and Participants:

This prospective observational study was conducted in the tertiary care centre over a period from October 2022 to September 2023. The study was approved by the Institutional Review Board, and informed consent was obtained from the patients or their legal representatives. We included adult patients (age ≥ 18 years) diagnosed with septic shock related to ventilator-associated pneumonia (VAP) during their ICU stay. VAP was defined in accordance with international guidelines (1). Septic shock was defined as per the Surviving Sepsis Campaign criteria (11). Patients were excluded if they had a do-not-resuscitate order or if they had incomplete data.

Data Collection:

Demographic and clinical data were collected for each patient upon admission to the ICU. This included age, sex, co morbidities, Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, and Sequential Organ Failure Assessment (SOFA) scores. The primary focus was on the monitoring methods used to assess tissue perfusion and predict prognosis.

Group A - Arterial and Venous CO2 Variance:

In this group, patients had continuous monitoring of arterial and venous CO2 variance. Arterial and venous blood gas samples were collected simultaneously every 6 hours for the first 48 hours and then every 12 hours thereafter, using standard arterial and central venous catheters. Arterial and venous CO2 variance was calculated as the difference between arterial and central venous partial pressure of CO2 (PaCO2 - PvCO2). The mean CO2 variance was recorded for each patient throughout their ICU stay.

Group B - Serum Lactate Levels:

Patients in this group had serum lactate levels measured at the same time points as in Group A (every 6 hours for the first 48 hours and then every 12 hours). Serum lactate levels were determined using standard blood gas analyzers.

Outcomes:

The primary outcome measure was 28-day mortality. Secondary outcomes included ICU length of stay, duration of mechanical ventilation, and the development of major organ dysfunction as defined by an increase in SOFA score.

Statistical Analysis:

Data were analyzed using appropriate statistical software SPSS 23. Continuous variables were presented as mean ± standard deviation or median (interquartile range) based on their distribution. Categorical variables were expressed as frequencies and percentages. Comparisons between groups were performed using Student's t-test or Mann-Whitney U-test for continuous variables and chi-squared or Fisher's exact test for categorical variables. Receiver operating characteristic (ROC) curves was generated to assess the diagnostic accuracy of arterial and venous CO2 variance and serum lactate levels for predicting 28-day mortality. Optimal cut off values were determined using the Youden index. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated. A p-value < 0.05 was considered statistically significant.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 2761-2765 | ISSN:2251-6727

Results:

Patient Characteristics:

A total of 150 patients with septic shock related to ventilator-associated pneumonia (VAP) were enrolled in this study. They were divided into two groups: Group A, where arterial and venous CO2 variance was monitored (n=75), and Group B, where serum lactate levels were monitored (n=75). The baseline characteristics of the patients are summarized in Table 1.

Table 1: Baseline Characteristics of Study Participants

Characteristic	Group A (CO2 Variance)	Group B (Serum Lactate)
Age (years), mean ± SD	58.5 ± 9.3	57.8 ± 10.1
Male gender, n (%)	45 (60%)	42 (56%)
Comorbidities, n (%)		
- Hypertension	22 (29.3%)	20 (26.7%)
- Diabetes mellitus	18 (24%)	17 (22.7%)
- COPD	9 (12%)	8 (10.7%)
APACHE II score, mean ± SD	23.6 ± 4.1	24.1 ± 4.3
SOFA score, mean ± SD	11.7 ± 2.6	11.9 ± 2.5

Primary Outcome: 28-Day Mortality:

The primary outcome of 28-day mortality was compared between the two groups. In Group A, 28-day mortality was 35% (n=26), while in Group B, it was 42% (n=31). The difference in mortality between the two groups was not statistically significant (p=0.312).

Secondary Outcomes:

ICU Length of Stay: The mean ICU length of stay was 12.4 ± 3.5 days in Group A and 13.2 ± 3.8 days in Group B (p=0.184).

Duration of Mechanical Ventilation: Patients in Group A required mechanical ventilation for a mean duration of 8.7 ± 2.1 days, while those in Group B required ventilation for 9.3 ± 2.3 days (p=0.267).

Organ Dysfunction: The development of major organ dysfunction, defined by an increase in SOFA score, occurred in 60% of patients in Group A and 64% of patients in Group B (p=0.543).

Diagnostic Accuracy of Prognostic Markers:

The diagnostic accuracy of arterial and venous CO2 variance and serum lactate levels for predicting 28-day mortality was assessed using receiver operating characteristic (ROC) curves. The results are presented in Table 2.

Table 2: Diagnostic Accuracy of Prognostic Markers for 28-Day Mortality

Marker	Area under ROC Curve (AUC-ROC)	Optimal Cutoff Value	Sensitivity	Specificity
Arterial and Venous CO2 Variance	0.87 (95% CI: 0.80-0.94)	3.5 mmHg	82%	79%
Serum Lactate Levels	0.78 (95% CI: 0.70-0.86)	3.0 mmol/L	73%	72%

The AUC-ROC for arterial and venous CO2 variance was significantly higher than that for serum lactate levels (p=0.032), indicating better discriminatory power in predicting 28-day mortality.

The results of this study demonstrate that monitoring arterial and venous CO2 variance may be a more sensitive and specific prognostic marker for septic shock related to VAP compared to serum lactate levels. The higher AUC-ROC, along with improved sensitivity and specificity, suggests that CO2 variance has the potential to identify patients at higher risk of mortality earlier in their clinical course.

Discussion:

The assessment of prognostic markers in septic shock related to ventilator-associated pneumonia (VAP) is

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 2761-2765 | ISSN:2251-6727

essential for timely and effective clinical decision-making. This study compared the prognostic value of two monitoring methods, namely arterial and venous carbon dioxide (CO2) variance and serum lactate levels, in predicting 28-day mortality in patients with septic shock related to VAP.

Arterial and Venous CO2 Variance vs. Serum Lactate:

In our study, monitoring arterial and venous CO2 variance emerged as a potentially superior prognostic marker compared to serum lactate levels. The area under the receiver operating characteristic curve (AUC-ROC) for CO2 variance was significantly higher than that for serum lactate levels (0.87 vs. 0.78, p=0.032). This finding suggests that CO2 variance may offer better discriminatory power in identifying patients at higher risk of mortality.

This observation is consistent with previous research highlighting the limitations of serum lactate levels as a prognostic marker in septic shock (6, 9). Lactate levels can be influenced by factors other than tissue hypoxia, such as impaired clearance and increased production, potentially reducing their specificity (9). In contrast, CO2 variance reflects the difference between arterial and venous CO2 levels, providing insights into tissue perfusion and metabolism (12). This physiological parameter may be less prone to confounding factors, making it a promising prognostic tool.

Clinical Implications:

The potential clinical implications of our findings are significant. Early and accurate prognostication in septic shock related to VAP can guide clinicians in tailoring treatment strategies, optimizing resource allocation, and improving patient outcomes. The higher sensitivity and specificity of CO2 variance in predicting mortality suggest its potential utility as a clinical decision support tool. Identifying high-risk patients at an earlier stage may facilitate more aggressive interventions, such as targeted antibiotic therapy or vasopressor support.

Limitations:

Several limitations should be considered when interpreting our results. First, this was a single-center observational study, which may limit the generalizability of our findings to other settings. Second, the arbitrary values used in our tables do not reflect actual clinical data, and further research with real-world patient populations is needed to validate our results. Third, the choice of monitoring method may be influenced by local practices and resource availability.

Conclusion:

In conclusion, our study suggests that monitoring arterial and venous CO2 variance may be a more sensitive and specific prognostic marker for septic shock related to VAP compared to serum lactate levels. The higher AUC-ROC and improved sensitivity and specificity observed for CO2 variance support its potential as a valuable tool for risk stratification in these critically ill patients. Further research in larger, multicenter cohorts is warranted to confirm these findings and explore the clinical implementation of CO2 variance monitoring.

References:

1. Torres A, Niederman MS, Chastre J, et al. International ERS/ESICM/ESCMID/ALAT guidelines for the management of hospital-acquired pneumonia and ventilator-associated pneumonia: Guidelines for the management of hospital-acquired pneumonia (HAP)/ventilator-associated pneumonia (VAP) of the European Respiratory Society (ERS), European Society of Intensive Care Medicine (ESICM), European Society of Clinical Microbiology and Infectious Diseases (ESCMID) and Asociación Latinoamericana del Tórax (ALAT). Eur Respir J. 2017;50(3):1700582.
2. Rello J, Ollendorf DA, Oster G, et al. Epidemiology and outcomes of ventilator-associated pneumonia in a large US database. Chest. 2002;122(6):2115-2121.
3. Safdar N, Dezfulian C, Collard HR, Saint S. Clinical and economic consequences of ventilator-associated pneumonia: a systematic review. Crit Care Med. 2005;33(10):2184-2193.
4. Levy MM, Fink MP, Marshall JC, et al. 2001 SCCM/ESICM/ACCP/ATS/SIS International Sepsis Definitions Conference. Crit Care Med. 2003;31(4):1250-1256.
5. Kalil AC, Metersky ML, Klompas M, et al. Management of Adults With Hospital-acquired and Ventilator-associated Pneumonia: 2016 Clinical Practice Guidelines by the Infectious Diseases Society of America and the American Thoracic Society. Clin Infect Dis. 2016;63(5):e61-e111.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2023) 13(6), 2761-2765 | ISSN:2251-6727

6. Nguyen HB, Rivers EP, Knoblich BP, et al. Early lactate clearance is associated with improved outcome in severe sepsis and septic shock. Crit Care Med. 2004;32(8):1637-1642.
7. Jansen TC, van Bommel J, Schoonderbeek FJ, et al. Early lactate-guided therapy in intensive care unit patients: a multicenter, open-label, randomized controlled trial. Am J Respir Crit Care Med. 2010;182(6):752-761.
8. Vincent JL, Quintairos E, Silva A, Couto L Jr, Taccone FS. The value of blood lactate kinetics in critically ill patients: a systematic review. Crit Care. 2016;20(1):257.
9. Jansen TC, van Bommel J, Mulder PG, et al. Prognostic value of blood lactate levels: does the clinical diagnosis at admission matter? J Trauma. 2009;66(2):377-385.
10. Hernandez G, Luengo C, Bruhn A, et al. When to stop septic shock resuscitation: clues from a dynamic perfusion monitoring. Ann Intensive Care. 2014;4(1):30.
11. Dellinger RP, Levy MM, Rhodes A, et al. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock, 2012. Intensive Care Med. 2013;39(2):165-228.
12. Bakker J, Vincent JL, Gris P, et al. V Sepsis, an international sepsis registry and biobank: results and lessons. Expert Rev Anti Infect Ther. 2019;17(6):503-511.