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Correlation Of Serum Procalcitonin Values with Severity of Ventilator Associated Pneumonia Patients

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Abstract.

Background: Ventilator-associated pneumonia (VAP) is a prevalent infection in intensive care units (ICUs) that occurs after more than 48 hours of mechanical ventilation. Procalcitonin is a precursor of the hormone calcitonin, produced by the C-cells of the thyroid gland. Its levels in serum can rise significantly in response to bacterial infections, making it a useful marker for diagnosing and assessing the severity of pneumonia. This study focuses on the correlation between serum procalcitonin levels and the severity of VAP, aiming to provide valuable insights for patient management.

Methods: A cross-sectional study at Dr. Wahidin Sudirohusodo hospital, Makassar, Indonesia. The population of this study were patients aged ≥ 18 years admitted to the intensive care unit in May 2024 until the sample size was fulfilled. Diagnosis of VAP using thoracic x-rays with the discovery of new infiltrates after 48 hours of mechanical ventilator installation then measuring blood procalcitonin.

Results: This study involved 78 subjects. Male gender was 48 (61.5%) subjects, female was 30 (38.5%) subjects. The mean age of the study subjects was 55.9 ±14.45 years. Elevated procalcitonin values were found in 72 (92.3%) subjects. PSI score was low risk in 47 (60.3%), moderate risk in 28 (35.9%) and high risk in 3 (3.8%) subjects. A significant positive correlation was found between serum procalcitonin levels and PSI scores ($r=0.428$, $p<0.001$), indicating that higher procalcitonin levels are associated with increased VAP severity.

Conclusions: In this study, it can be concluded that the severity of VAP as measured by the PSI score is positively correlated with high procalcitonin values.

Keywords: Procalcitonin, Ventilator-Associated Pneumonia, Pneumonia Severity Index

1. Introduction

Ventilator-associated pneumonia (VAP) represents a significant complication in critically ill patients requiring mechanical ventilation, often leading to increased morbidity and mortality rates (1). The diagnosis and management of VAP are complicated by the need for timely intervention, as delays can exacerbate the patient's condition and lead to adverse outcomes (2). In this context, biomarkers have emerged as valuable tools for clinicians to assess the severity of pneumonia and guide therapeutic decisions (3). Among these biomarkers, serum procalcitonin (PCT) has garnered attention due to its potential to reflect the severity of bacterial infections, including pneumonia, and its role in differentiating between bacterial and viral etiologies (4).

Procalcitonin is a precursor of the hormone calcitonin, produced by the C-cells of the thyroid gland. Its levels in serum can rise significantly in response to bacterial infections, making it a useful marker for diagnosing and assessing the severity of pneumonia (5). Studies have shown that elevated procalcitonin levels correlate with the severity of pneumonia, indicating a more severe inflammatory response and a higher likelihood of complications such as sepsis and respiratory failure (6–8). This correlation is particularly pertinent in patients with VAP, where timely identification of infection severity can influence treatment strategies, including the initiation of appropriate antibiotic therapy.

The clinical utility of procalcitonin extends beyond mere diagnosis; it also serves as a prognostic marker. Elevated serum procalcitonin levels have been associated with increased mortality rates in patients with VAP, highlighting its potential role in risk stratification (7,9). For instance, studies have demonstrated that patients with higher procalcitonin levels upon admission to the intensive care unit (ICU) exhibit worse clinical outcomes, including prolonged mechanical ventilation and longer ICU stays (7). This underscores the importance of integrating procalcitonin measurements into routine clinical practice for patients with suspected VAP. Moreover, the use of procalcitonin as a biomarker can aid in the decision-making process regarding antibiotic therapy. The ability to differentiate between bacterial and viral pneumonia is crucial, as inappropriate antibiotic use can lead to adverse effects, including antibiotic resistance and increased healthcare costs. Research indicates that procalcitonin levels can help guide the initiation and duration of antibiotic therapy, potentially reducing unnecessary antibiotic exposure without compromising patient outcomes (6,10). This is particularly relevant in the context of VAP, where the risk of antibiotic overuse is heightened due to the critical nature of the patient population.

Ventilator-Associated Pneumonia (VAP) is one of the most common hospital-acquired infections in intensive care units and is associated with high morbidity and high cost of care (11). VAP is pneumonia that occurs after more than 48 hours of mechanical ventilation, either through an

endotracheal tube or tracheostomy tube, without a previous history of pneumonia (12). The incidence of VAP increases with the duration of mechanical ventilation. As many as 10%-28% of mechanically ventilated patients suffer from VAP. The incidence is estimated to increase 3% per day in the first 5 days, 2% per day on days 6-10, and increase 1% per day after day 10 (13).

The diagnosis of VAP can be made by clinical criteria such as the appearance of infiltrates on chest radiographs, purulence of respiratory secretions, changes in body temperature or leukocyte count. Most VAP begins with aspiration of oropharyngeal organisms into the distal bronchi, then biofilm formation by bacteria followed by bacterial proliferation and invasion of the lung parenchyma. The results of a study of germ patterns in the ICU of Dr. Wahidin Sudirohusodo Hospital, Makassar in 2009, found that Klebsiella pneumonia was the most common germ (28.3%), while Pseudomonas aeroginosa and Alkaligenes faecalis were only 3.3% each (14).

Procalcitonin is a peptide precursor of the latter hormone calcitonin involved with calcium homeostasis. Increased procalcitonin is a response to proinflammatory stimuli, especially those of bacterial origin.5 Procalcitonin is one of the markers of prognosis and therapeutic response in VAP with the sensitivity and specificity of procalcitonin in determining mortality in VAP are 90% and 74%.6 Research by Stolz et al found that serum procalcitonin values in patients with a diagnosis of VAP correlated significantly with increasing severity of VAP ($p<0.001$) (15). Serum procalcitonin values vary widely based on the type and severity of infection. Several studies have analyzed the behavior of procalcitonin in lung infections. One of them mentioned that patients with confirmed VAP had higher procalcitonin levels than patients withoutAP (16). This study aims to determine the correlation of serum procalcitonin values with the severity of VAP patients.

2. Materials And Methods

Ethical Approval

Before the study was conducted, ethical approval was submitted to the Ethics Committee for Biomedical Research on Humans at the Faculty of Medicine, Hasanuddin University and research permission was obtained from Dr. Wahidin Sudirohusodo Hospital. Confidentiality of patient identity was maintained by including initials and medical record numbers without mentioning full names.

Study Population

The study population included all patients in the ICU of Dr. Wahidin Sudirohusodo Hospital who were diagnosed with Ventilator Associated Pneumonia (VAP).

Inclusion and exclusion criteria

Inclusion criteria were patients older than 18 years, using mechanical ventilation, and not using immunosuppressants before. Exclusion criteria were not specifically mentioned in the text but could be interpreted as patients who did not meet the inclusion criteria.

Clinical Data and Sample Collection

The study used secondary data from the medical records of patients diagnosed with VAP from January 2022 to December 2022. Data were taken from the medical records of patients hospitalized in the ICU of Dr. Wahidin Sudirohusodo Hospital.

Statistical Analysis

Data analysis was performed using the SPSS version 25 application with descriptive and statistical analysis methods (17–19). The statistical test used was the Spearman correlation test to assess the relationship between procalcitonin values and pneumonia severity as measured by the PSI score.

3. Result

Patient Characteristics

In this study 78 research subjects. Male gender was 48 (61.5%) subjects, female was 30 (38.5%) subjects. The mean age of the study subjects was 55.9 ±14.45 years. Elevated procalcitonin values were found in 72 (92.3%) subjects. PSI score was low risk in 47 (60.3%), moderate risk in 28 (35.9%) and high risk in 3 (3.8%) subjects.

Table 1. Patient Characteristics

Variable	N (78)	%
Sex		
Male	48	61.5
Female	30	38.5
Age	55.9 ±14.45	
Procalcitonin		
Normal	6	7.7
Increased	72	92.3
PSI Score		
Low risk	47	60.3
Medium risk	28	35.9
High risk	3	3.8

Correlation between Procalcitonin and Degree of VAP based on PSI Score

This study analyzed the correlation of procalcitonin values and the degree of VAP based on PSI scores. The mean procalcitonin value of the research subjects was 7.32 ± 31.9. The mean value of PSI score based on risk was obtained, low risk 65.4 ± 16.7, medium risk 104.8 ± 11.5 and high risk 166 ± 38.0. Significant results were obtained ($p<0.05$) with the nature of the correlation being a positive correlation (r; 0.428).

Table 2. Correlation Between Procalcitonin and Degree of VAP Based on PSI score

Variabel	n	Mean (SD)	r	p*
Procalcitonin	78	7.32 ± 31.9	0.428	0.000
PSI Score				
Low	47	65.4 ± 16.7		
Medium	28	104.8 ± 11.5		
High	3	166 ± 38.0		

**Spearman Correlation*

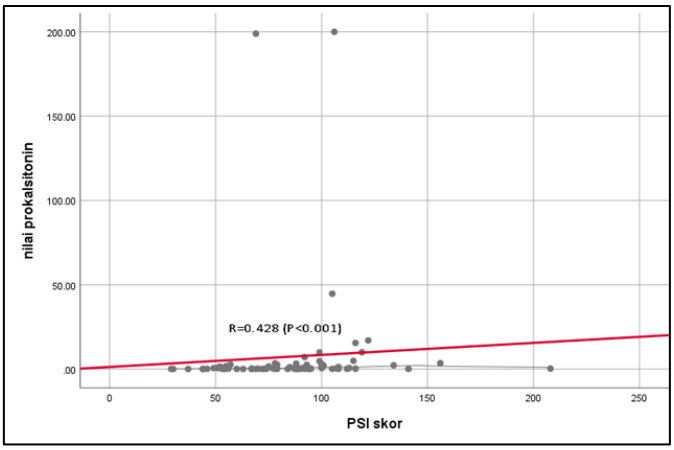

Figure 1. Correlation Between Procalcitonin and The Degree of VAP Based on PSI Score

4. Discussion

Research Characteristics

Based on Table 1. The table presents the characteristics of the subjects in this study, which involved a total of 78 subjects. Of these, 48 subjects (61.5%) were male, while 30 subjects (38.5%) were female. The mean age of the study sample was 55.9 years with a standard deviation of ±14.45 years. Increased procalcitonin values were found in 72 subjects (92.3%). Based on the PSI score, 47 subjects (60.3%) were in the low risk category, 28 subjects (35.9%) were in moderate risk, and 3 subjects (3.8%) were in high risk. Analysis based on gender showed that there were more males (48 subjects) than females (30 subjects). The mean age of the sample in this study was 55.9 years, which is in line with findings from previous studies. For example, Pawar et al. reported that of the 25 VAP subjects studied, 21 subjects (84%) were male, with a mean age of 59.7 years and a standard deviation of ±12.7 years (20). In addition, Lahoorpour et al. also found that the number of males was higher than females, with 39 male subjects versus 8 female subjects, and VAP was more prevalent in the age group of 41-60 years (21). This study confirms the same trend, showing that males are more likely to suffer from VAP and the mean age of the study subjects was within the same range as previous findings.

Correlation Between Procalcitonin and Degree of VAP Based on PSI Score

Based on Table 2. The table presents the correlation analysis between procalcitonin values and the degree of VAP as measured by the PSI score. The mean procalcitonin value in the study subjects was 7.32 with a standard deviation of ±31.9. Meanwhile, the average PSI score based on risk level was as follows: low risk 65.4 with a standard deviation of ±16.7, medium risk 104.8 with a standard deviation of ±11.5, and high risk 166 with a standard deviation of ±38.0. The analysis showed a significant positive correlation between procalcitonin values and PSI scores with a p value <0.05 and a correlation coefficient (r) of 0.428.

Ventilator-associated pneumonia (VAP) is a serious problem often faced by patients in intensive care units. Although various prevention efforts have been implemented, VAP remains a common occurrence and is often considered an indicator of quality of care in healthcare facilities, accounting for up to 25% of all nosocomial infections occurring in intensive care units (22). Procalcitonin is a biomarker used in diagnosis to differentiate bacterial infections from other causes of systemic inflammatory reactions, as well as serving as a marker of severity and a prognostic element in the evaluation of the impact of antibiotic treatment as well as certain organic infections (23).

This study is consistent with the findings of Diaz et al. who showed a significant association between high procalcitonin values and the incidence of VAP. Diaz et al. also noted that patients with high procalcitonin values had a greater risk of VAP, with an odds ratio (OR) of 8.39 and a 95% confidence interval between 5.4 and 12.6 (24). In addition, similar results were found by Wang et al. who reported that high procalcitonin values were significantly associated with the incidence of severe pneumonia (25). These findings support the role of procalcitonin as an important indicator in assessing the severity of VAP and provide prognostic information regarding the risk of developing severe pneumonia in patients in the intensive care unit.

5. Conclusion

In this study, it can be concluded that the severity of VAP as measured by the PSI score is positively correlated with high procalcitonin values.

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