Characteristics of Procalcitonin Values and Absolute Neutrophil Lymphocyte Ratio in Pneumonia Sepsis Patients in The Intensive Care Unit of a Hospital H. Adam Malik

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Abstract.

Sepsis pneumonia ranks among leading causes of global mortality, particularly in ICU settings, yet local biomarker profiles remain underexplored in resource-limited contexts like Indonesia. This study aimed to characterize procalcitonin (PCT) and absolute neutrophil-lymphocyte ratio (NLR) in ICU sepsis pneumonia patients at RSUP H. Adam Malik Medan (2023). Employing an observational analytic cross-sectional design, total sampling captured 132 patients meeting Sepsis-3 criteria (qSOFA ≥2, SOFA ≥2, age ≥18 years) with complete PCT/NLR data. Secondary data from medical records were analyzed using SPSS 25 via univariate descriptives and Spearman bivariate tests. Results revealed demographic dominance of males (61.37%) and age ≥60 years (40.15%), lymphopenia (94.70%), neutrophilia (90.90%), critical NLR (>17; 50%), and PCT predominantly in sepsis/infection range (0.5-2 ng/mL; 39.39%) followed by septic shock (>10 ng/mL; 29.55%). In conclusion, elevated NLR and PCT confirm severe inflammation patterns aligned with Sepsis-3, supporting biomarker-guided therapy to mitigate antibiotic overuse in Indonesian ICUs.

Keywords: *Critical Inflammation; Neutrophil-Lymphocyte Ratio; Procalcitonin, Sepsis Pneumonia and Septic Shock.*

I. INTRODUCTION

Pneumonic sepsis is a leading cause of global mortality, particularly in intensive care units. This introduction synthesizes current evidence regarding the characteristics of procalcitonin (PCT) and the neutrophil-lymphocyte ratio (NLR) to address diagnostic and prognostic gaps in these patients. Lower respiratory tract infections, including pneumonia, are a leading cause of death globally, with nearly 3 million fatal cases annually (Rudd et al., 2020). Sepsis, which accompanies pneumonia, exacerbates this burden, reaching 48.9 million cases and 11 million deaths in 2017, primarily in low- and middle-income countries (Rudd et al., 2020). Trends indicate a 37% increase in sepsis-related mortality from 1990 to 2017 due to aging populations and antimicrobial resistance (Evans et al., 2021). The economic impact includes hospitalization costs exceeding those for myocardial infarction in the elderly (Torres et al., 2021).The Sepsis-3 Consensus defines sepsis as life-threatening organ dysfunction resulting from a dysregulated host response to infection, evolving from SIRS criteria to the SOFA/qSOFA score (Singer et al., 2016). The grand theory refers to systemic inflammatory response syndrome (SIRS), in which pneumonia triggers a cytokine storm leading to endothelial dysfunction and multiorgan failure (Hotchkiss et al., 2016). The current theory emphasizes PCT as a bacteria-specific biomarker that rises within 2–3 hours via upregulation of the CALC-1 gene in macrophages, distinct from viral responses (Schuetz et al., 2020). The NLR reflects an imbalance between innate and adaptive immunity, with neutrophilia indicating acute inflammation and apoptotic lymphopenia (Barnes et al., 2020).

Supporting evidence suggests that PCT >0.5 ng/mL predicts bacterial sepsis with 85–95% specificity, superior to CRP in pneumonia cohorts (Wacker et al., 2013; Huang et al., 2018). NLR >10 correlates with severe inflammation and 30-day mortality (OR 2.5–4.0) in pneumonic sepsis, validated in ICU studies (Yao et al., 2019; Güell et al., 2019). The general methodology uses a retrospective cross-sectional design with ROC analysis for cutoff and multivariate regression for prognostic modeling (Pantzaris et al., 2018). Conflicting findings have emerged regarding the utility of PCT; while it supports antibiotic de-escalation (reducing the duration by 2–3 days), there have been reports of false positives in severe viral pneumonia or trauma (Schuetz et al., 2018 versus Gautam et al., 2020). NLR shows discordance: high values predict mortality in bacterial sepsis (Liu et al., 2016), but low thresholds in COVID-19 pneumonia question its generalizability (Man et al., 2021). This debate highlights contextual cutoffs, with prospective trials favoring a combined PCT-NLR panel over a single marker (Gregoriano et al., 2020).

In Indonesia, specifically in Sumatra, the burden of sepsis pneumonia burdens the ICU of H. Adam Malik General Hospital, with 40% of cases being aged ≥60 years and predominantly male (local thesis data, 2023). Characteristics include a critical inflammation NLR (>17) in 50% and a sepsis-range PCT (0.5-2 ng/mL) in 39%, amidst increasing antimicrobial resistance (Ministry of Health, 2022). Regional studies note a high prevalence due to COPD/TB comorbidities, exacerbating tropical climate vulnerability (Ritonga, 2022).Despite global progress, gaps remain in the characterization of absolute NLR and PCT thresholds in Indonesian ICU sepsis pneumonia, where priority studies focus on correlation rather than distribution (Adilla, 2022). Local data are limited to demographics ≥60 years and conflicting biomarker cutoffs hamper tailored prognostication (Dafitri et al., 2020). Integration of the pipeline from global epidemiology to site-specific profiles is rare, neglecting the 132-case cohort at H. Adam Malik General Hospital (2023).This study aims to describe the characteristics of absolute PCT and NLR in ICU patients with sepsis and pneumonia at H. Adam Malik General Hospital (2023), addressing the gap through descriptive analysis. The theoretical contribution sharpens the application of Sepsis-3 in limited resource settings; the practical benefit is biomarker-based therapy guidance, potentially reducing antibiotic overuse and mortality by 20-30% (Schuetz et al., 2020).

II. METHODS

Pneumonia sepsis is a major cause of global mortality, particularly in intensive care units. The methods section of this study was systematically designed to characterize procalcitonin (PCT) values and absolute neutrophil-lymphocyte ratio (NLR) in patients with pneumonic sepsis in the Intensive Care Unit (IPI) of H. Adam Malik General Hospital (RSUP) Medan in 2023, following a funnel approach from global issues to the local context as outlined in the introduction.

Types and Methods of Research

This study used an observational analytical design with a cross-sectional approach, which allows for simultaneous data collection to describe PCT and NLR characteristics at a single point in time without intervention (Sugiyono, 2019; Cresswell & Cresswell, 2023). This approach aligns with the Surviving Sepsis Campaign's recommendations for biomarker studies in the ICU setting, where univariate and bivariate analyses are used to explore variable relationships, as reported in global studies (Evans et al., 2021). According to Sudaryono (2020), cross-sectional designs are effective for high-mortality ICU populations such as pneumonic sepsis, while Emzir (2021) emphasizes their validity in identifying biomarker distribution patterns without temporal bias. This study adopted the Sepsis-3 framework for case classification (Singer et al., 2016), ensuring consistency with the evolution of sepsis definitions from SIRS to SOFA/qSOFA.

Data Analysis Instruments and Techniques

The primary instrument included secondary data from patient medical records, including PCT laboratory results (ng/mL), absolute neutrophil and lymphocyte counts for NLR calculation, and demographic variables such as age and gender, extracted using a structured data collection sheet (Cresswell & Cresswell, 2023). Data analysis techniques were performed using SPSS version 25 software, including univariate descriptives (frequency, mean, median, range) for characteristics, followed by bivariate analysis such as the Spearman test for the PCT-NLR relationship considering the non-normal distribution (Sugiyono,

2019; Emzir, 2021). Instrument validity was verified through laboratory calibration at H. Adam Malik General Hospital according to CLSI standards, while data reliability was strengthened by double-entry by two independent researchers (Sudaryono, 2020). This analysis aligns with biomarker meta-analyses that use ROC for prognostic cutoffs (Schuetz et al., 2020); Yao et al., 2019), allows for the synthesis of supporting citations and evaluation of conflicts such as the NLR threshold >10 for mortality (Rudd et al., 2020).

Population and Sample

The study population consisted of all sepsis pneumonia patients treated in the IPI Ward of H. Adam Malik General Hospital Medan during January-December 2023, a total of 132 subjects based on the inclusion criteria: diagnosis of sepsis pneumonia according to Sepsis-3 (qSOFA ≥2 and SOFA ≥2), age ≥18 years, and complete laboratory data of PCT and NLR (Singer et al., 2016). Samples were taken by total sampling without significant exclusions except incomplete data <5%, resulting in 132 representative samples with dominant characteristics of men (61.37%) and age ≥60 years (40.15%) (local thesis file, 2023). The Slovin formula was not required due to the limited population, according to Sugiyono's (2019) guidelines for retrospective ICU studies, while Cresswell & Cresswell (2023) support purposive sampling for local generalization in the Sumatran context such as H. Adam Malik General Hospital. These criteria address the research gap in elderly demographics and COPD/TB comorbidities in Indonesia (Evans et al., 2021).

Research Procedures

The procedure began with ethical approval from the USU Faculty of Medicine Health Research Ethics Committee (Annual No. 2023), followed by retrospective data collection from electronic medical records via the Picture Archiving and Communication System (PACS) and the H. Adam Malik General Hospital Clinical Laboratory for 6 months (Sudaryono, 2020). Data were validated through triangulation with IPI attending physician notes, then coded and analyzed in stages: data cleaning, descriptive analysis, and bivariate analysis with a significance level of $p<0.05$ (Emzir, 2021; Cresswell & Cresswell, 2023). This process adhered to the Helsinki principles for observational studies, with subject anonymity to maintain confidentiality, in line with the urgency of research in resource-limited settings (Schuetz et al., 2020). Results were interpreted in the context of global-local evidence conflicts, contributing to practical benefits such as biomarker therapy guidelines (Rudd et al., 2020).

III. RESULT AND DISCUSSION

1. Demographic Overview of Sepsis Pneumonia Patients

The demographic description of patients with sepsis pneumonia is depicted in the following table:

Table 1. Demographic Description of Sepsis Pneumonia Patients

Variables	n	%
AGE		
≥ 19-30 years	15	11.36
31-45 years	22	16.64
46-59 years	42	31.85
≥60 years	53	40.15
GENDER		
Man	81	61.37
Woman	51	38.63
	132	100

Based on table 4.1 above, the most common age is≥60 years old as many as 53 people (40.15%) and the most common gender was male as many as 81 people (61.37%).

2. Overview of Lymphocyte LevelsSepsis Pneumonia Patients

The description of lymphocyte levels in patients with sepsis pneumonia is depicted in the following table:

Table 2. Lymphocyte Level OverviewSepsis Pneumonia Patients

Lymphocyte Levels	n	%
Increased (>40)	1	0.75
Normal (20-40)	6	4.55
Decreasing (<20)	125	94.70
Total	132	100

Based on table 4.2 above, it is known that the highest lymphocyte levels decreased in 125 patients (94.70%), and the lowest neutrophil levels increased in 1 patient (0.75%).

3. Neutrophil Level OverviewSepsis Pneumonia Patients

The description of neutrophil levels in patients with sepsis pneumonia is depicted in the following table:

Table 3. Neutrophil Level OverviewSepsis Pneumonia Patients

Neutrophil Level	n	%
Increased (>70)	120	90.90
Normal (50-70)	10	7.58
Decreasing (<50)	2	1.52
Total	132	100

Based on table 4.3 above, it is known that the highest neutrophil levels were increased in 120 patients (90.90%), and the lowest neutrophil levels were decreased in 2 patients (1.52%).

4. Description of the NLR Ratio of Sepsis Pneumonia Patients

The NLR ratio of sepsis pneumonia is depicted in the following table:

Table 4. Description of NLR Ratio in Sepsis Pneumonia Patients

NLR Ratio	n	%
Reverse Severe (0.1 – 0.7)	2	1.52
Normal (1 – 2)	2	1.52
Low Inflammation (2 – 3)	5	3.79
Mild to Moderate Inflammation (3 – 7)	20	15.15
Moderate Inflammation (7 – 11)	20	15.15
Critical Inflammation (>17)	66	50.00
Severe Inflammation (11 – 17)	17	12.88
	132	100

Based on table 4.4 above, it is known that the patients with the highest NLR ratio were critical inflammation, namely 66 patients (50%).

5. Description of Procalcitonin Values in Patients with Sepsis and Pneumonia

The description of procalcitonin values in patients with sepsis pneumonia is depicted in the following table:

Table 5. Description of Procalcitonin Values in Patients with Sepsis and Pneumonia

Procalcitonin Value	n	%
Normal (< 0.5)	18	13.64
Sepsis (> 2)	7	5.30
severe sepsis (2 – 10)	16	12.12
sepsis/other infections (0.5 – 2)	52	39.39
Septic shock (>10)	39	29.55
	132	100

Based on table 4.5 above, the most common procalcitonin values in sepsis patients were sepsis/other infections, amounting to 52 patients (39.39%).

Discussion

Sepsis affects both sexes, but there is a marked male predominance among sepsis patients. Several studies have consistently shown that men are more frequently diagnosed with sepsis compared to women. For example, a study analyzing data from 19 hospitals in South Korea found that 56.7% of sepsis patients were male [50]. Similarly, a large-scale analysis of 34 studies involving 498,146 adult septic patients revealed a male predominance, with 54–61% of patients being male [51].Sepsis is a critical condition that disproportionately affects the elderly, with most septic patients being over 65 years of age. Studies show that nearly 60% of sepsis cases occur in this age group, highlighting the vulnerability of older adults to this severe infection [52][53]. The incidence and severity of sepsis increase with age due to factors such as comorbidities, institutionalization, and decreased immune function [54].Lymphocyte levels in pneumonic sepsis are significantly affected, often presenting as lymphopenia, which is a critical marker for prognosis. Studies have shown that lymphopenia, defined as a lymphocyte count below 675 cells/mm³ or 501 cells/mm³, is associated with a 2.32- and 3.76-fold increased risk of death in patients with or without septic shock, respectively [55]. This decrease in lymphocyte count is a common feature in sepsis, with up to 52% of

patients exhibiting lymphopenia, which correlates with higher mortality rates at 30 and 100 days [56]. Elevated neutrophil counts are a significant marker in pneumonic sepsis, reflecting the body's immune response to infection. The neutrophil-to-lymphocyte ratio (NLR) has been identified as a useful prognostic marker in sepsis, with higher NLR levels correlating with increased mortality and disease severity [57][58].

In patients with community-acquired pneumonia (CAP), elevated neutrophil counts are common, and the presence of toxic granulations, Döhle bodies, and toxic vacuolation in neutrophils may indicate severe bacterial infection [59]. In pneumonic sepsis, the mechanisms leading to decreased lymphocyte counts and increased neutrophil counts involve a complex interplay of immune responses and cellular signaling. Neutrophils are rapidly recruited to the site of infection to combat pathogens, a process regulated by chemokines such as CXCL1, which enhance neutrophil influx and bacterial clearance [60]. This recruitment is part of an emergency granulopoietic response, in which the bone marrow increases neutrophil production to meet the increased demand during systemic infection [61]. Concurrently, neutrophils in sepsis can express programmed cell death ligand 1 (PD-L1), which inhibits lymphocyte proliferation and induces lymphocyte apoptosis, contributing to lymphopenia [62].The neutrophil-to-lymphocyte ratio (NLR) is a significant marker for indicating critical inflammation in sepsis and pneumonia. Studies have shown that NLR is a simple, cost-effective, and readily available biomarker that correlates well with other inflammatory markers such as C-reactive protein (CRP) and procalcitonin (PCT) [63] [64] [65]. In patients with community-acquired pneumonia (CAP), a high NLR has been associated with increased severity and poor outcomes, including higher mortality rates [66].

IV. CONCLUSION

This study found that in 132 patients with sepsis pneumonia in the ICU of H. Adam Malik General Hospital in 2023, demographic characteristics were predominantly male (61.37%) and aged ≥60 years (40.15%). Lymphocyte levels were mostly decreased (94.70%), while neutrophils increased (90.90%), resulting in the highest NLR ratio in the critical inflammation category (>17) at 50%. Procalcitonin (PCT) values were dominant in the sepsis/other infections range (0.5-2 ng/mL) with 39.39%, followed by septic shock (>10 ng/mL) at 29.55%. These findings confirm NLR and PCT as relevant indicators of severe inflammation in the local Indonesian context, in line with Sepsis-3. However, limitations include the retrospective cross-sectional design, which is susceptible to selection bias, and the lack of longitudinal data to monitor biomarker dynamics. Suggestions for future research include prospective cohort studies with a combined biomarker panel (PCT-NLR-CRP) and multivariate analysis of prognostic factors such as comorbidities. Practically, these results support biomarker-based therapy guidelines for antibiotic de-escalation, potentially reducing antimicrobial resistance and the 20-30% mortality in resource-limited ICUs.

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