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Association Between Early Intravenous Corticosteroids and Length of Stay in Pediatric Laboratory-confirmed Eosinophilic Asthma

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Background:
In pediatric eosinophilic asthma attacks, every minute of delayed treatment can stretch a child's suffering and hospital stay. Corticosteroids are a proven therapy, yet the critical timing for intravenous administration has never been clearly defined.
Objective:
To examine whether the timing of intravenous corticosteroid (IVCS) administration influences hospital length of stay (LOS) in children with eosinophilic asthma exacerbation.
Methods:
We conducted a retrospective cohort study at Wangaya General Hospital, Denpasar (2022–2025) involving children aged 2–17 years admitted with acute asthma exacerbation and laboratory-confirmed eosinophilia. Exclusion criteria included no intravenous IVCS in the emergency department, outpatient care, major comorbidities, or incomplete records. Patients were classified into early (<60 minutes) and delayed (>60 minutes) IVCS administration groups. Bivariate tests identified candidate variables, which were then entered into a multiple linear regression.
Results:
Sixty patients were analyzed (mean age 9.26±5.13 years; 58% male). The mean LOS was 3.58 ± 2.23 days. In bivariate analysis, leukocytosis ($p=0.039$) and delayed IVCS administration ($p<0.001$) were associated with longer LOS; other factors showed no significance. Children receiving IVCS after 60 minutes stayed longer (4.51 ± 2.78 days versus 2.66 ± 0.79 days). Multivariate analysis confirmed delayed IVCS as an independent predictor of prolonged LOS ($B = –0.173$; $p<0.001$) after adjusting for leukocyte count.
Conclusion:
Timely intervention is critical from the very first moment when a child with eosinophilic asthma arrives at the hospital. Administering intravenous corticosteroids within the first hour can significantly shorten recovery and discharge time, underscoring the urgency for rapid intervention.

Keywords: asthma, corticosteroid, eosinophilia, length of stay, pediatrics

Introduction

Asthma is a serious global health problem that occurs primarily in children. This chronic respiratory disease causes emergency visits and hospitalization worldwide. More than 260 million individuals are affected globally, with children experiencing higher morbidity rates and recurrent exacerbations. In Indonesia, asthma prevalence among children ranges from 2–5%, with wide regional variability. Interestingly, asthma and its exacerbation happen more often in children than adults, even in Indonesia. The Center for Disease Control and Prevention (CDC) reports an increase in asthma incidence in the last 2 decades despite advances in therapy with various national and international management guidelines. This may be due to the heterogeneous nature of asthma, where different phenotypes and endotypes lead to diverse clinical manifestations and therapeutic responses. Therefore, identifying these subtypes is important to support targeted treatment and improve outcomes [1–5].

One of the asthma phenotypes that often happens in children is eosinophilic asthma. Although an accepted definition is still elusive, many clinical trials classify eosinophilic asthma using peripheral blood eosinophil, such as ≥150, ≥300, or ≥400 cells/μL, which can be measured in primary care settings. Alternatively, Eosinophilic asthma can also be identified through sputum eosinophil analysis, considered the gold standard for detecting airway eosinophilic inflammation, although it is less available in many low- and middle-income country health services due to limited laboratory facilities [6–9].

Accumulation of eosinophils in the airway may cause inflammation and tissue damage [6]. Fortunately, this phenotype responds well to corticosteroid treatment that can reduce airway remodeling and slow the progression of asthma [3,10]. Corticosteroids are first-line therapy in eosinophilic asthma, as Th2-mediated allergic activation causes eosinophil recruitment and inflammatory mediator release, which corticosteroids suppress effectively by inhibiting eosinophil activation, reducing cytokines, and inducing eosinophil apoptosis [8]. All of these mechanisms require time to take effect in clinical improvement. This anti-inflammatory agent begins within several hours after administration. Earlier interruption of this cascade allows faster resolution of bronchospasm and hypoxia, reduces the need for prolonged bronchodilator therapy or oxygen supplementation, and ultimately shortens the duration of hospitalization. Conversely, delayed steroid therapy allows inflammation to progress, leading to more severe airway obstruction and a longer recovery period [7,11–15)\].

Despite this, there remains little evidence evaluating whether early intravenous corticosteroid administration directly translates into shorter length of stay, especially among pediatric patients with blood eosinophilia [3,4,11,16–18]. This study, therefore, investigates whether the timing of IVCS (Intravenous Corticosteroid) administration affects hospital Length Of Stay (LOS) in children with laboratory-confirmed eosinophilic asthma.

Methods

Study design

We conducted a cohort-retrospective observational study at Wangaya General Hospital, Denpasar, Indonesia, from August 2022 – August 2025. The study was approved by the Pediatric Department and the institutional ethics committee of Wangaya General Hospital, Denpasar, Indonesia.

Population and Eligibility

Patients were eligible if they were aged 2-17 years old and came with an acute asthma exacerbation with peripheral blood showing eosinophilia. Exclusion criteria were not receiving intravenous corticosteroid at the emergency department, outpatient asthma, major comorbidities (e.g., congenital heart disease, cystic fibrosis, bronchopulmonary dysplasia), and incomplete medical records. Patients were selected using consecutive sampling. No matching or sample-size balancing procedure was performed.

Exposure and Outcome

The primary exposure in this study was the timing of intravenous corticosteroid (IVCS) administration. Patients were categorized into two groups based on the interval between arrival in the Emergency Department and initiation of IVCS therapy as early administration, defined as administration within less than 60 minutes, and delayed administration, defined as more than 60 minutes after arrival. The primary outcome was hospital length of stay (LOS), measured in days from admission to discharge.

Data Collection

Data were obtained from electronic medical records and included patient age, sex, nutritional status, asthma severity at presentation, leukocyte count, type of corticosteroid administered, IVCS timing, and total LOS. Peripheral eosinophilia was defined as a blood eosinophil count of ≥300 cells/μL.

Several clinical variables were included as potential confounders because of their known association with asthma severity and recovery. Nutritional status was classified according to WHO and CDC growth standards. Children were categorized as well-nourished if weight-for-height fell between –2 SD and +1 SD for those younger than five years, or if weight-for-age exceeded the 90th percentile for those older than five years. Malnutrition was defined as weight-for-height below –2 SD in children younger than five years, or weight-for-age greater than +1 SD confirmed by BMI-for-age exceeding +2 SD for children under two years, or above the 85th percentile using CDC reference curves for those aged two years and older. For children older than five years, malnutrition was defined as BMI-for-age below –2 SD or above the 85th percentile.

Asthma attack severity was classified into *mild–moderate,* or *severe* based on clinical criteria. Mild–moderate exacerbations were characterized by absence of agitation, the ability to speak in full sentences, increased respiratory rate, minimal retractions, and oxygen saturation between 92–95% on room air. Severe exacerbations were defined by agitation, the ability to speak only in words, elevated respiratory rate, marked retractions, and oxygen saturation below 92% on room air.

Leukocyte count was dichotomized into *normal* and leukocytosis. Leukocytosis was defined as a total leukocyte count greater than 12,000/mm³ for children aged 2–9 years, and greater than 10,500/mm³ for children aged 10–17 years. Values below these thresholds were categorized as normal.

In cases where patients had multiple hospital visits during the study period, only data from the first acute care encounter were included in the analysis.

Statistical Analysis

Categorical variables were analyzed using chi-square tests, while continuous variables were evaluated using independent t-tests or Mann–Whitney tests, based on data distribution. In addition to IVCS timing, several clinical variables that may influence hospital stay were evaluated as potential confounders. These included nutritional status, asthma severity on presentation, leukocyte count, and the type of corticosteroid administered.

Variables with a p-value <0.25 in the bivariate analysis were entered into a multivariate linear regression model to identify independent predictors of LOS. Statistical significance was determined at $p<0.05$. All analyses were performed using SPSS version 26.0.

Results

A total of 60 children were included in the study, divided into 2 groups. With 30 receiving systemic corticosteroids within <60 minutes (early corticosteroid) and 30 receiving treatment after >60 minutes (delayed corticosteroid) of arrival. The baseline characteristics of both groups are summarized in Table 1. The mean age of children in the early group was 10.34 ± 5.13 years, while those in the delayed group had a mean age of 9.26 ± 4.89 years. Overall, there were no significant differences in age, sex distribution, nutritional status, asthma attack severity, or corticosteroid type between groups (all $p > 0.05$). However, leukocytosis was significantly more common among children receiving corticosteroids after 60 minutes of arrival (80% vs. 53%, $p = 0.028$). Except for leukocyte count, baseline characteristics were generally comparable between the two groups.

Table 1. Baseline characteristics of the children in both groups

Characteristics	**Time to IVCS < 60 (n = 30)**	**Time to IVCS > 60 (n = 30)**	**p-value**
Age, years (Mean ± SD)	10,34 ± 4,88	9,26 ± 5,13	0,4
Sex, n (%)			0,018*
Boys	13 (43%)	22 (73%)	
Girls	17 (57%)	8 (27%)	
Nutritional Status			0,347
Good Nutrition	25 (83%)	22 (73%)	
Poor Nutrition	5 (17%)	8 (27%)	
Asthma Exacerbation			0,754
Mild-Moderate	24 (80%)	23 (77%)	
Severe	6 (20%)	7 (23%)	
Leukocyte			0,028*
Normal	14 (47%)	6 (20%)	
Leukocytosis	16 (53%)	24 (80%)	

Type of Steroid			0,243
Dexamethasone	24 (80%)	20 (67%)	
Methylprednisolone	6 (20%)	10 (33%)	

Abbreviations: IVCS, Intravenous Corticosteroid
*p-value < 0.05 considered as significant

Bivariate analysis was conducted to examine the association between study variables and length of hospital stay (LOS) among children with eosinophilic asthma (Table 2). The analysis demonstrated that the timing of intravenous corticosteroid (ICS) administration was significantly associated with length of hospital stay (LOS). Children who received early corticosteroids had a shorter mean LOS of 2.66 ± 0.79 days, compared with 4.51 ± 2.78 days in those delayed corticosteroid group (mean difference –1.86 days; 95% CI –2.23 to –0.84; p < 0.001). This finding shows that early corticosteroid administration was associated with a reduced length of stay.

No significant associations were observed between LOS and asthma attack severity, nutritional status, and the type of corticosteroid used was not significantly associated with LOS

Although children with leukocytosis tended to have a longer hospital stay (3.93 ± 2.57 days) compared to those with normal leukocyte counts (2.90 ± 1.07 days), this difference did not reach statistical significance (p = 0.078). Overall, these results suggest that early systemic corticosteroid administration (<60 minutes) is the main factor associated with a shorter LOS, while other clinical and laboratory characteristics, including leukocyte count, showed no significant independent association.

Table 2. Bivariate analysis of predictors with length of stay

Variable	Mean LOS (days) ± SD	Mean Difference (95% CI)	p-value
Asthma Attack			0.625
Mild-moderate	3.58 ± 2.42	–0.03	
Severe	3.60 ± 1.40	(–0.16 to 0.10)	
Nutritional Status			0.326
Good Nutrition	3.53 ± 2.44	–0.06	
Malnutrition	3.76 ± 1.28	(–0.19 to 0.06)	
Steroid Type			0.201†
Dexamethasone	3.40 ± 2.04	–0.08	
Methylprednisolone	4.10 ± 2.69	(–0.19 to 0.04)	
Leukocyte Count *(tran_LOS)*			0.078†
Normal	2.90 ± 1.07	–0.10	
Leukocytosis	3.93 ± 2.57	(–0.21 to 0.02)	

Variable	Mean LOS (days) ± SD	Mean Difference (95% CI)	p-value
ICS Timing (Primary Outcome)			<0.001*†
Normal	2.66 ± 0.79	–1.86	
Leukocytosis	4.51 ± 2.78	(–2.23 to –0.84)	

Abbreviations: IVCS, Intravenous Corticosteroid; LOS, Length of Stay; CI, Confidence Interval; SD, Standard Deviation.

*p-value < 0,05 considered as significant, † Variables with p < 0.25 in the bivariate analysis were included in the multivariate model.

Variables with a *p*-value < 0.25 in the bivariate analysis (IVCS timing, steroid type, and leukocyte count) were entered into a multiple linear regression model to identify independent predictors of hospital length of stay (LOS) (Table 3). The overall model was statistically significant, explaining about one-fourth of the variance in LOS (adjusted $R^2 = 0.20$, $p = 0.001$).

After adjustment, only the timing of intravenous corticosteroid (IVCS) administration remained an independent predictor of LOS, with delayed administration (>60 minutes) associated with longer hospitalization. Neither the type of corticosteroid used nor the leukocyte count contributed significantly to the model. These results confirm that early IVCS administration (<60 minutes) independently predicts shorter hospital stay in children with eosinophilic asthma, regardless of other clinical or laboratory characteristics.

Table 3. Multivariate analysis of predictors with length of stay

Variable	B (Unstandardized Coefficient)	SE	β (Standardized Coefficient)	95% CI for B	*p*-value
ICS Timing	–0.176	0.049	–0.435	–0.275 – –0.077	<0.001*
Leukocyte Count	0.039	0.053	0.090	–0.067 – 0.144	0.464
Steroid Type	0.039	0.054	0.085	–0.070 – 0.148	0.478

Abbreviations: CI, confidence interval; LOS, length of stay.
*p < 0.05 was considered statistically significant.

Discussion

This study demonstrated that early administration of intravenous corticosteroids (IVCS) within 60 minutes of arrival was independently associated with a shorter hospital length of stay (LOS) of approximately 1.8 days among children with blood eosinophilic asthma. This finding aligns with previous studies that consistently report improved outcomes with prompt corticosteroid initiation. Bhogal et al. (2012) found that systemic corticosteroid administration within 75 minutes significantly reduced hospitalization risk and duration of active treatment in children presenting with moderate to severe asthma exacerbations. Similarly, a multicenter pediatric emergency study showed that each hour of delay in corticosteroid

administration correlated with longer LOS and prolonged oxygen therapy. A retrospective analysis from the Children's Medical Center Connecticut also demonstrated that corticosteroid administration within 60 minutes was associated with approximately 25 minutes shorter LOS compared with delayed treatment [4,17,19]

Although corticosteroid therapy is one of the key interventions, the therapeutic response varies among asthma phenotypes. The eosinophilic phenotype is triggered by allergen exposure and driven by type 2 (Th2) immune responses through cytokines such as IL-4, IL-5, and IL-13, which tend to respond well to corticosteroid therapy [20]. Activation of Th2 cells promotes eosinophil proliferation and activation, followed by their migration into the bloodstream and infiltration into bronchial tissue within approximately 4–8 hours, where eosinophils degranulate and release oxidative mediators that damage the airway epithelium and contribute to remodeling [21–23]. Meanwhile, eosinophils will migrate to the liver, spleen, and bone marrow for apoptosis within 1-3 hours after corticosteroid administration [15]. Therefore, early systemic corticosteroid administration may suppress inflammation before eosinophilic infiltration becomes dominant, providing a pathophysiological explanation for the observed reduction in LOS.

In our study, neither corticosteroid type (dexamethasone vs methylprednisolone) nor leukocyte count was independently associated with LOS after adjustment. This finding suggests that the timing of administration may have a more pronounced impact on clinical recovery than the specific corticosteroid selected. Leukocytosis was initially considered a potential confounding factor, since we suspected bacterial infections could prolong hospitalization in children with asthma. However, leukocytosis alone has limited sensitivity and specificity for bacterial infection compared with biomarkers such as C-reactive protein (CRP) or procalcitonin [24,25]. The absence of such biomarkers in the present dataset may have limited the ability to differentiate infection-related leukocytosis from eosinophil-related inflammation.

Nutritional status and asthma attack severity were also analyzed as possible cofactors. Although neither showed a significant association with LOS in this study, previous research has reported that malnutrition may contribute to prolonged recovery and increased morbidity in pediatric respiratory illnesses [26,27]. This lack of association might be because most participants in our study were well-nourished and presented with mild to moderate exacerbations.

This study was conducted at Wangaya Hospital, a secondary-level facility with limited access to sputum eosinophil analysis; therefore, eosinophilic classification was based on peripheral blood eosinophil counts. While this may limit comparison with studies using sputum markers, peripheral eosinophilia remains a practical and validated surrogate of airway eosinophilic inflammation in low-resource settings.

Previous research has primarily evaluated general asthma populations without considering inflammatory phenotypes. The present study provides novel evidence by focusing specifically on pediatric eosinophilic asthma, a subtype known for strong corticosteroid responsiveness but rarely investigated regarding corticosteroid timing. Meanwhile, pediatric patients frequently exhibit peripheral eosinophilia than adults. Studying this group enhances the specificity and clinical relevance of corticosteroid-timing outcomes.

Several limitations should be acknowledged. The retrospective single-center design and relatively small sample size may limit the generalizability of the findings. Because this study relied on medical record data, important variables such as prior corticosteroid exposure, adherence to inhaled controller therapy,

and detailed medication history could not be fully assessed or verified. As a result, residual confounding related to treatment adherence, previous corticosteroid use, or undetected infection cannot be entirely excluded. In addition, the use of blood eosinophil counts rather than sputum eosinophils may limit direct comparison with studies employing airway samples. Nevertheless, the study provides clinically meaningful insights applicable to real-world, resource-limited pediatric asthma management.

Conclusion

In summary, early intravenous corticosteroid administration within 60 minutes independently predicted shorter hospitalization among children with blood eosinophilic asthma, regardless of leukocyte count or corticosteroid type. These findings reinforce the importance of rapid corticosteroid delivery in suppressing early airway inflammation and preventing eosinophil-driven tissue damage, thereby improving clinical outcomes in pediatric asthma exacerbations.

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