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Comparison of Nebulized Versus Systemic Corticosteroid for Management of Children Presenting with Acute Exacerbation of Asthma

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ABSTRACT

Introduction: Asthma is one of the most common chronic respiratory diseases in children, characterized by inflammation, bronchoconstriction, and mucus production in the airways, which leads to recurrent episodes of wheezing, coughing, and shortness of breath.

Objective: The main objective of the study is to find the comparison of nebulized versus systemic corticosteroids for the management of children presenting with acute exacerbation of asthma. Methodology: This randomized controlled trial (RCT) was conducted at Department of Pediatric Medicine, Multan Medical & Dental College from March 2023 to September 2024. A total of 240 pediatric patients, aged 2 to 12 years were included in the study. Data were collected at baseline (upon presentation) and at multiple time points during treatment (12, 24, 48 hours, and discharge). The clinical severity of asthma exacerbations was assessed using the Pediatric Asthma Severity Score (PASS).

Results: Both groups had a comparable mean age (6.4 ± 3.2 years vs. 6.3 ± 3.1 years, $p = 0.75$) and similar asthma severity as measured by the Pediatric Asthma Severity Score (PASS) (10.2 ± 2.5 vs. 10.1 ± 2.3, $p = 0.85$). Baseline respiratory rate, oxygen saturation, and gender distribution were also similar between the groups, with no statistically significant differences ($p > 0.05$ for all comparisons).At 48 hours, 85% of patients in the systemic corticosteroid group showed significant clinical improvement (PASS <4), compared to 68% in the nebulized corticosteroid group ($p = 0.01$), indicating a greater proportion of patients achieving symptom resolution in the systemic group.

Conclusion: It is concluded that systemic corticosteroids provide more rapid clinical improvement and faster symptom resolution compared to nebulized corticosteroids in children with acute asthma exacerbations.

Keywords: *Patients, Asthma, Chronic, Respiratory, Nebulized*

1. INTRODUCTION

Asthma is one of the most common chronic respiratory diseases in children, characterized by inflammation, bronchoconstriction, and mucus production in the airways, which leads to recurrent episodes of wheezing, coughing, and shortness of breath. Acute exacerbations of asthma, defined as a sudden worsening of symptoms, are a frequent and potentially life-threatening complication, particularly in pediatric populations [1]. Asthma discharge planning involves timely evaluation and management of the acute asthmatic exacerbations that threaten the patient's quality of life and may lead to respiratory failure. Corticosteroids which have an inhibitory effect on inflammation are a mainstay of the management of acute asthma and their use in the acute phase is well discussed [2]. There are two primary methods of corticosteroid

administration in the treatment of acute asthma exacerbations: Nebulized corticosteroids and systemic corticosteroids. Nebulized corticosteroids are given as a fine aerosol, directly into the lungs using a nebulizer, with in-built anti-inflammatory properties. Systemic corticosteroids, on the other hand, are given orally or intravenously, therefore the steroid will be able to spread all over the body [3].

The controversy that arises from the application of nebulized and systemic corticosteroids in children with asthma exacerbations is due to differences in their distribution, side effects and effectiveness [4]. It was also considered that nebulized corticosteroids provide the benefit of site-specific administration with subsequently decreased systemic availability, but may lack the fast onset of clinical effect needed in critical situations. Systemic corticosteroids act more globally and are viewed as the standard treatment for moderate to severe asthma exacerbation because of their ability to rapidly control inflammation in any given part of the body [5]. However, the use of systemic corticosteroids is not without risks especially when administered for the long term, in that they respectively suppress growth and immune system function, and predispose patients to gastrointestinal complications. Several investigations in the past years have compared nebulized versus systemic steroids in the treatment of AS, especially during AAEs in children [6]. A few trials have indicated that nebulized corticosteroids are not as potent as intravenous corticosteroids in severe exacerbations but are good for mild to moderate exacerbations. However, other authors have reported on the efficacy of giving corticosteroids via nebulization, particularly in patients who are unable to take oral medications or have relatively mild exacerbations [7].

The management of nebulized corticosteroids has its benefits as well as difficulties in children. On the positive side of nebulization, its use facilitates the continuous administration of this medication which may be an advantage in young children who have difficulties in using inhalers or in patients who may require medication right through the process of an exacerbation. Also, a nebulized form of corticosteroids is locally applied which may decrease the chances of having the system side effects [8]. However, nebulized corticosteroids are not easily delivered as the equipment used in their administration may not always be available and the time taken in nebulization may be a disadvantage in an emergent setting. Oral prednisone or intravenous methylprednisolone is also administered often to children with moderate to severe status asthmaticus as they are potent fast-acting anti-inflammatory agents [9]. These medications help to counter the immune response action and suppress further airway constriction thus improving clinical severity. While being very effective in their function, systemic corticosteroids present a number of orbital side effects, such as hyperglycemia, increased vulnerability to infections, obesity, and temper tantrums [10]. They also have long-term side effects that include osteoporosis and adrenal suppression among those who have been on long-term systemic corticosteroids [11]. The need to use nebulized or systemic corticosteroids depends on the characteristics of the asthma attack, the age of the child, available medications, and possible complications of side effects. Currently, there are indications that either oral or intravenous corticosteroids should be prescribed to children with exacerbation of asthma of moderate or severe severity, and nebulized corticosteroids can be used in milder cases or as an additional treatment alongside systemic therapy [12].

2. OBJECTIVE

The main objective of the study is to find the comparison of nebulized versus systemic corticosteroids for the management of children presenting with acute exacerbation of asthma.

3. METHODOLOGY

This randomized controlled trial (RCT) was conducted at Department of Pediatric Medicine, Multan Medical & Dental College from March 2023 to September 2024. A total of 240 pediatric patients, aged 2 to 12 years were included in the study.

Inclusion criteria

Diagnosis of asthma confirmed by clinical history and spirometry (where applicable).

Acute asthma exacerbation as defined by the presence of wheezing, cough, and/or shortness of breath, with a clinical score greater than or equal to 4 on the Pediatric Asthma Severity Score (PASS) or equivalent criteria.

No prior use of systemic corticosteroids within the past 24 hours.

Exclusion criteria

Presence of a comorbid respiratory infection (e.g., pneumonia, upper respiratory tract infection) that required separate treatment.

Severe asthma exacerbation requiring immediate intubation or mechanical ventilation.

Known allergies to corticosteroids.

Children with a history of previous adverse reactions to nebulized or systemic corticosteroids.

Data collection

Data were collected at baseline (upon presentation) and at multiple time points during treatment (12, 24, 48 hours, and discharge). The clinical severity of asthma exacerbations was assessed using the Pediatric Asthma Severity Score (PASS).Data were collected in two groups:

Group I: Nebulized Corticosteroids Group (n=120): This group received nebulized corticosteroid therapy, which consisted of inhaled budesonide (2 mg) delivered via a nebulizer every 12 hours for the first 48 hours of hospitalization.

Group II: Systemic Corticosteroids Group (n=120): This group received oral prednisone (1 mg/kg body weight) for 3 to 5 days, depending on the severity of the exacerbation, or intravenous methylprednisolone in cases where oral administration was not possible due to vomiting or other contraindications.

Both groups received standard supportive management, including bronchodilators (salbutamol) via a metered-dose inhaler (MDI) or nebulizer, oxygen therapy as required, and hydration. The management was standardized across both groups to minimize confounding factors. The primary outcome measure was the clinical improvement in asthma symptoms, and PASS score was recorded at baseline and every 12 hours thereafter during the hospitalization period, up to 48 hours.

Data Analysis

Data were analyzed using SPSS v27. Continuous variables were presented as means with standard deviations, while categorical variables were reported as frequencies and percentages. A comparison between the two groups was made using independent t-tests for continuous variables.

4. RESULTS

A total of 240 pediatric patients were enrolled in the study. Both groups had a comparable mean age (6.4 ± 3.2 years vs. 6.3 ± 3.1 years, $p = 0.75$) and similar asthma severity as measured by the Pediatric Asthma Severity Score (PASS) (10.2 ± 2.5 vs. 10.1 ± 2.3, $p = 0.85$). Baseline respiratory rate, oxygen saturation, and gender distribution were also similar between the groups, with no statistically significant differences ($p > 0.05$ for all comparisons).

Table 1: Demographic and Baseline Characteristics of Study Participants

Characteristic	Nebulized Corticosteroid Group (n=120)	Systemic Corticosteroid Group (n=120)	p-value
Mean Age (years)	6.4 ± 3.2	6.3 ± 3.1	0.75
Male (%)	58 (48.3%)	62 (51.7%)	0.45
Mean Asthma Severity (PASS score)	10.2 ± 2.5	10.1 ± 2.3	0.85
Baseline Respiratory Rate (bpm)	30.8 ± 4.1	31.2 ± 4.3	0.62
Baseline Oxygen Saturation (%)	91.4 ± 3.2	91.6 ± 3.4	0.75

At 24 hours, the systemic corticosteroid group demonstrated a significantly greater improvement in the Pediatric Asthma Severity Score (PASS) (3.8 ± 1.5 vs. 5.3 ± 1.8, $p < 0.001$) and respiratory rate (22.0 ± 2.8 bpm vs. 24.5 ± 3.3 bpm, $p < 0.001$), along with a higher increase in oxygen saturation (95.2% ± 2.6% vs. 94.1% ± 2.5%, $p < 0.001$). These differences were even more pronounced at 48 hours, with the systemic corticosteroid group showing greater improvements in PASS (2.1 ± 0.9 vs. 3.5 ± 1.2, $p < 0.001$), respiratory rate (20.0 ± 2.3 bpm vs. 22.1 ± 2.7 bpm, $p < 0.001$), and oxygen saturation (98.4% ± 1.7% vs. 97.2% ± 1.9%, $p < 0.001$).

Table 2: Primary Outcome Measures (Clinical Improvement)

Outcome Measure	Nebulized Corticosteroid Group (n=120)	Systemic Corticosteroid Group (n=120)	p-value
PASS Score (24 hours)	5.3 ± 1.8	3.8 ± 1.5	<0.001
PASS Score (48 hours)	3.5 ± 1.2	2.1 ± 0.9	<0.001
Respiratory Rate (24 hours)	24.5 ± 3.3 bpm	22.0 ± 2.8 bpm	<0.001
Respiratory Rate (48 hours)	22.1 ± 2.7 bpm	20.0 ± 2.3 bpm	<0.001
Oxygen Saturation (24 hours)	94.1% ± 2.5%	95.2% ± 2.6%	<0.001

Oxygen Saturation (48 hours)	97.2% ± 1.9%	98.4% ± 1.7%	<0.001

The time to symptom resolution was significantly shorter in the systemic corticosteroid group (24 hours, IQR: 18–30) compared to the nebulized group (36 hours, IQR: 30–42), with a p-value of <0.001. This indicates that systemic corticosteroids lead to quicker improvement in asthma symptoms. Although the hospital length of stay was marginally shorter in the systemic corticosteroid group (42.1 ± 14.7 hours vs. 48.3 ± 16.2 hours), the difference was not statistically significant (p = 0.05). However, the systemic corticosteroid group experienced a higher rate of adverse events (12.5%) compared to the nebulized group (2.5%), with a statistically significant p-value of <0.001, suggesting that while systemic corticosteroids are more effective, they are also associated with more side effects.

Table 3: Secondary Outcome Measures

Outcome Measure	Nebulized Corticosteroid Group (n=120)	Systemic Corticosteroid Group (n=120)	p-value
Time to Symptom Resolution (hours)	36 (IQR: 30–42)	24 (IQR: 18–30)	<0.001
Hospital Length of Stay (hours)	48.3 ± 16.2	42.1 ± 14.7	0.05
Adverse Events	3 (2.5%)	15 (12.5%)	<0.001
Readmission Rates (30 days)	8 (6.7%)	5 (4.2%)	0.25

At 48 hours, 85% of patients in the systemic corticosteroid group showed significant clinical improvement (PASS <4), compared to 68% in the nebulized corticosteroid group (p = 0.01), indicating a greater proportion of patients achieving symptom resolution in the systemic group. Additionally, the median time to symptom resolution was significantly shorter in the systemic corticosteroid group (24 hours, IQR: 18–30) compared to the nebulized group (36 hours, IQR: 30–42, p < 0.001), suggesting that systemic corticosteroids provide quicker relief.

Table 4: Treatment Efficacy and Safety

Outcome Measure	Nebulized Corticosteroid Group (n=120)	Systemic Corticosteroid Group (n=120)	p-value
Improvement in Clinical Symptoms (PASS <4) at 48 hours	68% (82/120)	85% (102/120)	0.01
Median Time to Symptom Resolution	36 hours (IQR: 30–42 hours)	24 hours (IQR: 18–30 hours)	<0.001
Mean Hospital Stay (hours)	48.3 ± 16.2	42.1 ± 14.7	0.05
Adverse Event Rate	2.5% (3/120)	12.5% (15/120)	<0.001
Readmission Rate (30 days)	6.7% (8/120)	4.2% (5/120)	0.25

Table 5: Oxygen Saturation Improvement by Treatment Group (24 and 48 Hours)

Time Point	Nebulized Corticosteroid Group (n=120)	Systemic Corticosteroid Group (n=120)	p-value
Baseline Oxygen Saturation (%)	91.4% ± 3.2%	91.6% ± 3.4%	0.75
Oxygen Saturation (24 hours)	94.1% ± 2.5%	95.2% ± 2.6%	<0.001
Oxygen Saturation (48 hours)	97.2% ± 1.9%	98.4% ± 1.7%	<0.001

Difference from Baseline (24 hours)	+2.7% ± 2.5%	+3.6% ± 2.6%	<0.001
Difference from Baseline (48 hours)	+5.8% ± 3.2%	+6.8% ± 3.1%	<0.001

5. DISCUSSION

The findings demonstrate that both treatment options lead to significant clinical improvement, but systemic corticosteroids were associated with faster resolution of symptoms, greater improvement in key respiratory parameters, and a shorter hospital length of stay. But the concentration of systemic corticosteroid group more often reactions, primary to behavior and appetite. Here, both nebulized and systemic corticosteroids had an excellent reduction capacity of the severity of asthma exacerbations [13]. The first clinical outcome, the Pediatric Asthma Severity Score, was statistically significantly better than baseline at 24 and 48 hours in both groups. Indeed, the improvement within the systemic corticosteroid group was significantly more pronounced and developed more quickly [14]. At 48h, the mean PASS score of the patients under systemic corticosteroid was thus considerably lower than patients under nebulised group (2.1 vs 3.5, $p < 0.001$) indicating earlier symptom resolution. This observation is also in line with other scholarly work indicating that systemic administered corticosteroids particular in asthma act directly to the inflammatory processes and are likely to be rapidly effective than the nebulized forms, which act mostly on the airways [15].

Respiratory rate and oxygen saturation had also a relatively better trend in the systemic corticosteroid group. Among the patients under systemic corticosteroids the decrease in respiratory rate and increase in oxygen saturation at both 24 and 48 hours was far more significant than the nebulized group. Possibly, enhancing the acute raise in oxygen saturation resulted from ramping of the systemic corticosteroids absorption and distribution to achieve more extensive inflammation attenuation throughout the body [16]. At the end of the study, another important revelation established was the difference in the time taken by the two groups of patients to recover their symptoms. The systemic corticosteroid group showed a median time to symptom resolution of 24 hours (IQR: Patients in the “hot” aerosol group spent 30 hours (IQR 18–30 hours) compared to 36 hours (IQR 30–42) in nebulized group $p < 0.001$. This raises the possibility that systemic corticosteroids provide a more rapid pathway to symptom relief in children with moderate to severe asthma exacerbations [17]. Quicker and better relievers are crucial not only to improve the clinical results but also for the decreased rate of health-care consumption, for example, days on hospital, follow-up visits, etc. The result indicated that the use of systemic corticosteroids had a significant advantage in clinical efficacy, however, the serious side effects were observed more frequently in this group. Amongst the patients, which received systemic corticosteroid treatment and placebo, 12.5% had side effects such as irritability, increase in appetite and mild increase in weight – which are common side effects associated with corticosteroids [18]. Most of these adverse events are acute and disappear once corticosteroid administration has been stopped. However, the adverse effects in the nebulized corticosteroids were lower (2.5%), minor throat irritation, and hoarseness as compared to the side effects of systemic oral steroids [19]. This highlights a critical point in the management of pediatric asthma exacerbations: Nonetheless and despite the fact that there is evidence for greater efficacy as reflected by the improvement of some symptoms within the first few days of therapy being higher with systemic corticosteroids than with oral prednisolone the side effects among them behavioral changes and weight gain pose the long term use especially in younger children as a concern. Enhanced lung deposition produces a slower onset but nebulized corticosteroids can be used as a first-line agent in children who are at higher risk for corticosteroid related side effects or those who require a targeted treatment [20]. This study also showed that those children who received systemic corticosteroids had a shorter hospital length of stay (mean of 42.1± 14.7 hours) than the group that was administered nebulized corticosteroids (mean of 48.3 ± 16.2 hours although the p-value was = 0.05). EAR is advantageous not only from the financial point of view but also with regards to preventing the transmission of infections more prevalent in kids admitted in hospitals [21]. Thus the utilization of systemic corticosteroids may result in early discharge from the hospital which in turn could enhance the general organization of asthma exacerbation. Based on the result of the present research, the following points of practical significance can be identified. Even though both nebulized and systemic corticosteroids are standard parts of asthma exacerbation treatment, the clinician may consider using systemic corticosteroids for children with moderate and severe exacerbation that need improvement urgently. These patients especially find the systemic therapy favourable in that they realize quicker relief, less breathing difficulties and shorter hospitalization periods [22].

Limitations

While the results of this study are promising, several limitations should be acknowledged. First, the study design was limited to a 48-hour follow-up period, and longer-term outcomes such as the risk of recurrent asthma attacks or the impact on lung growth and development were not assessed.

6. CONCLUSION

It is concluded that systemic corticosteroids provide more rapid clinical improvement and faster symptom resolution compared to nebulized corticosteroids in children with acute asthma exacerbations. However, nebulized corticosteroids are associated with fewer side effects and may be a safer option for children at risk of corticosteroid-related adverse effects. Treatment selection should be guided by the severity of the exacerbation and individual patient considerations

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