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Comparison between Nebulized Magnesium Sulphate ($MgSO_4$) Versus Nebulized Salbutamol in Acute Exacerbation of Asthma in Children: A Clinical Trial

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ABSTRACT

Objective: This study aimed to evaluate whether nebulized magnesium sulphate ($MgSO_4$) offers any clinical advantage over nebulized salbutamol in children presenting with acute asthma exacerbations. **Methods:** We carried out a six-month randomized controlled trial from September 2024 to March 2025 in the Paediatrics Department at Shaikh Zayed Hospital, Lahore. A total of 100 children between 2 and 12 years of age, all with moderate to severe exacerbations (Paediatric Asthma Severity Score [PASS] > 8), were recruited. Using a double-blind design, they were randomly assigned to receive either nebulized $MgSO_4$ (Group A, n=50) or nebulized salbutamol (Group B, n=50). Each child was given three nebulizations 20 minutes apart. The primary outcome was defined as a fall of at least 4 points in PASS after 6 hours. **Results:** The two groups were well matched at baseline, with mean ages of 7.1 ± 2.6 years in the $MgSO_4$ group and 7.4 ± 2.8 years in the salbutamol group, and a slight male predominance in both (60% and 58%, respectively). After six hours, children receiving $MgSO_4$ demonstrated a greater improvement: mean PASS dropped by 5.3 ± 1.4 points compared with 4.1 ± 1.6 points in the salbutamol group (p=0.002). A clinically meaningful response (≥4-point reduction) was achieved in 86% of children on $MgSO_4$ versus 68% on salbutamol (p=0.04). Oxygen saturation also rose more sharply in the $MgSO_4$ group, from 89.3% ± 3.4 to 96.8% ± 2.1, compared with an increase from 89.6% ± 3.6 to 95.2% ± 2.8 in the salbutamol group (p=0.03). No serious adverse effects were observed, apart from minor throat irritation in a few cases. **Conclusion:** Nebulized magnesium sulphate proved more effective than salbutamol alone in improving clinical outcomes for children with acute asthma exacerbations. Its ease of administration, safety profile, and low cost support its potential role as an adjunct therapy in routine pediatric emergency care.

INTRODUCTION

Asthma is one of the leading chronic respiratory diseases in children worldwide and continues to be a major cause of emergency hospital visits. In Pakistan, the burden is particularly high, with prevalence rates rising to almost 20% of the pediatric population. This growing trend not only reflects the increasing exposure of children to environmental triggers such as pollution, allergens, and infections, but also places a significant strain on healthcare systems.(1) Acute asthma exacerbations are especially dangerous because they can escalate quickly, leading to severe respiratory distress and, in some cases, respiratory failure. Management in emergency settings typically includes oxygen supplementation, rapid-acting β2-agonists like salbutamol, anticholinergics, and systemic corticosteroids. While effective for many children, research shows that up to 50% of patients achieve only partial relief, leaving a substantial group of children at risk of prolonged symptoms, hospital admission, or complications.(2)

Magnesium sulphate ($MgSO_4$) has emerged as a promising adjunctive therapy in these situations. Physiologically, magnesium is a key intracellular cation involved in smooth muscle regulation, neuromuscular transmission, and enzyme function. Its bronchodilatory effect is primarily mediated by antagonizing calcium influx into airway smooth muscle cells, thereby reducing muscle contraction.(3) Additionally, $MgSO_4$ decreases the release of acetylcholine at the neuromuscular junction, stabilizes mast cells to limit histamine release, and augments β2-adrenergic responsiveness.(4) These mechanisms together produce relaxation of the bronchial musculature and improved airflow. Intravenous magnesium has been widely studied in severe asthma and has consistently demonstrated benefits, including improved lung function and reduced hospitalization rates. However, systemic

administration carries risks such as hypotension, flushing, and arrhythmias, limiting its routine use in children.[5,6]

Nebulized $MgSO_4$ offers a safer and more practical alternative, delivering the drug directly to the bronchial tree where its action is most needed. This route allows for a rapid onset of bronchodilation, reduced systemic absorption, and fewer side effects compared with intravenous use.[7] Several clinical trials abroad have reported encouraging results, showing that nebulized $MgSO_4$, either alone or in combination with salbutamol, can improve pulmonary function and reduce the need for hospital admission.[8] Yet, the findings are not entirely consistent, and evidence in the South Asian pediatric population remains scarce. Considering the high burden of asthma in Pakistani children, limited therapeutic options for non-responders, and the potential of $MgSO_4$ as a cost-effective therapy, it is crucial to investigate its role further. This trial was therefore designed to directly compare the clinical efficacy of nebulized $MgSO_4$ with nebulized salbutamol in acute asthma exacerbations among children in our setting.[9,10]

METHODOLOGY

This study was designed as a double-blind, randomized controlled trial conducted in the Department of Paediatrics, Shaikh Zayed Hospital, Lahore. The trial was carried out over a period of six months from September 2024 to March 2025, following approval from the CPSP ethical review committee. A total of 100 children were enrolled, with the sample size calculated using standard confidence interval and power analysis techniques. Participants were randomly assigned in equal numbers to the two study groups.

Study Population

Children between the ages of 2 and 12 years, of either gender, presenting with acute moderate to severe asthma exacerbation were eligible for inclusion. Severity was defined by a Paediatric Asthma Severity Score (PASS) greater than 8, and only those who remained unresponsive to standard therapy after 60 minutes were recruited. Children with a history of chronic lung disease, abnormal renal or hepatic function, hypersensitivity to magnesium sulphate, or other significant comorbid illnesses were excluded to minimize confounding factors.

Interventions

Participants were allocated into two groups by random coding. Group A received nebulized magnesium sulphate in the form of a 6% isotonic solution (2.5 mL per dose) administered three times at 20-minute intervals. Group B received standard nebulized salbutamol at a dose of 2.5 mg per session, also given three times at 20-minute intervals. Both groups continued to receive standard emergency care, which included oxygen supplementation and systemic corticosteroids, as per hospital protocol.

Outcome Measures

The primary outcome was defined as a reduction of at least four points in PASS at six hours post-intervention. Secondary outcomes included improvements in respiratory rate, oxygen saturation levels, and auscultatory findings on chest examination. All observations were recorded on a structured proforma by trained pediatric residents who were blinded to the group allocation.

Data Collection & Analysis

All study data were collected on a predesigned structured proforma that captured demographic characteristics, baseline clinical details, and outcome measures for each participant. Data entry and analysis were performed using SPSS version 26. Continuous variables such as age, Paediatric Asthma Severity Score (PASS), and oxygen saturation were summarized as mean ± standard deviation (SD). Categorical variables, including gender distribution, response rates, and adverse effects, were presented as frequencies and percentages.

For comparison between the two treatment groups, independent sample t-tests were applied to assess differences in continuous variables, while chi-square tests were used for categorical outcomes. A p-value of less than 0.05 was taken as the threshold for statistical significance. This approach ensured robust evaluation of both clinical efficacy and safety outcomes across the two treatment arms.

RESULTS

The baseline demographic and clinical characteristics of the two groups are presented in Table 1. There were no statistically significant differences between the magnesium sulphate ($MgSO_4$) and salbutamol groups with respect to age, gender distribution, baseline Paediatric Asthma Severity Score (PASS), or initial oxygen saturation, indicating that the groups were comparable at baseline.

Table 1

Baseline Characteristics of Patients

Variable	$MgSO_4$ Group (n=50)	Salbutamol Group (n=50)	p-value
Mean Age (years)	7.1 ± 2.6	7.4 ± 2.8	0.62
Gender (M/F)	30/20	29/21	0.84
Mean Baseline PASS	12.2 ± 1.3	12.1 ± 1.5	0.76
Baseline SpO_2 (%)	89.3 ± 3.4	89.6 ± 3.6	0.72

Clinical outcomes at six hours post-treatment are summarized in Table 2. Children in the $MgSO_4$ group showed a significantly greater reduction in PASS compared to the salbutamol group. The proportion of patients achieving an effective clinical response (≥4-point reduction in PASS) was also higher in the $MgSO_4$ group. Similarly, oxygen saturation improved more with $MgSO_4$, whereas the need for admission and adverse effects did not differ significantly between groups.

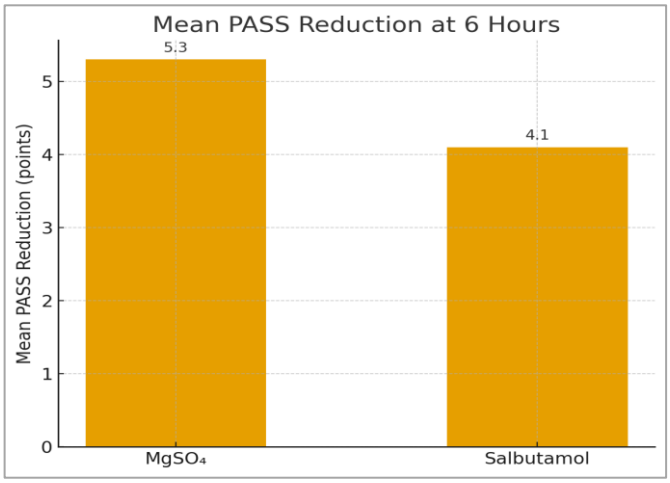
Table 2

Clinical Outcomes at 6 Hours

Outcome	$MgSO_4$ Group (n=50)	Salbutamol Group (n=50)	p-value
Mean PASS reduction	5.3 ± 1.4	4.1 ± 1.6	0.002
Efficacy (≥4 point PASS drop)	43 (86%)	34 (68%)	0.04
Final SpO_2 (%)	96.8 ± 2.1	95.2 ± 2.8	0.03
Need for admission	12 (24%)	19 (38%)	0.12
Adverse effects	2 (4%)	3 (6%)	0.64

Figure 1

Mean PASS reduction at 6 hours. The bar chart demonstrates that children treated with $MgSO_4$ had a greater reduction in PASS compared to those who received salbutamol.



DISCUSSION

This randomized controlled trial provides evidence that nebulized magnesium sulphate ($MgSO_4$) is more effective than salbutamol alone in reducing asthma severity scores and improving oxygenation in children with acute exacerbations.[1,2] The $MgSO_4$ group not only demonstrated a greater mean reduction in Paediatric Asthma Severity Scores (PASS) but also showed higher rates of clinically meaningful improvement compared with the salbutamol group. These findings highlight the potential role of $MgSO_4$ as a front-line adjunctive therapy in pediatric asthma management. The results align with several previous studies conducted internationally, which reported enhanced bronchodilation and improved lung function when $MgSO_4$ was combined with standard therapy. Importantly, our trial confirms that the nebulized route is both safe and effective, avoiding the systemic adverse effects associated with intravenous administration.[3]

From a clinical and public health perspective, these results carry important implications. Acute asthma exacerbations are a major cause of pediatric emergency visits, hospitalizations, and even mortality in low- and middle-income countries.[4] In Pakistan, where healthcare resources are limited and many families cannot afford prolonged hospital stays, introducing a low-cost and readily available intervention such as nebulized $MgSO_4$ could have significant benefits. Its rapid onset of action, favorable safety profile, and affordability make it especially suitable for busy emergency departments as well as secondary-level hospitals where advanced facilities may not be available.[5,6] By reducing the proportion of children requiring hospital admission, $MgSO_4$ could also help ease the burden on tertiary hospitals and improve the efficiency of healthcare delivery. Thus, beyond individual patient benefits, this intervention has the potential to strengthen the healthcare system as a whole.[7]

Nevertheless, it is important to interpret these findings in the context of the study's limitations. The trial was conducted at a single tertiary care hospital, which may limit the generalizability of the results to other regions, particularly rural areas where patient demographics and healthcare delivery differ.[8,9] The sample size, although statistically powered, was relatively modest and may not capture the full spectrum of variability in treatment response.[10] Furthermore, the study assessed outcomes primarily at six hours, which provides insight into short-term efficacy but does not address longer-term control, relapse rates, or the impact on readmissions. Future research should therefore focus on larger, multicenter trials that include diverse populations, evaluate outcomes over extended follow-up periods, and examine the role of $MgSO_4$ in combination with different bronchodilator regimens. Such studies could also explore optimal dosing strategies and investigate whether certain subgroups of children, such as those with severe baseline hypoxemia, derive greater benefit.[11,12]

CONCLUSION

This study demonstrated that nebulized magnesium sulphate is superior to salbutamol alone in reducing asthma severity and improving oxygenation in children presenting with acute exacerbations. The intervention was well tolerated, with only minor and self-limiting side effects, and offered rapid clinical improvement within the first six hours of therapy. These findings suggest that $MgSO_4$ delivered via nebulization is not only effective but also practical in the pediatric emergency setting. Its safety, affordability, and ease of administration make it particularly valuable in low-resource healthcare environments such as Pakistan, where the burden of pediatric asthma is high and access to advanced therapies is often limited.

Recommendations

Based on these results, nebulized $MgSO_4$ should be considered as an adjunctive option in the emergency management of children with moderate to severe acute asthma exacerbations, particularly when the response to standard therapy is inadequate. Incorporating $MgSO_4$ into local asthma management protocols could help reduce hospital admissions, improve patient outcomes, and decrease the overall strain on healthcare services.

Future research should build upon these findings by conducting larger, multicenter trials that include diverse patient populations and longer follow-up periods to evaluate sustained efficacy and relapse rates. Studies exploring the optimal dosage, frequency, and potential synergistic effects when combined with other bronchodilators would provide further clarity. Additionally, cost-effectiveness analyses in the local healthcare context would be useful to strengthen policy recommendations and guide integration into clinical practice.

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