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Clinical Outcomes of Magnesium Sulphate Nebulization in Acute Bronchiolitis Patients Admitted in a Tertiary Care Hospital

Nadia Iqbal, Khurram Fayyaz, Nadeem Sadiq, Saadia Karim, Ehsan Qadir, Imrana Atta

ABSTRACT

Objective: The objective of this research is to analyze the treatment results of nebulized magnesium sulphate for acute bronchiolitis patients requiring hospital admission at a tertiary care medical facility.

Study design and Setting: After the ethical approval from the institutional review board of PNS Shifa, this prospective observational study was conducted at PNS Shifa hospital, Karachi, from December 2024 to May 2025.

Methodology: This prospective observational study was conducted at PNS Shifa Hospital, Karachi (Dec 2024–May 2025; ERC/2023/Paeds/25-A). One hundred children (1–24 months) with acute bronchiolitis were enrolled; exclusions were congenital heart or lung disease, immunodeficiency, bacterial pneumonia, or prior intubation. Patients received either standard supportive care or standard care plus nebulized magnesium sulphate (150 mg in 2 mL NS every 6 hours for 24–48 h). Respiratory parameters, ICU admission, ventilator need, and hospital stay were assessed. Data were analyzed in SPSS v25 using paired t-test/chi-square with significance at $p<0.05$.

Results: A total of 100 children were enrolled (33 standard nebulization, 67 magnesium sulphate). Baseline demographics, weight, respiratory rate, and oxygen saturation were comparable between groups ($p>0.05$). Post-treatment oxygen saturation improved significantly with magnesium sulphate (97.2% vs. 95.8%, $p=0.003$), while respiratory rate reduction was similar ($p=0.666$). ICU admissions were lower with magnesium sulphate (15% vs. 30%, $p=0.017$). Length of stay, number of nebulization, need for ventilation, and mortality showed no significant differences.

Conclusions: Nebulized magnesium sulphate in addition to standard care significantly improved oxygen saturation and reduced ICU admissions in children with acute bronchiolitis.

Keywords: Bronchiolitis, Children, Magnesium Sulphate, Nebulization.

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INTRODUCTION

Acute bronchiolitis is one of the leading lower respiratory tract infections in infants younger than 2 years and accounts for a considerable proportion of pediatric morbidity and hospitalizations worldwide. It is most commonly the result of Respiratory Syncytial Virus (RSV), but other pathogens such as parainfluenza virus, adenovirus, human metapneumovirus and rhinovirus have also been identified. Inflammation, edema of the smaller airways and mucus plugging occur as a consequence of infection, making airflow obstruction secondary to gas exchange disturbances and respiratory distress.[1,2] In low-income countries bronchiolitis presents an additional formidable challenge owing to restricted access to intensive care units (ICUs), higher rates of viral transmission in crowding living environments, and a higher prevalence of malnutrition and comorbid respiratory conditions.

Although etiologies are well known after many years of research, acute bronchiolitis is managed mostly with supportive therapies.[2] Standard therapy involves euvolumia, oxygen supplementation for hypoxemia and ventilator support as required. Pharmacological interventions (e.g., bronchodilators, corticosteroids, epinephrine and antiviral

agents) are not without conflicting evidence in reducing duration of symptoms, time spent in hospital or the requirement for intensive care facilities.[2] The 2014 AAP guidelines do not recommend routine bronchodilator or corticosteroid use in the treatment of bronchiolitis, and they highlight role management.[2] Nevertheless, given the high worldwide prevalence and cost limitations of current therapy options, there is an urgent need for low-cost pharmacological alternatives that are accessible to all patients everywhere and can achieve better clinical results.

One such candidate treatment under investigation is magnesium sulphate (MgSO4), a drug with established smooth muscle relaxant and anti-inflammatory properties. Physiologically, magnesium acts as a calcium antagonist by blunting calcium influx into smooth muscle cells and curtailing the release of acetylcholine at neuromuscular junctions.[3] This effect leads to bronchodilation, diminished airway hyperactivity and potential reversal of bronchospasm in obstructive airway diseases. Second, magnesium is an anti-inflammatory agent and has membrane-stabilizing properties. This might reduce airway mucosal edema and oxidative damage in bronchiolar epithelium.[4]

Magnesium sulphate has a recognized beneficial effect in acute severe asthma, and is known to improve peak expiratory flow rate, oxygen saturation, and the hospitalization of individuals.[5-7] With these advances for the treatment of asthma, there has been clinical interest in whether similar benefits could be derived for bronchiolitis, because of some shared pathogenic pathways of airway obstruction and inflammation.

However, studies of MgSO4 in acute bronchiolitis have yielded conflicting results. Some RCTs investigating the nebulized strategy of MGSO4 in children have showed several advantages including lower clinical severity score, good improvement in oxygenation and less length of hospital stay.[3-5] For example, Sharma et al. (2013) and Gadomski et al. (2016) found that respiratory rate and oxygen saturation improved remarkably in children treated nebulized $MgSO_4$ as compared to those given normal saline. These findings indicated that magnesium would increase the airway relaxation and mucociliary clearance, accelerating the recovery.[4-5]

On the other hand, other studies have been unable to confirm these results. In researchers studies that presented by Modaresi et al. (2017) and Ralston et al. (2018) observed that severity scores of clinical, oxygen requirements and duration of hospital stay were not significantly different between the magnesium-treated and control groups.[6] Furthermore, a small number of studies have implied or reported potential negative aspects of this practice, such as incomplete readiness for departure from the hospital and high readmission rate in some subgroups treated with intravenous magnesium sulphate.[6-8]

A Cochrane review on the use of magnesium in bronchiolitis concluded that available evidence is scarce, its quality heterogeneous and it cannot be supported for clinical practice routinely.[1] The studies ranged greatly in terms of sample size, method of administration (neb vs IV), dose, outcome measurements and enrollment criteria. Likewise, a recently published network meta-analysis in 2023 has retired that magnesium sulphate is a bloomer as bronchodilator while evidences are unsounded to support standard therapy in bronchiolitis.[9]

Notwithstanding these caveats, magnesium sulphate is still a promising candidate to study further. Inexpensive, readily available even in resource-limited conditions, and generally safe in pediatric patients when used within recommended therapeutic boundaries.[8] Side effects such as hypotension, bradycardia, and hyporeflexia are uncommon at nebulized doses except with very high intravenous concentrations. Furthermore, the anti-inflammatory, vasodilatory and mucolytic effects could reasonably support effectively due to the supportive treatment of children with bronchiolitis that might lead to a distinct decrease of the airway obstruction rate and an increase in O2.

In this context, we conducted the present study to assess the therapeutic effectiveness of nebulized magnesium sulphate in infants with acute bronchiolitis. In particular, clinical severity scores, oxygen saturation and hospital length of stay versus standard supportive therapy. Through studying clinical as well as biochemical parameters in a tertiary care hospital, this study aims to establish if magnesium sulphate can make a difference to patient outcomes and join the divide that exists between hope on paper and applicability at bedside.

In this manner, the trial supports an evolving evidence base on management of bronchiolitis and helps frame future large trials that may define the role of $MgSO_4$ in pediatric respiratory practice. If successful, nebulized magnesium sulphate might provide a cheap, safe and easily available option to facilitate recovery in the young infants suffering from acute bronchiolitis by expediting their discharge from hospital—especially at resource-limited settings where pharmacological alternatives are far-fetched.

METHODOLOGY

This is a prospective comparative cohort study conducted in the Department of Paediatrics PNS Shifa Hospital, Karachi, with approval from the Institutional Review Board (Approval No. ERC/2023/Paeds/25-A). The study was done following the ethical principles of the Declaration of Helsinki. Before enrolling, written informed consent was obtained from all parents/legal guardians. Participants' confidentiality and anonymity were kept throughout the study and they could drop off at any point of the study without impacting their medical management.

During the study period, a consecutive sample of 150 eligible children aged 1–24 months with acute bronchiolitis was

admitted. A consultant paediatrician confirmed the diagnosis based on World Health Organization (WHO) clinical criteria and the Respiratory Distress Assessment Instrument (RDAI) was used to assess the diagnosis. Diagnostic features were cough, wheezing, tachypnea, nasal flaring, and chest retractions after an upper respiratory tract infection. The study excluded children with congenital heart disease, chronic lung disease, immunodeficiency syndromes (including HIV infection), bacterial pneumonia, previous endotracheal intubation or mechanical ventilation for respiratory failure, and those undergoing any of the investigational treatment for bronchiolitis.

After enrolment, the participants were divided into two groups based on the treatment plan decided by the treating pediatrician. The comparison group included patients who received standard supportive treatment and the intervention group included patients who received standard supportive treatment plus nebulized magnesium sulphate ($MgSO_4$).

Standard supportive care consisted of humidified oxygen therapy, fluid management as appropriate and inhaled normal saline and/or bronchodilators (salbutamol or epinephrine) if clinically indicated. Neubulized $MgSO_4$ was given as an intervention along with standard care. Nebulizations consisted of 150 mg of $MgSO_4$ in 2 mL of normal saline and were given every six hours for 24–48 hours as dictated by the patient's clinical response and the physician's discretion. All treatments were provided under trained paediatric supervision and oxygen saturations and heart rate monitored using pulse oximetry. Antibiotics and other adjunctive treatment were not routinely administered unless clinically indicated.

At the baseline and during hospitalization until discharge, clinical and demographic data were recorded. The main outcome variables were difference in clinical severity score, respiratory rate and oxygen saturation after treatment. Secondary outcome measures were number of nebulization sessions required, length of hospital stay, need for intensive care unit (ICU) admission and need for mechanical ventilation, adverse events and survival to discharge.

The severity of respiratory distress was determined by a validated clinical scoring system, based on respiratory rate, severity of wheezing, chest retractions and feeding intolerance. Hypoxemia was defined as oxygen saturation < 92% on room air. Active surveillance and management of possible side effects of magnesium sulphate treatment such as facial flushing, bradycardia and hypotension were undertaken.

All the demographic and clinical data were documented on a predesigned structured proforma. Completed forms were checked daily for completeness and correctness of data by the principal investigator. Standardized equipment and uniform assessment procedures were used throughout the study, thereby minimizing variability in measurements. Prior training of the nursing and clinical staff was provided on the study procedures and data collection techniques.

SPSS version 25.0 was used for data analysis. The continuous data were presented as mean ± standard deviation (SD) and the categorical data as frequencies and percentages. Independent-samples t-test and Chi-square or Fisher's exact test was used to compare the standard nebulization and magnesium sulphate nebulization groups as appropriate. A p-value <0.05 was considered statistically significant.

All participant identifiers were coded using coded numbers and the information was kept in electronic databases with password protection so as to maintain confidentiality. The Institutional Review Board was contacted with any adverse or unexpected events. The ethical principles of beneficence, respect for persons, autonomy and confidentiality were respected at all phases of the study.

RESULTS

A total of 100 children with acute bronchiolitis were enrolled, comprising 33 in the standard nebulization group and 67 in the nebulized magnesium sulphate group. The mean age was 13.5 ± 6.4 months in the standard group and 11.6 ± 6.4 months in the magnesium sulphate group (p=0.374). Male patients constituted 51% (n=17) in the standard group and 61% (n=41) in the magnesium sulphate group, while females accounted for 49% (n=16) and 39% (n=26), respectively (p=0.475). Mean weight was 7.03 ± 2.25 kg in the standard group compared to 7.8 ± 2.5 kg in the magnesium sulphate group (p=0.263). The demographic details are shown in Table 1. Table 2 shows the comparison of respiratory parameters in the two treatment groups. There was no difference between the standard nebulization and the magnesium sulphate group regarding RR at baseline (60.87 ± 10.6 vs. 62.9 ± 11.1 breaths/min, p=0.146). Similarly, no significant differences existed between the groups with regard to baseline oxygen saturation (91.3 ± 4.0% vs. 90.8 ± 4.06%, p=0.755). After treatment, post treatment respiratory rates were similar in both groups (43.3 ± 9.4 vs. 42.02 ± 8.5 breaths/min, p=0.666). But post-treatment oxygen saturation was much better in kids who were nebulized with magnesium sulphate than in those who were nebulized without magnesium sulphate (97.2 ± 1.91% vs. 95.8 ± 2.4%, p=0.003). The clinical outcomes are reported in Table 3. The mean number of nebulization sessions was similar in both groups (2.78 ± 1.49 vs. 2.98 ± 1.5, p=0.392). There was no statistically significant difference in the length of hospital stay between the two groups (5.4 ± 2.1 vs. 6.0 ± 2.1 days, p=0.760) though it was slightly shorter in the magnesium sulphate group. There were fewer admissions in the magnesium sulphate group than the standard nebulization group (15% vs. 30%, p=0.017). The need for mechanical ventilation was reduced in the magnesium sulphate group; however, it was not statistically significant (p=0.103). There was a low mortality rate in both groups (p=0.572), two deaths (6%) in the standard nebulization

group and one death (1%) in the magnesium sulphate group. In sum, nebulized magnesium sulphate was more likely to be associated with better oxygen saturation and to have a reduced need for admission to the intensive care unit than standard nebulization therapy.

DISCUSSION

Bronchiolitis continues to be a major cause of morbidity, hospitalization and healthcare utilization in young infants in early winter months. There are few useful pharmacological treatments despite decades of research (management is largely supportive with measures aimed at trying to maintain oxygenation, hydration and nutrition). It is most commonly caused by infection with respiratory syncytial virus (RSV), which results in inflammation, mucosal edema and airway obstruction from plugging of bronchi and bronchioles by mucus. Based on this pathophysiology, recent efforts have been poured into investigating the potential role of bronchodilator and anti-inflammatory agents, such as magnesium sulphate (MgSO4), as adjunctive therapy to decrease airway obstruction and enhance ventilation in acute bronchiolitis.[11]

Table 1: Demographic profile of study participants

Variables	Standard Nebulization (n=33)	Magnesium Sulphate Nebulization (n=67)	p-value
Age (months)	13.5 ± 6.4	11.6 ± 6.4	0.374
Gender			
• Male	17 (51%)	41 (61%)	0.475
• Female	16 (49%)	26 (39%)	
Weight (kg)	7.03 ± 2.25	7.8 ± 2.5	0.263

Table 2: Between-group comparison of respiratory rate and oxygen saturation before and after treatment

Variables	Standard Nebulization (n=33)	Magnesium Sulphate Nebulization (n=67)	p-value
Baseline respiratory rate (breaths/min)	60.87 ± 10.6	62.9 ± 11.1	0.146
Baseline oxygen saturation (%)	91.3 ± 4.0	90.8 ± 4.06	0.755
Post-treatment respiratory rate (breaths/min)	43.3 ± 9.4	42.02 ± 8.5	0.666
Post-treatment oxygen saturation (%)	95.8 ± 2.4	97.2 ± 1.91	0.003*

* Significant at $p < 0.05$

Table 3: Clinical outcomes of study participants

Variables	Standard Nebulization (n=33)	Magnesium Sulphate Nebulization (n=67)	p-value
Number of nebulization sessions	2.78 ± 1.49	2.98 ± 1.5	0.392
Length of hospital stay (days)	6.0 ± 2.1	5.4 ± 2.1	0.760
ICU admission	10 (30%)	10 (15%)	0.017*
Mechanical ventilation	6 (18%)	4 (6%)	0.103
Outcome			
• Expired	2 (6%)	1 (1%)	0.572
• Discharged	31 (94%)	66 (99%)	

* Significant at $p < 0.05$

Magnesium is crucial as a calcium antagonist in smooth muscle relaxation with resultant reduced calcium inward flow into cells and decreased acetylcholine release at neuromuscular junctions. These effects have a synergistic beneficial impact on bronchodilation and airway hyperactivity-administered as nebulized combination products.[12] In addition, magnesium has anti-inflammatory and membrane-stabilizing effects and could work to reduce airway oedema and hypersecretion of mucus. These physiologic characteristics have established its potential role in the treatment of acute severe asthma and generated interest for its use in bronchiolitis, particularly among infants with moderate to severe respiratory distress who do not improve with traditional therapies.

Recent studies evaluating the clinical efficacy of magnesium sulphate in children with respiratory diseases, especially bronchiolitis, have yielded contradictory data. [a]1k et al. observed that intravenous $MgSO_4$ significantly increased clinical scores, oxygen saturation and reduced hospital stay in children with acute bronchiolitis, indicating potential benefit in moderate–severe cases of the disease where an airway obstruction and airway inflammation are more intense.[13] Similarly, Guruprasad et al. demonstrated the efficacy of $MgSO_4$ nebulization for moderate bronchiolitis, but also found that it was only minimally effective with no reduction in length of stay. This indicated that magnesium may alleviate the symptoms for mild cases or when mechanical supportive therapy is already effective, but not produce significant changes in disease development.[12]

However, there are also studies that have shown no or equivocal effect. In a RCT, compared nebulized $MgSO_4$ with nebulized salbutamol and saline; they also noticed no difference between the groups in clinical improvement or time to discharge. Their results reinforced the need for interpretive caution with respect to presumed efficacy of $MgSO_4$ agent, since studies differed in patient populations, doses and severity of illness.[13] However, these findings should not completely rule out a potential therapeutic benefit of magnesium but underscore the need to identify subgroups of patients in whom it may be justified.

Credible evidence from high risk pediatric populations also offers tempered optimism. Yasin et al. found beneficial effects of intravenous $MgSO_4$ on respiratory outcomes and the need for mechanical ventilation in acute pediatric respiratory conditions, such as bronchiolitis. Their results corroborate the theory that magnesium could prevent an increased need for care by enhancing bronchial smooth muscle relaxation and diminishing inflammatory damage. Similarly, nebulized magnesium sulphate with hypertonic saline and reported that clinical scores were better, respiratory distress was improved faster with magnesium but there was no significant reduction in length of stay or requirement for ICU. These results indicate that magnesium may shorten the symptom duration and does not necessarily reduce total disease length.[14-15]

Additional perspective may be obtained from the use of magnesium in pediatric asthma, a disease with similar pathophysiology that includes bronchoconstriction and airway inflammation. The trial protocol of the MagNUM PA trial and the subsequent report by Schuh and colleagues found modest benefit from adding nebulized $MgSO_4$ to albuterol in pediatric refractory asthma, further supporting the idea that magnesium's efficacy can be small and indication-specific. However, study conducted a meta-analysis pooled both intravenous and nebulized $MgSO_4$ led to improved oxygenation and decreased hospitalization of children with acute exacerbations of asthma. Such similarities of asthma and bronchiolitis pathophysiology provide an indirect support regarding the potential role of magnesium as a therapeutic agent in correcting small airway obstruction and ventilation-perfusion mismatch in bronchiolitis.[16-17]

The discrepancies have also been addressed by large-scale reviews and meta-analyses. In a 2024 systematic review, found that nebulized magnesium sulphate was a safe and well-tolerated adjunct for treatment of asthma, but efficacy differed between studies.[18] The variability in outcomes was primarily attributable to variations of the dosing schedule, duration of treatment, nebulation methodology and the degree of initial disease severity in included subjects. More recently, study showed that early intravenous magnesium administration in acute childhood asthma decreased the severity of symptoms, length of hospital stay and improved clinical outcome and provided further justification for studying its use in other pediatric airway disease such as bronchiolitis.[19]

Our evidence fits within this emerging evidence base. We also saw a statistically significant elevation in oxygen saturation and a drop in the number of patients requiring ICU admission for those who received nebulized magnesium sulphate vs alone with standard therapy. These findings indicate that magnesium might be of benefit in moderate-to-severe bronchiolitis by promoting bronchodilation, increasing ventilation and possibly reducing the risk of clinical deterioration requiring intensive care support. The absence of significant adverse effects in our series confirms the outstanding safety profile of nebulized magnesium if cautiously used under clinical control.[20]

Nevertheless, despite these promising results, there are some limitations to be taken into account. The amount of benefit in such studies is, however, significant rather than spectacular and may not always represent a clinically important difference, especially regarding time to hospital discharge or total recovery time. Besides, the difference in causative agent, viral strains and immune responses of patients may affect therapeutic effects. Magnesium treatment, therefore, should not be substituted for established supportive care measures but rather may be an adjunct in a subgroup of patients who present with moderate respiratory distress. The totality of the evidence, based on the current literature suggests that despite being safe, low-cost and physiologically justified adjuvant therapy magnesium sulphate is not consistently effective in bronchiolitis. Variations in study populations, size of the sample studied, route of administration, dosing schedule and severity of disease may explain the discrepancy between trials. Our results of a beneficial effect for oxygenation and reduced ICU requirement, also lend support to targeted use in specific pediatric populations. However, further large-scale multicenter randomized controlled trials with standardized protocols are required to clarify the best-dosing regimen, duration of treatment and patient selection who will likely benefit from magnesium therapy. Until such evidence arrives, magnesium sulphate ought to be viewed more as a welcome adjunct than the treatment of choice in acute bronchiolitis.

CONCLUSION

Our observational study suggests that adjunctive nebulized magnesium sulfate may enhance oxygenation and reduce ICU transfer in pediatric acute bronchiolitis, with potential but as yet unconfirmed benefits in other outcomes. Given the limited and heterogeneous body of existing evidence, high-quality randomized trials are essential to define the role, dosage and patient populations in which magnesium therapy could be beneficial.

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Nadia Iqbal: Conception and design of study, data collection, drafting of manuscript, and final approval.
Khurram Fayyaz: Study supervision, methodology refinement, and critical review of manuscript.
Nadeem Sadiq: Data interpretation, technical guidance, and literature review
Sadia Karim: Assistance in manuscript writing, literature search, and referencing.
Ehsan Qadir: Statistical analysis, interpretation of results, and preparation of tables/figures.
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