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Original Research Article

Comparative Evaluation of Nebulized 3% Hypertonic Saline and Nebulized Adrenaline in the Management of Acute Bronchiolitis in Pediatric Patients: A Prospective Hospital-Based Study

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Abstract:

Background: Acute bronchiolitis is the most common lower respiratory tract infection among infants and children younger than two years of age and remains a major cause of hospitalization worldwide. The disease is characterized by inflammation, edema, necrosis of epithelial cells lining the small airways, and increased mucus production, resulting in airway obstruction and respiratory distress. Respiratory Syncytial Virus (RSV) is the most frequently implicated pathogen, accounting for approximately 60–80% of cases. Although supportive care remains the cornerstone of treatment, nebulized therapies such as hypertonic saline and adrenaline are widely used to improve clinical outcomes.

Aim: To compare the efficacy and duration of hospitalization associated with nebulized 3% hypertonic saline and nebulized adrenaline in pediatric patients suffering from acute bronchiolitis.

Materials and Methods: A prospective observational study was conducted in the Departments of Pharmacology and Pediatrics at Muzaffarnagar Medical College and Hospital, Uttar Pradesh. A total of 100 children aged 3 months to 3 years diagnosed with acute bronchiolitis were enrolled. Fifty patients received nebulized 3% hypertonic saline and fifty received nebulized adrenaline. Clinical severity was assessed using the Wang Bronchiolitis. Statistical analysis was performed using SPSS version 29.

Results: Among the enrolled patients, 96 completed the study. Hypertonic saline therapy resulted in significantly greater improvement in respiratory rate scores, wheezing scores, chest retraction scores, and general appearance scores compared to adrenaline therapy. By Day 3, respiratory rate scores decreased from 2.22±0.61 to 1.34±0.47 in the hypertonic saline group compared with 2.44±0.67 to 1.80±0.53 in the adrenaline group. Wheezing scores declined significantly by Day 3 (0.92±0.27 vs 1.31±0.27, $p<0.05$). Mean duration of hospitalization was significantly shorter in the hypertonic saline group (4.32±0.59 days) compared to the adrenaline group (8.72±0.72 days; $p<0.001$).

Conclusion: Patients receiving nebulized hypertonic saline showed greater reductions in respiratory distress, wheezing, chest retractions, and overall disease severity scores, along with a significantly shorter duration of hospitalization. These findings suggest that nebulized 3% hypertonic saline is an effective and clinically beneficial therapeutic option for the management of acute bronchiolitis in pediatric patients.

Keywords: Acute bronchiolitis, Hypertonic saline, Adrenaline, Respiratory Syncytial Virus, Nebulization, Wang Bronchiolitis Severity Score.

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Introduction

Acute bronchiolitis is one of the most common causes of lower respiratory tract infection and hospitalization among infants and young children worldwide. It is a viral infection predominantly affecting children younger than two years of age and is characterized by inflammation, edema, and necrosis of the epithelial lining of the small airways accompanied by increased mucus production and bronchospasm. These pathological changes result in airway obstruction, impaired gas exchange, respiratory distress, wheezing, and feeding difficulties. Acute bronchiolitis represents a substantial burden on healthcare systems because of its high incidence, frequent hospital admissions, and significant morbidity among young children, particularly in developing countries where access to healthcare resources may be limited. [1,2]

Bronchiolitis was first described in the early twentieth century as a distinct clinical entity affecting infants and has since become recognized as a major public health concern. The disease affects nearly every child during the first two years of life, with approximately 2–3% requiring hospitalization annually. Recent epidemiological studies have estimated that bronchiolitis accounts for more than 3 million hospital admissions globally each year and remains a leading cause of infant hospitalization during winter months. [3,4].

Respiratory Syncytial Virus (RSV) is responsible for approximately 60–80% of bronchiolitis cases worldwide and continues to be the predominant etiological agent. Other viral pathogens include rhinovirus, human metapneumovirus, parainfluenza virus, adenovirus, influenza virus, coronavirus, and bocavirus. Mixed viral infections are increasingly recognized owing to advances in molecular diagnostic techniques.[5–7]Recent surveillance studies have shown changing epidemiological trends following the COVID-19 pandemic, with alterations in RSV seasonality and increased susceptibility among infants due to reduced viral exposure during lockdown periods.[8,9].The pathophysiology of bronchiolitis involves viral invasion of bronchiolar epithelial cells resulting in inflammation, cellular necrosis, mucosal edema, and increased mucus production. These changes cause narrowing and obstruction of small airways, leading to air trapping, atelectasis, ventilation-perfusion mismatch, and hypoxemia. The immature immune system of infants contributes to increased susceptibility and severity of infection. [10,11]

Several risk factors have been associated with severe bronchiolitis including prematurity, low birth weight, congenital heart disease, chronic lung disease, immunodeficiency, passive smoking, overcrowding, malnutrition, lack of breastfeeding, and socioeconomic deprivation. Recent multicenter studies have identified environmental pollution and climate-related factors as emerging contributors to bronchiolitis severity. [12–14]. Clinically, bronchiolitis typically begins with symptoms of upper respiratory tract infection such as rhinorrhea, nasal congestion, and low-grade fever, followed by cough, wheezing, tachypnea, chest retractions, crackles, and respiratory distress. Severe cases may present with apnea, cyanosis, dehydration, or respiratory failure requiring intensive care support. [15,16]. The diagnosis of bronchiolitis remains largely clinical and is based on history and physical examination findings. Routine laboratory investigations and radiographic imaging are generally not recommended in uncomplicated cases because they rarely alter management and may increase healthcare costs. Clinical scoring systems such as the Wang Bronchiolitis Severity Score are frequently employed to assess disease severity and monitor therapeutic response. [17,18]. Management of acute bronchiolitis has evolved considerably over the last decade. Current international guidelines emphasize supportive therapy including hydration, nutritional support, oxygen supplementation, and monitoring of respiratory status. However, despite evidence-based recommendations, considerable variation exists in clinical practice regarding pharmacological interventions. [19,20]

Nebulized hypertonic saline has gained attention as a therapeutic option because of its ability to improve mucociliary clearance and reduce airway edema. Hypertonic saline exerts osmotic effects that draw water into the airway lumen, hydrate airway secretions, decrease mucus viscosity, and facilitate mucus clearance. Additionally, it may reduce inflammatory mediator activity and improve airway patency. Several randomized controlled trials and meta-analyses have demonstrated its potential to reduce hospital stay and improve clinical severity scores. [21,22] Adrenaline (epinephrine) is another commonly utilized nebulized therapy. Through alpha-adrenergic receptor stimulation, adrenaline induces vasoconstriction and reduces airway edema, while beta-adrenergic receptor activation results in bronchodilation and improved airflow. Earlier studies suggested beneficial short-term effects; however, subsequent evidence has produced conflicting results regarding sustained clinical improvement and hospitalization outcomes. [23,24]

Recent systematic reviews have highlighted inconsistencies among studies evaluating nebulized therapies for bronchiolitis. Differences in study design, patient populations, disease severity, treatment pro-

tocols, and outcome measures have contributed to variable findings. Consequently, identifying the most effective and safest nebulized therapy remains an important clinical challenge.[25]. In view of the continuing burden of bronchiolitis and the need for effective therapeutic strategies that can reduce disease severity and hospitalization, the present study was undertaken to compare nebulized 3% hypertonic saline and nebulized adrenaline in pediatric patients suffering from acute bronchiolitis. The findings are expected to provide valuable evidence regarding the relative efficacy and impact on hospital stay associated with these commonly used treatment modalities.

Material and Methods

The study was conducted in the Department of Pharmacology in collaboration with Department of Paediatrics of Muzaffarnagar Medical College and hospital. It was an open-label study. Before starting the study, approval was received from Institutional Ethical committee. Before enrollment of the patients into the study, all the information about the objectives, procedures, risk and benefits of the study was explained to the guardian. Written informed consent was obtained from the legal guardian of the patients.

Demographic data and detailed history of the participants was recorded in case record form and information regarding clinical symptoms and investigations were also recorded. Initial oxygen saturation was also recorded on arrival to the paediatric department.

A total of 100 IPD pediatric patients aged between 3 months to 3 years diagnosed with acute bronchiolitis were enrolled using purposive sampling. Inclusion criteria included patient of age 3 months to 3 years, both male and female patients, history of first episode of wheezing, meets clinical definition of bronchiolitis and parents willing to give consent. Whereas exclusion criteria included patients of age less than 3 months and more than 3 years, patients suffering from Pneumonia, Bronchopulmonary dysplasia, Gastroesophageal reflux disease and Cystic fibrosis, other causes of wheezing due to foreign body, loss to follow up and parents not willing to give consent.

Eligible participants were assigned into two comparative treatment groups, Group A received nebulization of 3% Hypertonic saline (HS) three times a day and Group B received nebulization of 2-3 ml of Adrenaline three times a day. Both groups received doses of treatment by nebulizer through well fitted mask. Nebulization continued till nebulization chamber was empty. Hospitalized patients were examined daily.

Records were maintained of the parameters for improvement or worsening of the condition. Wang Bronchiolitis Severity Score (WBSS)[26] was recorded on admission and then at 24 hourly intervals for the first three days of treatment.

Wang Bronchiolitis Severity Score

Score	Respiratory Rate	Wheezing	Chest Retraction	General Appearance
0	<30	None	None	Normal
1	30-45	Terminal expiration or only with stethoscope	Intercostal recession	
2	46-60	Entire expiration or audible on expiration without stethoscope	Trachea-sternal recession	
3	>60	Inspiration and expiration, without a stethoscope	severe	Irritable, lethargic, poor feeding

Statistical Analysis: Data was entered and analyzed using SPSS software version 29. Appropriate statistical tests were applied based on the type of variables and study objectives. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequency and percentage. To evaluate the difference in symptom improvement between the two treatment groups Z-test was performed. A p-value <0.05 was considered statistically significant.

Results

A total of 100 patients were enrolled in the study. The participants were assigned into two groups, group A hypertonic saline (HS) (n=50) and group B adrenaline (Adr) (n=50). During the study period, 4 patients in the adrenaline group dropped out of the study, so 96 patients completed the study.

Finally, the results were displayed in the form of graphs and tables.

Table 1: Age and gender distribution in HS group and Adr group.

Age (months)	HS group (n)	HS group (%)	Adr group (n)	Adr group (%)
3-5	26	52%	9	19.5%
6-8	13	26%	9	19.5%
9-11	7	14%	14	30%
≥12	4	8%	14	30%
Total	50	100%	46	100%
Mean ± SD	6.48 ± 3.4		11.02 ± 7.95	
Gender	**HS group (n)**	**HS group (%)**	**Adr group (n)**	**Adr group (%)**
Male	37	74%	36	78.2%
Female	13	26%	10	21.73%
Total	50	100%	46	100%

*HS- Hypertonic saline, Adr- Adrenaline

In our study of 96 patients, the mean age in HS group was 6.48 ± 3.4 (Mean ± SD) and the mean age in Adr group was 11.02 ± 7.95. Out of 96, in HS group 37(74%) were males and 13(26%) were females. Whereas in Adr group 36(78.2%) were males and 10(21.73%) were females.

Table No. 2: Comparison of post inhalation Wang Bronchiolitis severity score between HS group and Adr group.

Table 2- A: Respiratory rate scoring

Respiratory rate Scoring	HS group		Adr group		P value
	MEAN	SD	MEAN	SD	
Day 0	2.22	0.6158	2.44	0.6749	0.0886
Day 1	2.06	0.5859	2.38	0.6667	0.0108
Day 2	1.82	0.4819	2.20	0.5803	0.0087*
Day 3	1.34	0.4785	1.8	0.5345	<0.001**

* P<0.05 – Significant, ** P<0.001 – Highly Significant

The result of Z- Test revealed that the respiratory rate scoring decreased significantly from day 0 to day 3 in hypertonic saline group (2.22 to 1.34) as compared to adrenaline group (2.44 to 1.8).

Table No. 2-B: Wheezing (WBSS)

Wheezing	HS group		Adrenaline group		P value
	Mean	SD	Mean	SD	
Day 0	1.60	0.4949	1.54	0.5014	0.1083
Day 1	1.60	0.4949	1.54	0.5014	0.1083
Day 2	1.36	0.4849	1.49	0.3881	0.0404*
Day 3	0.92	0.2740	1.31	0.2740	0.0035*

* P<0.05 – Significant

This table reveals that although nebulized adrenaline showed an earlier reduction in wheezing scores, nebulized hypertonic saline resulted in a significantly greater and sustained improvement by Day 2 and Day 3 with p<0.0404 and p<0.0035 respectively.

Table 2 C: Chest Retraction (WBSS)

Chest retraction	HS group		Adrenaline group		P value
	Mean	SD	Mean	SD	
Day 0	1.28	0.4536	1.46	0.5035	0.0603
Day 1	1.28	0.4536	1.46	0.5035	0.0603
Day 2	1.18	0.3881	1.40	0.4949	0.0134
Day 3	0.74	0.4870	1.16	0.3703	<0.001**

* P<0.05 – Significant, ** P<0.001 – Highly Significant

This table reveals that nebulized hypertonic saline produced a significantly greater reduction in chest retraction scores from Day 2 onward with p<0.0134 and highly significant improvement by Day 3 with p<0.001.

Table 2 D: General Appearance (WBSS)

General appearance	HS group		Adrenaline group		P value
	Mean	SD	Mean	SD	
Day 0	1	0	1	0	-
Day 1	1	0	1	0	-
Day2	1	0	1	0	-
Day 3	0.7600	0.4314	1	0	0.001**

** P<0.001 – Highly SignificanT

This table reveals that there was significant improvement in general appearance in the hypertonic saline group by Day 3(P<0.001).

Table 3: Comparison between HS group and Adr group according to duration of hospitalization.

Duration of hospitalization	HS Group		Adr Group		P value
	n	%	n	%	
1-5 Days	48	96%	0	0%	-
6-10 Days	2	4%	46	100%	<0.001**
Total	50	100%	46	100%	-
Mean ± SD	4.32 ± 0.59		8.72 ± 0.72		<0.001**

** P<0.001 – Highly Significant, HS- Hypertonic saline, Adr- Adrenaline

This table reveals that in hypertonic saline group, most infants stayed in hospital for 4-5 days, whereas in adrenaline group, infants stayed in hospital for 6-10 days. Therefore, there was a highly significant difference (p<0.001) in duration of hospitalization between the two groups.

Discussion

The management of acute bronchiolitis has remained a subject of considerable debate over the last two decades because numerous pharmacological interventions have shown inconsistent benefits in clinical trials. Although supportive treatment remains the foundation of management, clinicians continue to seek therapeutic strategies capable of reducing disease severity, shortening hospitalization, and improving patient comfort.

In our study most patients were at the age of 3 months to 3 years. The mean age of patients in the hypertonic saline (HS) group was 6.48 ± 3.4 months, whereas in the adrenaline (Adr) group it was 11.02 ± 7.95 months. The highest percentage of patients belonged to the 3–5 months age category. These findings are consistent with several epidemiological studies reporting a similar age distribution among children with acute bronchiolitis. [26, 27]. In this study, males represented the largest demographic portion in both groups. In HS group there were 74% male and in Adr group there were 78% males whereas female count was 26% and 21.73% in HS and Adr group respectively.

Among the 50 infants who received hypertonic saline, the mean post-inhalation respiratory score showed a significant reduction on both day 2 and day 3 compared with the adrenaline group. The difference was found to be highly statistically significant (p < 0.0001), suggesting that nebulized hypertonic saline was more effective in improving respiratory status than nebulized adrenaline. These findings are consistent with those reported by Pamecha P et al. [26], who observed a significantly greater reduction in respiratory rate scores on both day 2 and day 3 among patients treated with hypertonic saline compared to those receiving adrenaline. Likewise, Florin et al. [1] reported that hypertonic saline produced sustained clinical improvement compared with bronchodilator therapy alone.

Improvement in respiratory distress not only reflects resolution of airway obstruction but also contributes to improved feeding, hydration, and overall patient comfort. Similar observations have been reported by Skjerven et al. [25], who demonstrated that hypertonic saline significantly reduced work of breathing in hospitalized infants with moderate bronchiolitis.

Another notable finding was the marked reduction in wheezing scores by Day 2 and Day 3 among children receiving hypertonic saline when comparing it with nebulized adrenaline Wheezing in bronchiolitis primarily results from narrowing of small airways due to edema and mucus accumulation rather than bronchospasm alone. Consequently, therapies targeting mucus clearance may be more effective than bronchodilators in improving airflow. This concept has gained increasing acceptance in recent years and is reflected in contemporary bronchiolitis guidelines.[20]

Nebulized hypertonic saline resulted in a greater reduction in chest retraction scores, with mean scores decreasing on Day 2 and Day 3 in comparison with the adrenaline group. These findings indicate that hypertonic saline was more effective than adrenaline in reducing chest retractions and, consequently, the work of breathing. The results of the present study are in agreement with those reported by Singh S et al. [28] and Anwar S et al [29]., who also observed superior improvement in chest retractions with neb-

ulized hypertonic saline. However, our findings differ from those of Elkhateeb NEAG et al. [30], who reported better improvement in chest retractions among patients treated with nebulized adrenaline compared to nebulized hypertonic saline.

In the present study, a significant improvement in general appearance was observed in the hypertonic saline (HS) group by Day 3 compared to the adrenaline group. This difference was highly statistically significant ($p < 0.0001$). The improvement in general appearance contributed to a greater reduction in the Wang Bronchiolitis Severity Score, indicating a faster and more pronounced clinical recovery in the HS group. In contrast, patients in the adrenaline group demonstrated noticeable improvement only from Day 5 onwards, suggesting that the beneficial effects of adrenaline may be relatively short-lived. These findings differ from those reported by Pamecha P et al. [26], who observed improvement in the general condition of infants in both treatment groups, with no statistically significant difference between nebulized hypertonic saline and nebulized adrenaline ($p > 0.05$).

A particularly significant outcome of the present study was the reduction in duration of hospitalization. Hospital stay is a clinically meaningful endpoint because it reflects overall disease resolution, resource utilization, and healthcare expenditure. The observed reduction from 8.72 days in the adrenaline group to 4.32 days in the hypertonic saline group represents a substantial improvement with important implications for hospital management and healthcare costs. Similar reductions have been reported by Zhang et al. [21], Luo et al. [22], and Bont et al. [31], all of whom demonstrated shorter hospital stays among infants treated with hypertonic saline.

Overall, the present study provides strong evidence that nebulized 3% hypertonic saline is superior to nebulized adrenaline for the treatment of hospitalized infants with acute bronchiolitis. The therapy demonstrated greater clinical efficacy and significant reductions in hospitalization duration. These findings support increasing incorporation of hypertonic saline into evidence-based management protocols for pediatric bronchiolitis and align with contemporary international literature emphasizing airway hydration and mucus clearance as key therapeutic targets.

Conclusion

Hypertonic saline therapy was associated with faster improvement in respiratory rate, wheezing, chest retractions, and general clinical condition. Furthermore, treatment with hypertonic saline resulted in a shorter duration of hospitalization, reflecting an earlier resolution of disease severity and a reduced healthcare burden. Taken together, the findings of this study support the use of nebulized 3% hypertonic saline as an effective and preferable therapeutic modality over nebulized adrenaline in infants with acute bronchiolitis, especially in resource-limited tertiary care settings

Limitations of the Study

1. The study was conducted at a single tertiary center.
2. The sample size was relatively small.

Declarations: Conflicts of interest: There is no any conflict of interest associated with this study

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