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COMPARISON OF EFFICACY OF NEUBULIZATION BETWEEN 3% HYPERTRONIC SALINE AND NORMAL SALINE IN ACUTE BRONCHIOLITIS

Original Research

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ABSTRACT

Background: Acute bronchiolitis is a common lower respiratory tract infection in infants and young children, primarily caused by the respiratory syncytial virus (RSV). It leads to airway inflammation, mucus hypersecretion, and obstruction, resulting in respiratory distress. Despite supportive care being the mainstay of management, nebulized hypertonic saline has gained attention for its potential to improve airway clearance, reduce airway edema, and enhance mucociliary function. This study compares the efficacy of 3% hypertonic saline versus normal saline in the treatment of acute bronchiolitis.

Objective: To evaluate and compare the efficacy of nebulized 3% hypertonic saline and 0.9% normal saline in improving clinical outcomes among children diagnosed with acute bronchiolitis.

Methods: This randomized controlled trial (RCT) was conducted at the Department of Paediatrics, Sughra Shafi Medical Complex, Narowal, over six months from November 14, 2022, to May 14, 2023. A total of 100 children aged 2 months to 2 years with a clinical diagnosis of acute bronchiolitis were enrolled. Patients were randomly assigned to either Group A (nebulized 3% hypertonic saline) or Group B (nebulized 0.9% normal saline). The primary outcome was the change in clinical severity scores, measured using the Respiratory Distress Assessment Instrument (RDAI) at different time intervals (baseline, 12, 24, 48, and 72 hours). Secondary outcomes included oxygen saturation levels, duration of oxygen therapy, length of hospital stay, recovery rates, and hospital readmission. Data were collected using standardized data forms and analyzed using IBM SPSS, version 27.0. Statistical significance was set at $p < 0.05$.

Results: Group A comprised 31 (62%) males and 19 (38%) females, while Group B had 27 (54%) males and 23 (46%) females. Upon admission, Group A had a slightly higher mean oxygen saturation level (92.79 ± 1.41) than Group B (92.20 ± 1.54, $p = 0.049$). At discharge, oxygen saturation significantly improved in both groups, with Group A showing higher levels ($p < 0.001$). Clinical severity scores were consistently lower in Group A compared to Group B at 12 hours (6.74 ± 0.56 vs. 7.54 ± 0.65), 24 hours (3.90 ± 0.65 vs. 4.82 ± 0.60), 48 hours (2.32 ± 0.55 vs. 3.40 ± 0.61), and 72 hours (1.34 ± 0.56 vs. 2.26 ± 0.63) ($p < 0.001$ for all). The duration of oxygen therapy was significantly shorter in Group A (13.88 ± 2.89 hours) compared to Group B (26.30 ± 2.31 hours) ($p < 0.001$). Rapid recovery within 72 hours was achieved by 94% ($n = 47$) in Group A compared to 38% ($n = 19$) in Group B ($p < 0.001$). Group A had a significantly shorter hospital stay (62.50 ± 11.57 hours) than Group B (76.40 ± 11.22 hours) ($p < 0.001$).

Conclusion: This study demonstrates that nebulized 3% hypertonic saline is more effective than normal saline in managing acute bronchiolitis in children. Patients treated with hypertonic saline exhibited significantly shorter hospital stays, faster recovery rates, improved oxygen saturation, and lower clinical severity scores. These findings suggest that 3% hypertonic saline should be considered a preferred treatment option for acute bronchiolitis in pediatric care.

Keywords: Acute Bronchiolitis, Airway Obstruction, Hospitalization, Hypertonic Saline Solution, Nebulization, Oxygen Therapy, Respiratory Distress.

INTRODUCTION

Acute bronchiolitis is a prevalent respiratory condition that predominantly affects infants and young children, characterized by inflammation and obstruction of the small airways, leading to significant morbidity. The condition is primarily caused by viral pathogens, with respiratory syncytial virus (RSV) being the most frequent culprit. Other viruses, including adenovirus, influenza, and parainfluenza, have also been implicated in its pathogenesis. The clinical presentation typically begins with upper respiratory symptoms such as nasal congestion, cough, and fever, which may rapidly progress to respiratory distress, wheezing, tachypnea, and difficulty breathing. According to the World Health Organization (WHO), acute lower respiratory infections, including bronchiolitis, constitute a major cause of morbidity and mortality among children under five years of age, contributing to approximately 55,800 deaths in this population in 2019 and accounting for 5% of the total global deaths in this age group (4). The burden of this condition underscores the necessity for effective management strategies to reduce complications and improve clinical outcomes.

The pathophysiology of bronchiolitis is primarily driven by viral-induced inflammation, resulting in airway edema, mucus hypersecretion, and epithelial damage. The subsequent narrowing of the bronchioles impairs airflow and gas exchange, often necessitating supportive interventions. Additionally, the virus-mediated disruption of mucociliary function further exacerbates airway obstruction and predisposes patients to secondary bacterial colonization, complicating the disease course (5,6). The diagnosis of acute bronchiolitis is largely clinical, relying on characteristic signs and symptoms alongside a history of recent viral respiratory infection. Although various therapeutic modalities have been explored, the management of bronchiolitis remains predominantly supportive, emphasizing symptomatic relief and respiratory assistance as required. This often includes humidified oxygen therapy to maintain adequate oxygen saturation, nasal suctioning to clear excessive secretions, and ensuring optimal hydration and nutritional support. The role of nebulized bronchodilators, particularly beta-agonists like albuterol, remains controversial in bronchiolitis, with inconsistent evidence regarding their efficacy, especially in patients without significant bronchospasm (7). Consequently, alternative approaches, such as nebulized saline solutions, have garnered attention for their potential benefits in alleviating airway obstruction and improving respiratory function.

Hypertonic saline (3%) has emerged as a promising intervention in the treatment of acute bronchiolitis, owing to its multifaceted mechanisms of action. It facilitates mucociliary clearance, reduces airway edema, and modulates inflammatory responses, thereby aiding in symptom relief and enhancing clinical outcomes (8). In contrast, normal saline (0.9%) remains widely utilized in nebulization therapy, primarily for its role in airway hydration and mucus clearance. However, unlike hypertonic saline, it lacks the osmotic properties that contribute to airway surface liquid restoration and ciliary function enhancement (9). Despite extensive research on nebulized saline therapy in bronchiolitis, there remains a paucity of data specific to the Pakistani pediatric population, highlighting the need for regionally relevant studies to optimize clinical decision-making. A comparative evaluation of hypertonic saline versus normal saline in bronchiolitis management is imperative to establish evidence-based guidelines tailored to local healthcare settings.

This study aims to address this knowledge gap by systematically comparing the efficacy of nebulized 3% hypertonic saline with that of normal saline in children diagnosed with acute bronchiolitis. By assessing clinical outcomes, symptom resolution, and the need for additional interventions, this research seeks to provide robust evidence that can inform treatment protocols and optimize patient care. The findings will have important implications for pediatric healthcare providers in Pakistan, potentially shaping clinical practice and influencing healthcare policy to ensure more effective management of bronchiolitis.

METHODS

The study design was a randomized controlled trial. Ethical approval was obtained from the Institutional Review Board (IRB) of Hospital. Informed consent was obtained from parents or legal guardians of all participating children. The study was conducted at Department of Paediatrics Sughra Shafi Medical Complex, Narowal over duration of 6 months from 14 November 2022 to 14 May 2022. Sample size of 100 cases (50cases in each group) is calculated online with WHO calculator using 80% power of test and 5% level of significance while taking expected mean improvement in clinical score to be 2.21 ± 1.10 for HS and 5 3.05 ± 1.17 for NS group in children with acute bronchiolitis.[14] Participants eligible for inclusion were pediatric patients aged 2 months to 2 years who presented to

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

the emergency department with a clinical diagnosis of acute bronchiolitis. Patients with a history of chronic respiratory illness, congenital heart disease, immunodeficiency, or other significant comorbidities were excluded.

Eligible participants were randomized into two study groups using computer-generated randomization sequences. Participants randomized to the intervention group received nebulized 3% hypertonic saline, while those in the control group received nebulized 0.9% normal saline. Nebulization was administered according to standard protocols, with frequency and duration determined based on clinical severity and response to treatment.

Outcome measures included the change in clinical severity scores, assessed using standardized scoring systems such as the Respiratory Distress Assessment Instrument (RDAI). Secondary outcome measures included hospital length of stay, oxygen saturation, rate of hospital readmission, and recovery between two groups. Data were collected using standardized data collection forms. Demographic information, clinical characteristics, treatment protocols, and outcome measures were recorded systematically for each participant.

Collected data were processed and analyzed using IBM SPSS, version 27.0. Categorical variables are presented as frequency and percentage, and these were compared using the Chi-square. Continuous variables are expressed as mean and standard deviation (SD) and compared by Student's t-test. The results were visualized in the form of bar charts where possible for easier interpretation. Level of significance was set 5% and $p<0.05$ (at 95% CI) was considered significant.

RESULTS

Table 1 shows the age distribution of the cases, 31 (62%) patients (group A) were from the age group <6 months and 28 (56%) patients (group B) were from the same age group. The mean±SD of group A was5.84±4.05 and that of group B was 6.04±4.5. There were no statistically significant differences in the age distribution between Group A and Group B (p = 0.816).

Table 1: Age wise distribution of patients in both groups

	Group A		**Group B**		**p value** [a]
	n	**%**	**n**	**%**	
Age Groups (months)					0.816
Less than 6	31	62	28	56	
6 – 12	16	32	18	36	
More than 12	3	6	4	8	
Age (months), Mean ± SD	5.84 ± 4.05		6.04 ± 4.5		
[a]Unpaired t-test					

Table 2: Sex incidence in patients in both groups

Gender	**Group A**		**Group B**		**p value** [a]
	N	**%**	**N**	**%**	
Female	19	38.0	23	46.0	0.418
Male	31	62.0	27	54.0	
[a]Chi square test					

From the gender distribution of the study, the male was 31 (62%) and the female was 19 (38%) in groupA and the male was 27 (54%) and the female was 23 (46%) in group B. The p value of the gender distribution is 0.418 which is not statistically significant (Table 2).

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Table 3: Clinical presentation of patients on admission

	Group A		Group B	
	N	**%**	**n**	**%**
Runny nose	50	100 %	50	100 %
Cough	50	100 %	50	100 %
Breathing Difficulty	50	100 %	50	100 %
Fever	17	34 %	15	30 %
Wheeze	44	88 %	47	94 %
Ronchi	50	100 %	50	100 %
Chest Indrawing	50	100 %	50	100 %
Tachypnea	42	84 %	46	92 %
Tachycardia	39	78 %	43	86 %
Nasal Flaring	4	8 %	8	16 %

The duration of symptoms before hospital admission and differences in the frequency of runny nose, cough, breathing difficulty, wheeze, rhonchi, chest indrawing, tachypnea, tachycardia, and nasal flaring were not significantly different between the studied groups (Table 3).

Upon admission, patients in Group A exhibited slightly higher mean oxygen saturation levels compared to Group B (92.79 ± 1.41 vs. 92.20 ± 1.54, p = 0.049). At discharge, both groups experienced significant improvement, with Group A showing a higher mean saturation level compared to Group B (<0.001) (Table 4& Figure 1).

Table 4: Comparison of oxygen saturation between two groups

O_2Saturation	**Group A**	**Group B**	**p value[a]**
	Mean ± SD	**Mean ± SD**	
Admission	92.79 ± 1.41	92.20 ± 1.54	0.049
Discharge	98.69 ± 0.5	98.35 ± 0.45	<0.001
[a]Unpaired t-test			

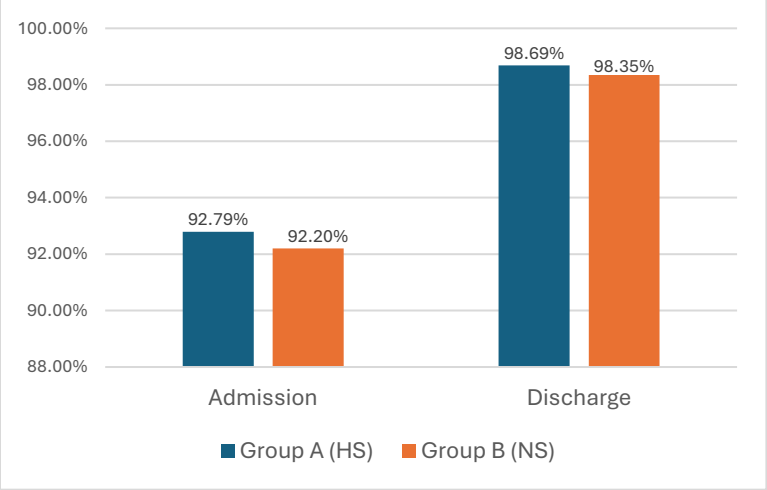

Figure 1 Oxygen Saturation at admission and discharge time in both groups

Table 5: Mean clinical severity score at a different time

Clinical Severity Score	Group A Mean ± SD	Group B Mean ± SD	p value[a]
Baseline	8.18 ± 0.56	8.56 ± 0.64	0.002
At 12 hours	6.74 ± 0.56	7.54 ± 0.65	<0.001
At 24 hours	3.90 ± 0.65	4.82 ± 0.60	<0.001
At 48 hours	2.32 ± 0.55	3.40 ± 0.61	<0.001
At 72 hours	1.34 ± 0.56	2.26 ± 0.63	<0.001

[a]Unpaired t-test

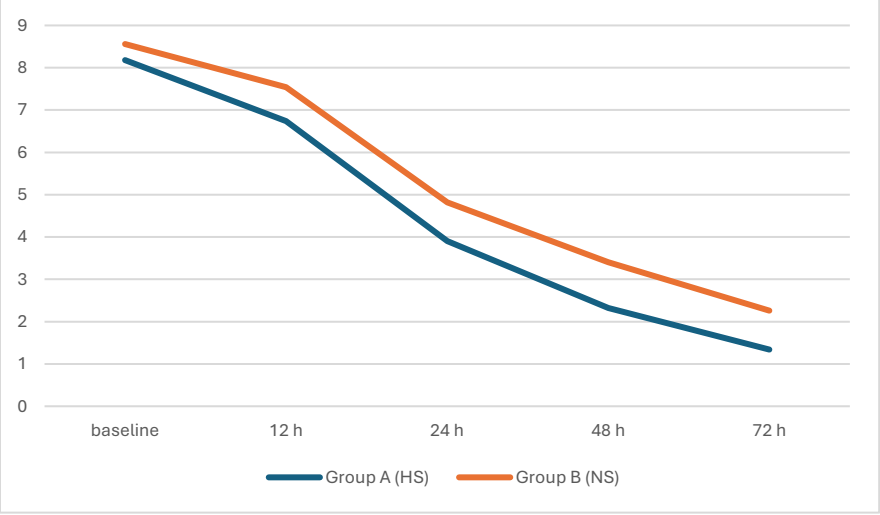

Figure 2 Clinical severity score at different time in both groups

INSIGHTS-JHR
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The mean clinical severity scores for both groups (Group A receiving 3% hypertonic saline and Group B receiving normal saline) demonstrated a significant reduction over time, indicating clinical improvement in both treatment arms. At baseline, Group A had a mean score of 8.18 ± 0.56, while Group B had a slightly higher score of 8.56 ± 0.64 (p=0.002). At 12 hours, Group A showed a reduction to 6.74 ± 0.56, whereas Group B had a higher score of 7.54 ± 0.65 (p<0.001). The trend continued at 24 hours, where the mean scores further declined to 3.90 ± 0.65 in Group A and 4.82 ± 0.60 in Group B (p<0.001). At 48 hours, Group A exhibited a significantly lower severity score of 2.32 ± 0.55 compared to 3.40 ± 0.61 in Group B (p<0.001). By 72 hours, the clinical severity scores had further decreased, with Group A reaching 1.34 ± 0.56 and Group B at 2.26 ± 0.63 (p<0.001). These findings indicate a statistically significant and faster reduction in clinical severity among patients treated with hypertonic saline, suggesting superior efficacy compared to normal saline in managing acute bronchiolitis.

Table 6: Comparison between two groups

Duration of oxygen therapy	**Group A**	**Group B**	**p value[a]**
	Mean ± SD	**Mean ± SD**	
Duration of Oxygen Therapy (hours)	13.88 ± 2.89	26.30 ± 2.31	<0.001
[a]Unpaired t-test			

Recovery					p value[a]
	n	**%**	**n**	**%**	
Rapid (within 72 hours)	47	94 %	19	38 %	<0.001
Gradual (after 72 hours)	3	6 %	31	62 %	
[a]Chi square test					

Length of Hospital stays	**Mean ± SD**	**Mean ± SD**	**p value[a]**
Length of Hospital Stay (hours)	62.50 ± 11.57	76.40 ± 11.22	<0.001
[a]Unpaired t-test			

The comparison between Group A (3% hypertonic saline) and Group B (normal saline) revealed significant differences in treatment outcomes, particularly in oxygen therapy duration, recovery rates, and hospital stay length. The mean duration of oxygen therapy was significantly shorter in Group A (13.88 ± 2.89 hours) compared to Group B (26.30 ± 2.31 hours) (p<0.001), indicating a faster improvement in respiratory function. Regarding recovery, 94% (n=47) of patients in Group A achieved rapid recovery within 72 hours, whereas only 38% (n=19) of patients in Group B showed similar improvement (p<0.001). Conversely, a greater proportion of patients in Group B (62%, n=31) experienced a gradual recovery after 72 hours compared to only 6% (n=3) in Group A. Additionally, the length of hospital stay was significantly shorter in Group A (62.50 ± 11.57 hours) than in Group B (76.40 ± 11.22 hours) (p<0.001), highlighting the superior clinical efficacy of hypertonic saline in reducing hospitalization duration and promoting faster recovery in children with acute bronchiolitis.

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DISCUSSION

Acute bronchiolitis is an acute lower respiratory tract infection that is most common in infants and children under two years of age. It is primarily caused by viral pathogens such as respiratory syncytial virus (RSV) and is characterized by inflammation and obstruction of the small airways, leading to symptoms such as cough, wheezing, and respiratory distress (11). Nebulized hypertonic saline has emerged as a potential treatment for acute bronchiolitis, with studies suggesting that it may help improve airway clearance, reduce airway edema, and enhance mucociliary clearance. This study aims to compare the efficacy of 3% hypertonic saline with normal saline in treating bronchiolitis.

Our investigation found that most patients in both groups were under six months old (5.84 ± 4.05 and 6.04 ± 4.5). In Rawalpindi, Abid et al. (2024) found that the mean ages of two groups were 7.26 ± 7.37 and 8.46 ± 6.31, respectively (12). Rumi et al. (2022) found a mean age of 5.2 ± 3.8 and 5.5 ± 3.2 in the two bronchiolitis study groups (13). A study by Hmar et al. (2020) in Manipur found that participants had a mean age of 10.02 ± and 8.45 ± 4.88 in the two study groups (14). According to Singh et al. (2020), the average age of bronchiolitis patients in two study groups was 9.4 ± 4.31 months and 8.5 ± 4.24 months, respectively (15). A study by Islam et al. (2019) in Bangladesh found a mean age of 7.81 ± 5.32 and 5.81 ± 4.62 in two groups of patients with bronchiolitis (16).

The gender distribution of patients in Group A (3% hypertonic saline) and Group B (normal saline) was also analyzed. We found that 62% of male patients were in Group A and 54% in Group B, compared to 38% and 46% female patients in both groups. Shehzad et al. (2022) found that 68.3% of males and 31.7% of females in Lahore, Pakistan, had this condition (17). Naveed et al. (2023) found that 56% and 64% of boys in both study groups had bronchiolitis (18). Hmar et al. (2020) found 53.2% and 62% males and 46.8% and 39.2% females in two bronchiolitis study groups (14).

Nebulization with 3% hypertonic saline vs. normal saline did not substantially differ in symptom duration or clinical symptom frequency before hospital admission. Islam et al. (2019) in Bangladesh also found 100% runny noses, coughs, and breathing difficulties. This reveals that Asia has similar bronchiolitis symptoms despite population disparities (16).

Our investigation revealed that patients in Group A (nebulized with 3% hypertonic saline) had somewhat higher mean oxygen saturation levels (92.79 ± 1.41) upon admission compared to Group B (92.20 ± 1.54). These findings were in accordance with Singh et al. (2020), in which the hypertonic saline group had higher O_2 saturation at discharge (98.66 ± 1.09) than the normal saline group (98.46 ± 0.96) (15).

Our investigation revealed that patients in Group A (nebulized with 3% hypertonic saline) had a lower initial clinical severity score (8.18 ± 0.56) compared to Group B (8.56 ± 0.64) ($p=0.002$). Compared to Group B, Group A consistently exhibited lower mean scores at each time point ($p<0.001$). The study by AL-Ansari et al. (2010) found similar clinical severity scores at 48 hours: 5% saline group: 3.69 ± 1.09, 0.9% saline group: 4.12 ± 1.11 ($P=0.04$) (19). Unlike our investigation, Sharma et al. (2013) found no statistically significant variations in clinical severity scores assessed every 12 hours until five days before discharge in the 3% and 0.9% saline groups (20). Abid et al. (2024) found no significant difference in clinical severity scores between the two groups: 5.42 ± 2.88 for saline and 4.50 ± 2.88 for hypertonic saline (12).

Our study revealed that patients in Group A (nebulized with 3% hypertonic saline) had a considerably lower mean oxygen therapy duration (13.88 ± 2.89 hours) compared to Group B (26.30 ± 2.31 hours). The shorter oxygen therapy duration in Group A aligns with a previous study by Abid et al. (2024), which found that the hypertonic saline group received oxygen therapy for 10.67 ± 7.91 hours, compared to normal saline groups receiving 27.21 ± 26.20 hours (12). Elesh, El-Khaleegy, and Elsamanoudy (2021) found that the hypertonic saline group needed reduced O_2 therapy time (16.2 ± 6.0 hours vs. 25.3 ± 5.4 hours) (21). Group A (94%) had a considerably higher rate of rapid recovery (within 72 hours) than Group B (38%). Two groups had significantly different recovery rates ($p<0.001$). This is similar to Islam et al.'s (2019) study in Bangladesh, where 94.4% of hypertonic saline patients recovered within 72 hours and 6.7% recovered gradually (16).

Our study revealed that Group A patients had a substantially shorter hospital stay (62.50 ± 11.57 hours) compared to Group B patients (76.40 ± 11.22 hours) ($p<0.001$). Shehzad et al. (2022) found that 3% hypertonic saline nebulization reduces hospital stay and symptom resolution (2.3 ± 1.1 vs. 3.1 ± 3.3 days) (17). A study by Saleem et al. contradicted our findings, showing that hospital stay durations were similar in Pakistan (2020), with 3.42 ± 2.1 vs. 3.71 ± 2.5 days (22). In Bosnia et al. (2023), no difference was found in hospital stay days between the two groups, with each staying five days (23).

INSIGHTS-JHR
INSIGHTS-JOURNAL OF HEALTH AND REHABILITATION

This study highlights the potential benefits of hypertonic saline despite its single-center design, limited sample size, subjective end measures, and short follow-up period. The findings would help pediatricians make timely and informed treatment decisions. This research will also enable future studies on appropriate dosing regimens, hypertonic saline mechanisms, biomarkers, and clinical predictors of treatment response.

CONCLUSION

In conclusion, our study demonstrates that nebulized 3% hypertonic saline shows promising efficacy compared to normal saline in treating acute bronchiolitis in children. Patients receiving hypertonic saline exhibited shorter hospital stays, faster recovery rates, and lower clinical severity scores, suggesting its potential as a preferred treatment option.

Author Contribution

Author	Contribution
Aqsa Faiz*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Nida Siddiquee	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Abdul Rehman Akram	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Amir Jalal	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published

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