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Observation of the beneficial effects of nasal saline irrigation combined with inhaled budesonide on acute asthma exacerbations in children: a retrospective study

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Abstract

Background: Acute asthma exacerbations remain a major cause of morbidity in children. While inhaled budesonide is a cornerstone of acute management, concurrent upper-airway inflammation may limit treatment efficacy. This study aimed to evaluate the clinical effects of nasal saline irrigation combined with inhaled budesonide in children with acute asthma exacerbations.

Methods: This retrospective study was conducted at Beijing Chaoyang Hospital, Capital Medical University. Children aged 1–14 years who were treated for acute asthma exacerbations were divided into a control group (inhaled budesonide alone) and a combination group (inhaled budesonide plus nasal saline irrigation). Clinical symptom scores, peripheral oxygen saturation (SpO_2), respiratory rate, length of hospital stay, and adverse events were compared between the two groups. The study was approved by the institutional ethics committee (BJCY-26-371).

Results: A total of 186 children were included (control group, n = 92; combination group, n = 94). Baseline characteristics were comparable between groups. The combination group showed significantly faster reductions in total and nasal symptom scores, more rapid improvement in SpO_2 and respiratory rate at 24–72 h, and a shorter median length of hospital stay (4.0 vs. 5.0 days, P = 0.003) compared with the control group. The requirement for additional systemic corticosteroids was also lower in the combination group. Nasal saline irrigation was well tolerated, with only mild, self-limiting adverse events reported.

Conclusions: Nasal saline irrigation combined with inhaled budesonide was associated with faster clinical improvement and a shorter hospital stay in children with acute asthma exacerbations compared with inhaled budesonide alone, without increasing adverse events. These findings support the potential value of nasal saline irrigation as a simple adjunctive therapy in this setting.

Keywords: acute asthma exacerbation. children. budesonide. nasal saline irrigation. united airway. retrospective study

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Introduction

Childhood asthma is one of the most prevalent chronic respiratory diseases worldwide and a leading cause of emergency department visits, hospitalizations, and school absenteeism among children [1,2]. Acute exacerbations are frequently triggered by viral respiratory infections, allergen exposure, or poor adherence to controller therapy, and they are characterized by rapidly worsening airway inflammation, bronchoconstriction, mucus hypersecretion, and variable airflow obstruction [3,4]. Despite advances in management, a substantial proportion of children continue to experience recurrent exacerbations that require intensified therapy, highlighting the need for adjunctive strategies that can accelerate recovery and reduce symptom burden [5].

Inhaled corticosteroids (ICS), particularly budesonide, form a cornerstone of both maintenance and acute asthma management in children [6,7]. Early administration of ICS, alone or in combination with short-acting β_2-agonists, has been shown to reduce airway inflammation, improve lung function, and shorten the duration of exacerbations [8,9]. Current guidelines recommend continuing or intensifying ICS during acute flares, and nebulized budesonide is widely used in pediatric practice because of its favorable safety profile and rapid local anti-inflammatory effects [10]. However, standard inhaled therapy primarily targets the lower airways and may not adequately address concurrent upper-airway pathology that commonly accompanies pediatric asthma exacerbations.

The "united airway" concept provides a strong rationale for integrated upper- and lower-airway interventions [11–14]. The nasal and bronchial mucosa share similar inflammatory mechanisms, and a large proportion of children with asthma have coexisting allergic rhinitis or other nasal conditions. Nasal inflammation can amplify lower-airway hyperresponsiveness through neural reflexes, postnasal drip, and systemic inflammatory mediators. Consequently, treatment of the upper airways has been associated with improved asthma control and reduced bronchial hyperresponsiveness [11,12].

Nasal saline irrigation (NSI) is a simple, low-cost, and well-tolerated intervention that improves mucociliary clearance, reduces nasal mucosal edema and allergen load, and decreases local inflammatory mediators [17–20]. Randomized trials and systematic reviews in children with allergic rhinitis (with or without asthma) have demonstrated that NSI significantly reduces nasal symptom scores, improves asthma-related outcomes (including bronchial hyperresponsiveness and Asthma Control Test scores), and may exert a medication-sparing effect when used alongside standard pharmacotherapy [15,16]. Additional studies have suggested that combining saline irrigation with budesonide (either via nasal nebulization or as an adjunct to inhaled therapy) can enhance clinical efficacy in respiratory allergic diseases and upper-airway cough syndrome in children.

Despite these promising findings, most available evidence has focused on chronic or subacute allergic rhinitis–asthma comorbidity rather than the acute exacerbation setting. Data specifically evaluating the additive benefit of nasal saline irrigation when combined with inhaled budesonide during acute pediatric asthma exacerbations remain limited. Therefore, the present retrospective study aimed to observe and compare the clinical outcomes of children with acute asthma exacerbations who received standard inhaled budesonide therapy alone versus those who received inhaled budesonide plus nasal saline irrigation, thereby providing real-world evidence on the potential synergistic effects of this combination approach.

Materials and Methods

Study Design and Setting

This was a single-center, retrospective observational study conducted at the Department of Pediatrics, Beijing Chaoyang Hospital, Capital Medical University (Beijing, China). Medical records of children hospitalized or treated for acute asthma exacerbations between 2022.12 and 2024.12 were reviewed. The study protocol was

approved by the Ethics Committee of Beijing Chaoyang Hospital, Capital Medical University (approval number: BJCY-26-371). Given the retrospective nature of the study and the use of anonymized clinical data, the requirement for informed consent was waived by the Ethics Committee.

Participants

Children aged 1–14 years who were diagnosed with acute asthma exacerbation and received treatment at our institution during the study period were eligible for inclusion. Acute asthma exacerbation was defined according to the Global Initiative for Asthma (GINA) criteria as an episode of progressive increase in symptoms of shortness of breath, cough, wheezing, or chest tightness, accompanied by a decrease in lung function (when measurable) that required intensified therapy beyond the patient's usual regimen.

Inclusion criteria were as follows:

(1) confirmed diagnosis of asthma based on clinical history, physical examination, and/or prior objective evidence of reversible airflow obstruction;
(2) presentation with an acute exacerbation requiring inhaled budesonide therapy;
(3) availability of complete clinical records, including symptom scores, oxygen saturation, and treatment response data; and
(4) treatment duration of at least 3–7 days (or until clinical stabilization).

Exclusion criteria included:

(1) chronic respiratory diseases other than asthma (e.g., cystic fibrosis, primary ciliary dyskinesia, or bronchopulmonary dysplasia);
(2) severe comorbidities (congenital heart disease, immunodeficiency, or neuromuscular disorders);
(3) concurrent use of systemic corticosteroids for >48 hours before admission or other experimental therapies;
(4) incomplete medical records; and
(5) transfer to another hospital or self-discharge before completion of treatment assessment.

Patients were retrospectively divided into two groups according to the treatment they actually received: **Control group:** standard treatment with inhaled (nebulized) budesonide plus short-acting β_2-agonists and other supportive care as needed; **Combination group:** standard inhaled budesonide therapy plus nasal saline irrigation.

Interventions

All patients received standard acute asthma care according to institutional protocols and GINA recommendations, which included oxygen supplementation (if SpO_2 <92–94%), nebulized short-acting β_2-agonists (salbutamol), and inhaled budesonide. Budesonide suspension was administered by jet nebulizer at a dose of 0.5–1 mg twice daily (adjusted for age and severity).

In the combination group, nasal saline irrigation was performed in addition to the above regimen. Isotonic (0.9%) saline solution was used for nasal irrigation 2–3 times daily via a squeeze bottle, syringe, or commercially available nasal irrigation device appropriate for the child's age. Irrigation was performed by trained nurses or under parental supervision after instruction. The duration of nasal saline irrigation was aligned with the period of intensified inhaled budesonide therapy (typically 5–7 days or until discharge).

Data Collection and Outcome Measures

Clinical data were extracted from the hospital electronic medical record system by two independent investigators using a standardized data collection form. Discrepancies were resolved by consensus or by a third investigator.

Baseline data included age, sex, weight, duration of asthma, previous exacerbation history, allergen sensitization status (if available), and severity of the current exacerbation (assessed by Pediatric Respiratory Assessment Measure [PRAM] score or equivalent clinical scoring system, oxygen saturation, and respiratory rate).
Primary and secondary outcomes were evaluated at baseline and at predefined time points (e.g., 24 h, 48 h, 72 h, and at discharge):

1. Clinical symptom scores (cough, wheezing, dyspnea, and nasal symptoms);
2. Oxygen saturation (SpO_2);
3. Respiratory rate and heart rate;
4. Time to clinical stabilization or length of hospital stay;
5. Need for additional therapies (systemic corticosteroids, magnesium sulfate, or intensive care);
6. Adverse events related to nasal irrigation or budesonide.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) according to the normality of distribution (assessed by the Shapiro–Wilk test). Categorical variables were presented as frequencies and percentages. Between-group comparisons were performed using the independent-samples *t*-test or Mann–Whitney *U* test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. Within-group changes over time were analyzed using repeated-measures ANOVA or the Friedman test, as appropriate. A two-sided P value < 0.05 was considered statistically significant. All statistical analyses were conducted using SPSS software (version 26.0 or later; IBM Corp., Armonk, NY, USA) or R software.

Ethical Statement

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of Beijing Chaoyang Hospital, Capital Medical University (BJCY-26-371). Patient data were anonymized prior to analysis to protect privacy.

Table 1. Baseline characteristics of the study population

Characteristic	Control group (n = 92)	Combination group (n = 94)	*P* value
Age (years), mean ± SD	6.4 ± 2.8	6.7 ± 3.1	0.482
Male, n (%)	53 (57.6)	58 (61.7)	0.568
Weight (kg), mean ± SD	22.8 ± 7.5	23.4 ± 8.1	0.597
Asthma duration (years), median (IQR)	2.5 (1.0–4.0)	2.0 (1.0–4.5)	0.714
Previous hospitalization, n (%)	28 (30.4)	31 (33.0)	0.706
Allergen sensitization, n (%)	61 (66.3)	65 (69.1)	0.679
Baseline PRAM score, mean ± SD	5.8 ± 1.6	6.0 ± 1.5	0.381
Baseline SpO_2 (%), mean ± SD	93.2 ± 2.1	93.0 ± 2.3	0.536
Baseline respiratory rate (breaths/min), mean ± SD	36.4 ± 6.2	37.1 ± 6.5	0.455

IQR, interquartile range; PRAM, Pediatric Respiratory Assessment Measure; SpO_2, peripheral oxygen saturation; SD, standard deviation.

Results

Baseline Characteristics

A total of 186 children with acute asthma exacerbations who met the inclusion and exclusion criteria were

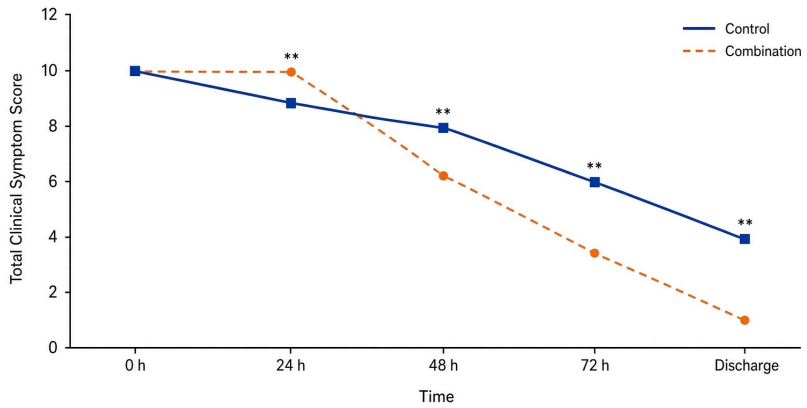
included in the final analysis. Of these, 92 patients received standard inhaled budesonide therapy alone (control group) and 94 patients received inhaled budesonide combined with nasal saline irrigation (combination group). Baseline demographic and clinical characteristics are summarized in Table 1. There were no statistically significant differences between the two groups in age, sex distribution, body weight, duration of asthma, previous hospitalization for asthma, allergen sensitization status, or baseline severity of the current exacerbation (assessed by Pediatric Respiratory Assessment Measure [PRAM] score, respiratory rate, heart rate, and peripheral oxygen saturation [SpO_2]) (all $P > 0.05$). This indicated good comparability between the groups.

Clinical Outcomes

Both groups showed significant improvement in clinical parameters over the treatment period. However, the combination group demonstrated faster and greater improvement compared with the control group.

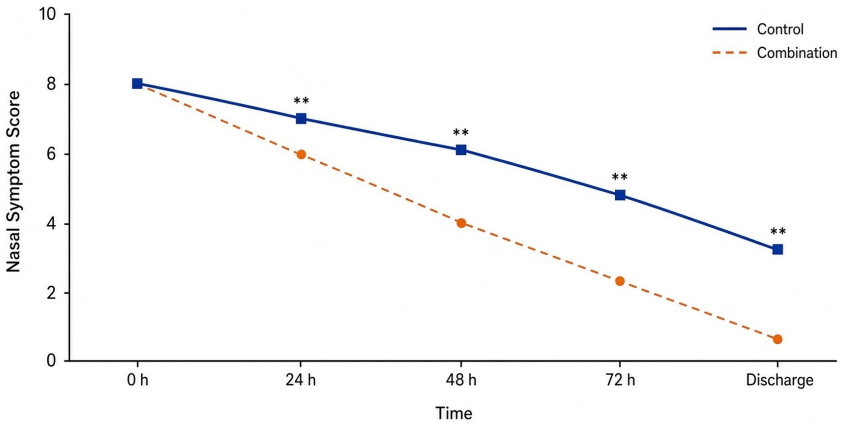
Symptom scores. As shown in Figure 1, the total clinical symptom score (including cough, wheezing, and dyspnea) decreased progressively in both groups. At 48 h and 72 h after treatment initiation, and at discharge, the combination group had significantly lower symptom scores than the control group ($P < 0.05$ at all time points after 24 h). Nasal symptom scores also declined more rapidly in the combination group (Figure 2).

Figure 1. Changes in total clinical symptom scores over time in the two groups.



Data are presented as mean ± SD. P < 0.05 vs. control group at the same time point.

Figure 2. Changes in nasal symptom scores over time.



Data are presented as mean ± SD. P < 0.05 vs. control group at the same time point.

Oxygen saturation and respiratory parameters. SpO_2 improved more rapidly in the combination group. Significant between-group differences in SpO_2 were observed at 24 h, 48 h, and 72 h ($P < 0.05$) (Table 2). Respiratory rate also decreased faster in the combination group at 48 h and 72 h ($P < 0.05$).

Table 2. Comparison of SpO_2 and respiratory rate between the two groups at different time points

Time point	SpO_2 (%), mean ± SD		*P* value	Respiratory rate (breaths/min), mean ± SD		*P* value
	Control	Combination		Control	Combination	
Baseline	93.2 ± 2.1	93.0 ± 2.3	0.536	36.4 ± 6.2	37.1 ± 6.5	0.455
24 h	94.8 ± 1.8	95.6 ± 1.6	0.002	30.2 ± 5.1	28.7 ± 4.8	0.041
48 h	95.7 ± 1.5	96.8 ± 1.3	< 0.001	26.5 ± 4.3	24.1 ± 3.9	< 0.001
72 h / discharge	96.4 ± 1.2	97.3 ± 1.1	< 0.001	24.1 ± 3.6	22.3 ± 3.2	< 0.001

Length of hospital stay and additional treatment requirements. The median length of hospital stay was significantly shorter in the combination group than in the control group (4.0 days [IQR 3.0–5.0] vs. 5.0 days [IQR 4.0–6.0], $P = 0.003$). Fewer patients in the combination group required systemic corticosteroids beyond the initial protocol or escalation of therapy (12.8% vs. 23.9%, $P = 0.049$).

Safety. Nasal saline irrigation was well tolerated. Mild, self-limiting adverse events related to irrigation (transient nasal discomfort or mild epistaxis) occurred in 6 patients (6.4%) in the combination group; no serious adverse events were reported in either group. No significant difference in the overall adverse event rate was observed between the two groups ($P = 0.312$).

Summary of Main Findings

Compared with inhaled budesonide alone, the addition of nasal saline irrigation was associated with more rapid improvement in clinical symptom scores, oxygen saturation, and respiratory rate, as well as a shorter length of hospital stay, without increasing the risk of adverse events.

Discussion

In this retrospective study, we observed that the combination of nasal saline irrigation with inhaled budesonide was associated with more rapid and greater improvement in clinical outcomes among children with acute asthma exacerbations compared with inhaled budesonide alone. Specifically, the combination group showed faster reductions in total and nasal symptom scores, more rapid improvement in peripheral oxygen saturation and respiratory rate, and a significantly shorter length of hospital stay, without an increase in adverse events.

These findings are consistent with the united airway concept, which posits that the upper and lower airways form a continuous inflammatory unit [11–14]. Nasal inflammation, mucosal edema, and impaired mucociliary clearance can amplify lower-airway hyperresponsiveness through neural reflexes, postnasal drip, and shared inflammatory mediators. By mechanically clearing nasal secretions, reducing allergen and irritant load, and improving mucociliary function, nasal saline irrigation may attenuate this upper-to-lower airway crosstalk, thereby enhancing the overall therapeutic response to inhaled corticosteroids such as budesonide [17,28,29].

Previous studies have mainly examined nasal saline irrigation in children with chronic allergic rhinitis with or without coexisting asthma, reporting improvements in bronchial hyperresponsiveness, asthma control scores, and medication-sparing effects [15,16,21–23,26,27]. A smaller number of Chinese studies have also suggested that nasal nebulization or irrigation with saline (sometimes combined with budesonide) can benefit children with respiratory allergic diseases or upper-airway cough syndrome [24,25]. Our results extend these observations to

the acute exacerbation setting, in which rapid symptom control and shortened hospital stay are particularly relevant clinical endpoints. The additive benefit observed here may stem from both the direct local effects of saline irrigation on the nasal mucosa and improved delivery or efficacy of inhaled budesonide once upper-airway obstruction is reduced [27,30].

The safety profile of the combination was favorable. Mild, self-limiting nasal discomfort occurred in a small minority of patients, and no serious adverse events related to irrigation were recorded. This aligns with the well-established safety of nasal saline irrigation in pediatric populations and supports its feasibility as an adjunctive intervention during acute care [31–33]. Systematic reviews and clinical guidelines have consistently confirmed that saline irrigation is a low-risk intervention with minimal adverse effects, further supporting its use as an adjunct in both acute and chronic upper-airway conditions [18,34–36].

Several limitations of the present study should be acknowledged. First, the retrospective design introduces the possibility of selection bias and residual confounding, even though baseline characteristics were comparable between groups. Second, the intensity and technique of nasal irrigation were not prospectively standardized and may have varied among patients [33]. Third, objective measures such as lung function, fractional exhaled nitric oxide, or nasal cytology were not routinely available for all participants. Finally, the single-center nature of the study may limit generalizability. Prospective randomized controlled trials with standardized irrigation protocols and longer follow-up are needed to confirm the efficacy and optimal application of this combination approach, in line with recommendations from position papers and clinical practice guidelines on rhinitis and rhinosinusitis [37–40].

Conclusion

In children with acute asthma exacerbations, the addition of nasal saline irrigation to inhaled budesonide therapy was associated with faster improvement in clinical symptoms, oxygen saturation, and respiratory rate, as well as a shorter length of hospital stay, compared with inhaled budesonide alone. The combination appeared safe and well tolerated. These real-world findings support the potential value of nasal saline irrigation as a simple, low-cost adjunctive intervention during acute pediatric asthma exacerbations and warrant further evaluation in prospective studies.

Author contributions Conceptualization: Q.Z and D.S; Methodology: Z.S; Validation: M.L; Formal analysis: M.L; Investigation: Q.Z; Data curation: Z.S; Supervision: D.S; Project administration: Q.Z All authors read and approved the final manuscript. Funding This research received no external funding.

Data availability The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate This retrospective study was approved by Beijing Chao-yang Hospital Human Research Ethics Committee (Approval No. BJCY2025-331). The requirement for informed consent was waived by the Ethics Committee because of the retrospective nature of the study and the use of anonymous data. All procedures were performed in accordance with the ethical standards of the institutional research committee and with the Declaration of Helsinki.

Consent for publication Not Applicable.

Competing interests The authors declare no competing interests.

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