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ORIGINAL ARTICLE

Efficacy of nasal irrigation in the treatment of acute sinusitis in atopic children

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Acute sinusitis;
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Pediatric Rhinoconjunctivitis Quality-of-Life Questionnaire

Background: Nasal irrigation has been used as adjunctive therapy for sinonasal disease but is under-researched in children. The study aim was to evaluate the effectiveness of nasal irrigation with normal saline in the management of acute sinusitis in atopic children.
Methods: We enrolled 60 atopic children with acute sinusitis, of whom 29 received nasal irrigation with normal saline and 31 did not receive nasal irrigation. All participants underwent a nasal peak expiratory flow rate (nPEFR) test, a nasal smear examination, and radiography (Water's projection) and were requested to complete a Pediatric Rhinoconjunctivitis Quality-of-Life Questionnaire (PRQLQ) during the baseline visit. All participants were requested to record symptoms in a daily diary and were followed up at 1-week intervals. A physical examination, nasal smear, and nPEFR were performed at each visit, and all daily diaries were collected. At the final visit (after 3 weeks), the symptom diaries were reviewed and participants were requested to complete the PRQLQ again. nPEFR, radiography, and a nasal smear were also repeated.
Results: There were significant improvements in mean PRQLQ and nPEFR values ($p < 0.05$) for the irrigation compared to the non-irrigation group. There was no significant difference in radiographic findings between the groups ($p > 0.05$). The irrigation group recorded significant improvements in eye congestion, rhinorrhea, nasal itching, sneezing, and cough symptoms compared with the non-irrigation group.
Conclusion: Nasal irrigation is an effective adjunctive treatment for acute sinusitis in atopic children.

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Introduction

Atopy in children is a state in which specific IgE antibodies to common aeroallergens are produced that may be detected by a skin prick test (SPT) or radio-allergosorbent test. The role of allergic sensitization is clear in rhinosinusitis, especially chronic sinusitis,[1] rhinoconjunctivitis and asthma. Rachelefsky et al reported that 54% of children with respiratory allergy had sinusitis as assessed by sinus radiography.[2] In 1992, Furukawa analyzed this study and a number of other investigations published only as abstracts, and estimated a concordance between allergy and sinusitis ranging from 25% to 70%.[3] A study in Thailand revealed that in 100 children with clinically diagnosed sinusitis and with abnormal paranasal sinus X-rays (the maxillary sinus was involved in 99% and the ethmoid sinus in 91% of cases), a positive skin test to common aeroallergens was found in 53% of patients.[4] We previously found that 27 of 66 (40.9%) children with acute sinusitis were atopic.[5] Sinusitis is a very common condition in children. The main symptoms associated with rhinosinusitis in children are cough (during the day or night, but generally worse at night), rhinorrhea, nasal obstruction, mouth breathing, hyponasal speech, and snoring. The rhinorrhea can be purulent but may be clear, minimal, or absent with severe congestion.[6]

Several studies have documented interesting results using nasal irrigation as an adjunctive treatment modality in many sinonasal diseases (including acute and chronic sinusitis) and allergic rhinitis.[7–13] Nasal irrigation is an inexpensive, patient-controlled therapy that flushes the nasal cavity with saline solution, facilitating washing of the structures within. It augments mucociliary flow, liquefies tenacious mucus, soothes irritated tissue, augments repair processes, reduces forceful nose blowing, and improves olfaction. Our previous study demonstrated that nasal irrigation with normal saline is effective in the management of acute sinusitis in children.[5] Some studies have suggested that atopic patients with sinusitis suffer more severe symptoms and radiological status.[14–16] Moreover, it has been shown that atopic children are a high-risk group for the development of allergic diseases.[17] The purpose of this study was to evaluate the effectiveness of nasal irrigation with normal saline in the management of acute sinusitis in atopic children.

Materials and methods

Participants

The study was conducted at the Division of Allergy, Asthma and Rheumatology, Department of Pediatrics, Chung Shan Medical University Hospital, Taichung, Taiwan between December 2006 and August 2009. Approval for the study was granted by the Chung Shan Medical University Hospital Institutional Review Board and written informed parental consent was obtained before commencing the study. The inclusion criteria were as follows: (1) a history of recent upper respiratory infection and purulent nasal discharge and/or cough (usually nocturnal) for more than 7 days; (2) abnormal findings (mucosal swelling, a horizontal fluid meniscus in the sinus or complete opacity) of one or both maxillary sinuses according to Water's projection; (3) positive SPT findings for common inhalant allergens; and (4) a positive atopy history (included atopic dermatitis, asthma, and allergy rhinitis) based on personal history.

Patients with severe symptoms (longer than 3 months), a history of any nasal or adenoid surgery, and those with probable complications (e.g., periorbital swelling) were excluded. Sixty atopic children with acute sinusitis aged 3—12 years met the inclusion criteria for the study.

Study design

All participants underwent a physical examination, nasal peak expiratory flow rate (nPEFR) test, nasal smear examination, and radiography (Water's projection) and were requested to complete the Pediatric Rhinoconjunctivitis Quality-of-Life Questionnaire (PRQLQ) during the baseline visit. This was a randomized, prospective, placebo-controlled study. The participants were randomly divided into two groups: 29 of the 60 participants received standard treatment (including systemic antibiotics, mucolytics and nasal decongestants) with nasal irrigation with normal saline, and the remaining 31 participants received the same standard treatment alone (placebo group). All participants were requested to record a symptom diary daily and were followed up every week for 3 weeks. A physical examination and nPEFR were performed at each visit, and all daily diary cards collected.

At the final visit after 3 weeks, the symptom diaries were reviewed and participants were requested to complete the PRQLQ again. nPEFR, radiography (Water's projection), and nasal smears were also repeated.

Daily diary for nasal symptom scores

Sinusitis symptoms were measured on a scale from 0 to 3 as follows: 0, none (symptoms not noticeable); 1, mild (symptoms noticeable but not bothersome); 2, moderate (symptoms noticeable and bothersome some of the time); and 3, severe (symptoms bothersome most of the time and/or very bothersome some of the time). Four nasal symptoms (rhinorrhea, nasal stuffiness/congestion, nasal itching, and sneezing) and four non-nasal symptoms (eye itching/burning, eye tearing/watering, eye redness, and itching of ears or palate) were recorded by the patients themselves every day unless they were too young (in general if they were younger than 6 years), in which case the parents helped. The total symptom score (TSS) was the sum of the eight symptom scores recorded. Baseline TSS and each symptom score were calculated as the mean daily score during the baseline period of 7 days. Patients were followed up after 1, 2, and 3 weeks of treatment.

PRQLQ

The PRQLQ has 23 items covering five areas: nasal symptoms, ocular symptoms, practical problems, other symptoms, and activity limitations. Each item is scored on a scale from 0 to 6.[18] The questionnaire can be completed

within 5 minutes by children, although children younger than 6 years may need parental help.

nPEFR

nPEFR was measured using a Mini-Wright peak expiratory flow meter equipped with a purpose-built face mask. The mask was placed on the patient's face and the seal with the face was checked. The patient was instructed to blow his/her nose forcefully after a deep inspiration while sitting with his/her mouth firmly closed. This test was performed three times and the highest value was recorded.

Nasal smear

The underside of the patient's inferior turbinate was rubbed with a cotton wool bud and then smeared on a glass slide. The slides were stained with Leu stain and examined under a light microscope. An experienced cytologist blinded to clinical status performed the assay. A minimum of 100 leukocytes were counted and the eosinophil and neutrophil counts were expressed as a proportion of the total number of leukocytes.

Water's projection

All 120 sinuses (60 participants) were examined by Water's view radiography at baseline and during the final visit. The radiologist was not aware of the history or clinical findings. The radiology score for each of the maxillary sinuses was divided into 32 areas and rated as 0 for opaque and 1 for normal. Each maxillary sinus was scored separately and the mean of the two scores was recorded. The score was compared for baseline (pre-treatment) and final (post-treatment) radiographs and the percentage improvement was recorded.

SPT

Before children were enrolled in the study, an SPT was performed for a standard battery of predefined aeroallergens (*Dermatophagoides pteronyssinus* and *Dermatophagoides farinae*) placed on the forearm in a standardized order. Two experienced allergy nurses performed all tests using the same standardized procedure. The weal perimeter was transferred from the skin to paper using translucent tape. The results were classified as positive if the mean diameter was 3 mm or more.

Nasal irrigation

Children assigned to the nasal irrigation group and their parents were instructed in usage. The children in this group irrigated each nostril with about 15-20 ml of normal saline (0.9 g of NaCl in 100 mL of H_2O) 1 to 3 times a day during the treatment period, discontinuing irrigation 2 to 3 days before the final visit. The normal saline solution was irrigated fast upward in a sitting or standing position, with the head pulled back to allow the secretions to flow downward from the nose without the patient breathing them in. The solution was immediately removed from the nose to minimize any salty or burning feeling.

Statistical analysis

Analyses were carried out using SPSS 12.0 software (SPSS, Inc., Chicago, IL, USA). All parametric data are expressed as mean $\pm$ SD. An independent-sample *t* test was chosen to compare radiographic improvement between the groups. The Mann–Whitney *U* test was used to compare improvements in nPEFR and mean TSS between the groups. It was also used to compare mean TSS between the two atopy groups. A p value <0.05 was considered significant.

Results

A total of 60 patients were enrolled and all completed the study. The mean age was 6 (range 3–12) years. Twenty-nine patients were assigned to the nasal irrigation group and 31 to the placebo group. There were no significant differences in baseline demographics and health characteristics between the groups, including age, sex, height, body weight, and family and personal history of allergy (allergic rhinitis, atopic dermatitis, and asthma) (Table 1).

Table 1 Demographic characteristics and baseline data for the two groups

Parameter	Irrigation	Non-irrigation	*p*
Number	29	31	
Sex			
Male	18 (62.1)	24 (77.4)	0.31
Female	11 (37.9)	7 (22.6)	0.62
Age			
Male	6.12 $\pm$ 2.01	6.24 $\pm$ 1.84	0.87
Female	6.30 $\pm$ 1.24	6.18 $\pm$ 2.29	0.99
Height (cm)	118.24 $\pm$ 9.74	116.94 $\pm$ 10.45	1.00
Weight (kg)	23.36 $\pm$ 5.73	22.48 $\pm$ 5.36	0.99
Personal history	14 (48.3)	15 (48.4)	0.80
AR	14 (48.3)	13 (41.9)	0.82
AD	2 (6.9)	6 (19.4)	0.30
AS	2 (6.9)	2 (6.5)	0.65
Family history	24 (82.8)	20 (64.5)	0.19
Father			
AR	13 (44.8)	11 (35.5)	0.64
AD	3 (10.3)	1 (3.2)	0.56
AS	0 (0)	1 (3.2)	0.97
Mother			
AR	10 (34.5)	11 (35.5)	0.85
AD	0 (0)	8 (25.8)	0.01*
AS	1 (3.4)	6 (19.4)	0.13
Siblings			
AR	7 (24.1)	6 (19.4)	0.89
AD	1 (3.4)	2 (6.5)	0.95
AS	4 (13.8)	1 (3.2)	0.31

Data are presented as *n* (%) or mean $\pm$ SD.
AD = atopic dermatitis; AR = allergic rhinitis; AS = asthma.
* Significant difference between groups at a level of 0.05 (independent *t* test).

The irrigation group showed significant improvements in nPEFR ($t = 2.96$, $p < 0.05$) and PRQLQ values ($t = 2.053$, $p < 0.05$) after 3 weeks of treatment compared with the placebo group (Figs. 1 and 2).

Although there was no significant difference in radiographic improvement between the groups ($t = 0.545$, $p > 0.05$), the irrigation group experienced a greater improvement than the placebo group (Fig. 3).

Mean changes in TSS from baseline are shown in Table 2. There were no significant differences between the groups except for nasal congestion and sleep quality. However, the improvement in mean TSS was significantly better in the irrigation than in the placebo group, with improvements in rhinorrhea (daytime $p = 0.0027$, nocturnal $p = 0.0156$) and cough (daytime $p = 0.0034$, nocturnal $p = 0.0192$; Tables 3 and 4).

Both groups showed a significant reduction in the proportion of neutrophils and a significant increase in the proportion of eosinophils in nasal smears after 3 weeks of treatment. The cell components of nasal smears did not significantly differ between the groups.

Discussion

This study demonstrates that nasal irrigation with normal saline is effective in the management of acute sinusitis in atopic children. There was an improvement in nPEFR values, mean PRQLQ values, mean TSS, and radiographic scores. Most clinical trials have shown that nasal irrigation is effective in children with chronic sinusitis and allergic rhinitis,[10–13] but there have been few clinical trials on the efficacy in children with acute sinusitis.

This study shows that nasal irrigation is effective in decreasing symptoms of sinonasal disease and improves allergic-related quality of life. The exact mechanism of action of saline nasal irrigation is unknown, but it may improve nasal mucosa function through several physiological effects, including: (1) direct cleansing[19,20]; (2) a decrease in mucosal edema; (3) removal of inflammatory mediators[21,22]; and (4) improved mucociliary function, as suggested by increased ciliary beat frequency.[12,23] The irrigation group achieved a significant clinical improvement in quality of life as measured by TSS and PRQLQ. Rabago et al reported that patients with sinonasal symptoms who used 2% saline daily in addition to routine care experienced a 64% improvement in overall symptom severity compared with patients who used routine care alone.[24] Patients also showed significant improvements in disease-specific quality of life as measured by the Rhinosinusitis Disability Index (RSDI), Sinus-Symptom Severity Assessment (SIA), and the Sino-Nasal Outcomes Test (SNOT-20).[25] Our study design involved self-reporting of nasal and sinus symptoms using self-report diaries (TSS) and questionnaires (PRQLQ). There is a possibility that patients over-reported compliance. However, given the positive study findings, we do not believe that this was a notable problem.

Several studies have used saline solutions that differed in tonicity and pH. In our study, irrigation with isotonic saline (0.9%) was effective for atopic children with acute sinusitis. It has been shown that hypertonic saline decreases ciliary movement in human nasal epithelium *in vitro*[26] and increases mucociliary transit times.[27] Homer et al found that mucociliary clearance results were similar when using isotonic and 3.0% hypertonic solution, but observed a decrease in clearance for solutions of 5%

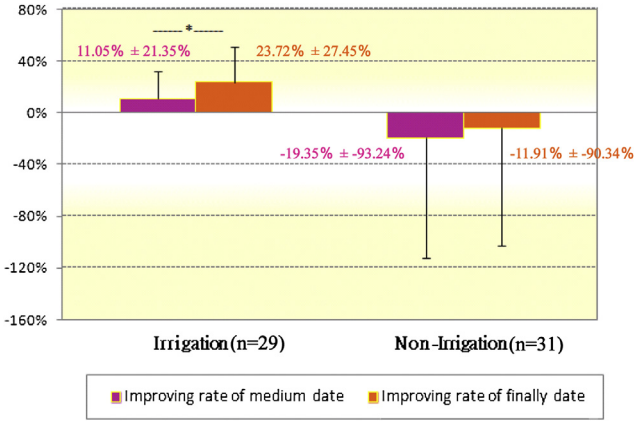

Figure 1. Improvement in nasal peak expiratory flow rate (nPEFR). The irrigation group showed a significant improvement in nPEFR compared with the non-irrigation group on intermediate and final dates. *$p < 0.05$, paired-sample t test.

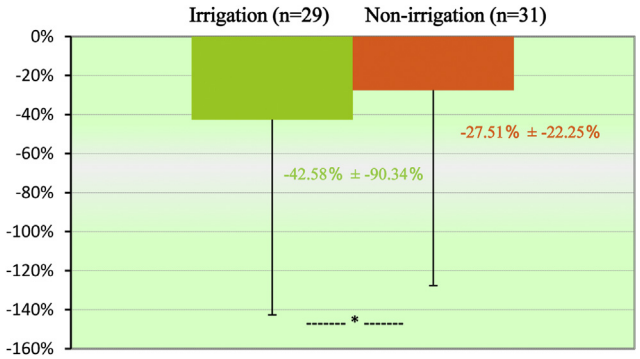

Figure 2. Improvement in Pediatric Rhinoconjunctivitis Quality-of-Life Questionnaire (PRQLQ) score. The irrigation group showed a significant improvement in PRQLQ values compared with the non-irrigation group after 3 weeks of treatment. *$p < 0.05$, independent t test.

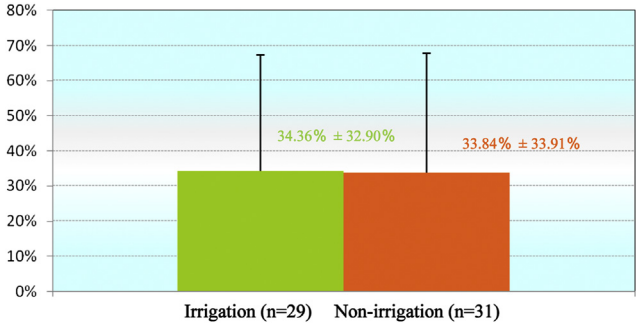

Figure 3. Change in radiographic assessment (Water's projection). There was no significant difference between the irrigation and non-irrigation groups (Mann–Whitney U test).

Table 2 Comparison of total symptom score between the groups

Symptom	Non-irrigation (n = 31)	Irrigation (n = 29)	p
Eye itching			
Day Wk 1	0.41 ± 0.72	0.37 ± 0.61	0.9440
Day Wk 2	0.30 ± 0.51	0.46 ± 0.71	0.5075
Day Wk 3	0.33 ± 0.55	0.35 ± 0.55	0.7747
Night Wk 1	0.44 ± 0.69	0.39 ± 0.59	0.9744
Night Wk 2	0.27 ± 0.47	0.45 ± 0.74	0.7012
Night Wk 3	0.30 ± 0.57	0.34 ± 0.60	0.5708
Tears			
Day Wk 1	0.13 ± 0.47	0.06 ± 0.21	0.4016
Day Wk 2	0.07 ± 0.21	0.09 ± 0.36	0.9103
Day Wk 3	0.08 ± 0.25	0.05 ± 0.20	0.6266
Night Wk 1	0.13 ± 0.46	0.10 ± 0.35	0.6424
Night Wk 2	0.04 ± 0.15	0.07 ± 0.29	0.7111
Night Wk 3	0.08 ± 0.22	0.07 ± 0.24	0.4523
Eye congestion			
Day Wk 1	0.13 ± 0.45	0.21 ± 0.54	0.7975
Day Wk 2	0.07 ± 0.23	0.17 ± 0.42	0.2315
Day Wk 3	0.08 ± 0.23	0.12 ± 0.35	0.9818
Night Wk 1	0.04 ± 0.12	0.18 ± 0.53	0.8210
Night Wk 2	0.06 ± 0.21	0.11 ± 0.32	0.3655
Night Wk 3	0.11 ± 0.26	0.11 ± 0.31	0.6851
Rhinorrhea			
Day Wk 1	0.81 ± 0.73	0.85 ± 0.67	0.6887
Day Wk 2	0.60 ± 0.68	0.54 ± 0.70	0.7267
Day Wk 3	0.53 ± 0.53	0.57 ± 0.65	0.9695
Night Wk 1	0.80 ± 0.65	0.79 ± 0.61	0.9822
Night Wk 2	0.52 ± 0.54	0.55 ± 0.69	0.8919
Night Wk 3	0.55 ± 0.52	0.47 ± 0.54	0.4471
Nasal congestion			
Day Wk 1	1.14 ± 0.74	0.71 ± 0.71	0.0168*
Day Wk 2	0.97 ± 0.77	0.52 ± 0.60	0.0066*
Day Wk 3	0.94 ± 0.75	0.58 ± 0.52	0.0790
Night Wk 1	1.33 ± 0.79	0.66 ± 0.75	0.0012*
Night Wk 2	1.14 ± 0.78	0.65 ± 0.73	0.0085*
Night Wk 3	1.11 ± 0.79	0.61 ± 0.65	0.0208*
Nasal itching			
Day Wk 1	0.63 ± 0.70	0.62 ± 0.68	0.9820
Day Wk 2	0.50 ± 0.55	0.49 ± 0.63	0.5952
Day Wk 3	0.53 ± 0.52	0.46 ± 0.58	0.3786
Night Wk 1	0.59 ± 0.63	0.64 ± 0.67	0.8811
Night Wk 2	0.47 ± 0.55	0.50 ± 0.67	0.9435
Night Wk 3	0.57 ± 0.62	0.38 ± 0.56	0.2663
Sneezing			
Day Wk 1	0.67 ± 0.43	0.65 ± 0.62	0.3807
Day Wk 2	0.53 ± 0.58	0.54 ± 0.67	0.8333
Day Wk 3	0.60 ± 0.53	0.42 ± 0.54	0.0949
Night Wk 1	0.49 ± 0.48	0.51 ± 0.66	0.6668
Night Wk 2	0.41 ± 0.51	0.41 ± 0.68	0.5310
Night Wk 3	0.48 ± 0.50	0.37 ± 0.54	0.2374
Throat itching			
Day Wk 1	0.33 ± 0.53	0.07 ± 0.14	0.1414
Day Wk 2	0.23 ± 0.37	0.05 ± 0.16	0.0976
Day Wk 3	0.23 ± 0.46	0.07 ± 0.18	0.1595
Night Wk 1	0.31 ± 0.44	0.15 ± 0.29	0.0530
Night Wk 2	0.20 ± 0.37	0.07 ± 0.17	0.2912
Night Wk 3	0.28 ± 0.50	0.06 ± 0.20	0.0632
Cough			
Day Wk 1	1.17 ± 0.65	0.98 ± 0.61	0.3698
Day Wk 2	0.76 ± 0.56	0.63 ± 0.55	0.3466
Day Wk 3	0.71 ± 0.49	0.52 ± 0.46	0.2085
Night Wk 1	1.09 ± 0.76	0.87 ± 0.56	0.4225
Night Wk 2	0.67 ± 0.70	0.61 ± 0.55	0.9344
Night Wk 3	0.76 ± 0.71	0.44 ± 0.4	0.0628
Sleep quality			
Wk 1	0.66 ± 0.67	0.31 ± 0.53	0.0177*
Wk 2	0.59 ± 0.62	0.33 ± 0.55	0.1025
Wk 3	0.47 ± 0.56	0.26 ± 0.46	0.0486*
Daytime sleep			
Wk 1	0.31 ± 0.55	0.21 ± 0.41	0.8325
Wk 2	0.19 ± 0.41	0.13 ± 0.32	0.3131
Wk 3	0.18 ± 0.48	0.12 ± 0.31	0.9307
Activity			
Wk 1	0.01 ± 0.04	0.09 ± 0.23	0.3429
Wk 2	0.00 ± 0.00	0.00 ± 0.00	1.0000
Wk 3	0.00 ± 0.00	0.05 ± 0.23	0.3272

Data are expressed as mean ± SD.
* Significant difference between groups at a level of 0.005 (Mann–Whitney U test).

tonicity.[28] Furthermore, it has been shown that mucociliary clearance is similar after irrigation with a solution buffered to pH 8 or a non-buffered solution. Hence, the common practice of adding sodium bicarbonate to the irrigating solution as an alkaline buffer may be of use by increasing tonicity but not by increasing pH.[29] Hypersaline nasal provocation leads to substance P release and glandular secretion via stimulation of nociceptive nerves, which can induce pain in patients.[30] In our study, no significant side effects were recorded in the isotonic saline irrigation group.Hyperosmolar challenge leads to histamine release and can be used as a simple diagnostic test for allergic rhinitis and may provide a model for nasal hyper-reactivity.[31] In the same study, isotonic normal saline did not cause these symptoms to result in hyperosmolar challenge.[31] Similarly, the isotonic saline irrigation group had no significant side effects in the current study.

Various studies have used different delivery systems, including bulb syringes, irrigation pots,[32] metered dose pumps, and squeezable bottles with fixed nozzles and detachable nozzles. In our study, high volumes of solution were delivered via a syringe (15–20 mL) to irrigate each nostril, which proved to be effective.[5] Similarly, Pynonen et al found that nasal irrigation performed with a large volume and delivered with a low positive pressure was more effective than saline sprays for the treatment of chronic nasal and sinus symptoms in a community-based population.[33]

Nasal saline irrigation reduces inflammatory mediators (histamine, prostaglandin D2, and leukotriene C4) and allergens in nasal secretions.[22] Therefore, nasal washing with saline is a cheap and effective method for treating inflammatory conditions of the upper respiratory tract such as the common cold, sinusitis, and allergic rhinitis. In our study, significant decreases and increases in the proportion of neutrophils and eosinophils, respectively, were observed in nasal secretions from all participants after 3 weeks. Cell

Table 3 Improvement in total symptom score in the non-irrigation group ($n = 31$)

Symptom	Wk 1	Wk 3	p
Eye itching			
Day	0.41 ± 0.72	0.33 ± 0.55	0.2392
Night	0.44 ± 0.69	0.30 ± 0.57	0.1056
Tears			
Day	0.13 ± 0.47	0.08 ± 0.25	0.2476
Night	0.13 ± 0.46	0.08 ± 0.22	0.4990
Eye congestion			
Day	0.13 ± 0.45	0.08 ± 0.23	0.1609
Night	0.04 ± 0.12	0.11 ± 0.26	0.0821
Rhinorrhea			
Day	0.81 ± 0.73	0.53 ± 0.53	0.0027*
Night	0.80 ± 0.65	0.55 ± 0.52	0.0156*
Nasal congestion			
Day	1.14 ± 0.74	0.94 ± 0.75	0.0914
Night	1.33 ± 0.79	1.11 ± 0.79	0.1941
Nasal itching			
Day	0.63 ± 0.70	0.53 ± 0.52	0.3440
Night	0.59 ± 0.63	0.57 ± 0.62	0.9095
Sneezing			
Day	0.67 ± 0.43	0.60 ± 0.53	0.3728
Night	0.49 ± 0.48	0.48 ± 0.50	0.9514
Throat itching			
Day	0.33 ± 0.53	0.23 ± 0.46	0.3482
Night	0.31 ± 0.44	0.28 ± 0.50	0.6787
Cough			
Day	1.17 ± 0.65	0.71 ± 0.49	0.0034*
Night	1.09 ± 0.76	0.76 ± 0.71	0.0192*
Sleep quality	0.66 ± 0.67	0.47 ± 0.56	0.0773
Daytime sleep	0.21 ± 0.41	0.12 ± 0.31	0.2125
Activity	0.09 ± 0.23	0.05 ± 0.23	0.4982

Data are expressed as mean ± SD.
* Significant difference between baseline and Wk 3 at a level of 0.05 (Wilcoxon signed rank test).

Table 4 Improvement in total symptom score in the irrigation group ($n = 29$)

Symptom	Wk 1	Wk 3	p
Eye itching			
Day	0.37 ± 0.61	0.35 ± 0.55	0.6189
Night	0.39 ± 0.59	0.34 ± 0.60	0.4064
Tears			
Day	0.06 ± 0.21	0.05 ± 0.20	1.0000
Night	0.10 ± 0.35	0.07 ± 0.24	0.4652
Eye congestion			
Day	0.21 ± 0.54	0.12 ± 0.35	0.0280*
Night	0.18 ± 0.53	0.11 ± 0.31	0.4652
Rhinorrhea			
Day	0.85 ± 0.67	0.57 ± 0.65	0.0331*
Night	0.79 ± 0.61	0.47 ± 0.54	0.0049*
Nasal congestion			
Day	0.71 ± 0.71	0.58 ± 0.52	0.2373
Night	0.66 ± 0.75	0.61 ± 0.65	0.9611
Nasal itching			
Day	0.62 ± 0.68	0.46 ± 0.58	0.0238*
Night	0.64 ± 0.67	0.38 ± 0.56	0.0057*
Sneezing			
Day	0.65 ± 0.62	0.42 ± 0.54	0.0052*
Night	0.51 ± 0.66	0.37 ± 0.54	0.1490
Throat itching			
Day	0.07 ± 0.14	0.07 ± 0.18	0.9049
Night	0.15 ± 0.29	0.06 ± 0.20	0.0966
Cough			
Day	0.98 ± 0.61	0.52 ± 0.46	0.0008*
Night	0.87 ± 0.56	0.44 ± 0.43	0.0005*
Sleep quality	0.31 ± 0.53	0.26 ± 0.46	0.3648
Daytime sleep	0.31 ± 0.55	0.18 ± 0.48	0.0850
Activity	0.01 ± 0.04	0.00 ± 0.00	0.1573

Data are expressed as mean ± SD.
* Significant difference between baseline and Wk 3 at a level of 0.05 (Wilcoxon signed rank test).

components of nasal smears did not differ between the groups. However, the nasal irrigation group experienced effective relief of sinonasal disease symptoms and improved allergic-related symptoms. Nasal irrigation may directly cleanse the nasal mucosa and remove inflammatory mediators. Therefore, the severity of sinonasal symptoms was not associated with changes in nasal eosinophil and neutrophil counts associated with inflammatory mediators and allergens. Although we did not measure inflammatory mediators and allergens in nasal secretions, this will be considered in a future study.

Cotton swabs were used to collect nasal smear specimens. This is a simple and inexpensive method, but false-positive and false-negative results are common. Better and more accurate results may be obtained if nasal smears are taken with a rhinoprobe rather than a cotton swab.

Some prospective nasal irrigation studies have shown decreases in medication use overall,[22] and specifically antibiotic use.[24] Our study design included antibiotic treatment for all participants during the study. Therefore, we did not measure any decreases in medication use in the irrigation group. In future studies, we will focus on short-term use of antibiotics for sinusitis.

Our study is limited by the relatively small sample size, undefined compliance rate, times per day of nasal irrigation, and differences in disease severity. We did not measure IgE or other serology parameters. Computed tomography (CT) is better than Water's projection radiography for sinus assessment; however, CT would have added the risk of radiation and increased the cost of performing the study. In addition, the nature of our study did not allow blinding, although we were diligent in our efforts to prevent any experimental bias. The methodological strengths of the study include low missing-data rates, a low drop-out rate, additional testing such as nPEFR and radiographic imaging, and a young mean age.

In conclusion, our study shows that nasal irrigation isotonic saline improves the quality of life for pediatric rhinoconjunctivitis and decreases acute sinusitis and allergic-related symptoms. Nasal irrigation is an inexpensive and effective adjunctive treatment for acute sinusitis in atopic children. Larger and longer extended studies to assess the conclusion are warranted.

Conflicts of interest

All contributing authors declare no conflicts of interest.

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