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ORIGINAL RESEARCH

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A multicenter survey on the effectiveness of nasal irrigation devices in rhinosinusitis patients

Patorn Piromchai MD, MSc, PhD, FRCOT, FICS[1] | Charoiboon Puvatanond MD[1] | Virat Kirtsreesakul MD, FRCOT[2] | Saisawat Chaiyasate MD, FRCOT[3] | Triphoom Suwanwech MD, FRCOT[4]

[1]Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

[2]Department of Otolaryngology, Faculty of Medicine, Prince of Songkla University, Songkhla, Thailand

[3]Department of Otolaryngology, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand

[4]Department of Otorhinolaryngology, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

Correspondence
Patorn Piromchai, Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Email: patorn@kku.ac.th

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Abstract

Background: Nasal irrigation is widely used as an adjunctive treatment for rhinosinusitis. However, there is little information available regarding the efficacy of the devices used in this procedure. The objective of this study was thus to evaluate the effectiveness of nasal irrigation devices based on the experiences of patients with rhinosinusitis.

Methods: We conducted a multicenter survey study between November 2017 and December 2019. The questionnaire was developed based on the available literature and expert opinion and submitted to the otolaryngology residents and staff of each center as well as those in their networks.

Results: Four hundred eighteen patients were enrolled in this study: 76 with acute viral rhinosinusitis (18%), 53 with acute bacterial rhinosinusitis (13%), 156 with chronic rhinosinusitis without nasal polyps (37%), and 133 with chronic rhinosinusitis with nasal polyps (32%). We found that high-volume devices were most effective in helping to clear secretion in patients with acute viral rhinosinusitis, chronic rhinosinusitis without nasal polyps, and acute bacterial rhinosinusitis (P = .017, .009, .002, respectively) and in reducing post-nasal drip in those with acute bacterial rhinosinusitis (P = .040). There were no statistically significant differences among devices in patients with chronic rhinosinusitis with nasal polyps.

Conclusions: Nasal irrigation with high-volume devices was an effective treatment for rhinosinusitis and was more effective at clearing nasal secretion and reducing post-nasal drip than that with other types of devices.

Level of Evidence: 2C

KEYWORDS

allergic rhinitis, cold, devices, nasal irrigation, sinusitis

1 | INTRODUCTION

Rhinosinusitis (acute or chronic) is a common disease that affects patients' quality of life.[1] Common symptoms are nasal blockage and discharge, though some patients may also experience postnasal drip, facial pain, loss of smell, or sleep disturbance.[2-4] The prevalence of acute rhinosinusitis ranges between 1500 to 4000 per 100 000 population, while the incidence of chronic rhinosinusitis is around 1800 to 2300 per 100 000 population.[5-9]

According to the 2020 EPOS guidelines, saline sprays or rinses are recommended for acute rhinosinusitis based on the very low quality of the evidence and chronic rhinosinusitis based on the mixed quality of the evidence. There is no specific recommendation as to what type of nasal irrigation device to use.[10]

Currently, there are limited data available regarding the comparative efficacy of the different devices (sprays or rinses) used in this procedure. In addition to randomized controlled trials, feedback from the patients is crucial in clinical practice.

In a previous study funded by the Thailand Research Fund, we evaluated the effectiveness of different nasal irrigation devices based on the experiences of patients and found that high-volume, high-pressure devices were able to clear nasal secretion, reduce nasal congestion, post-nasal drip, sinus pain, and headache, and improve taste, smell, and sleep quality in patients with nasal symptoms.[11] As the effects were significantly found in the allergic rhinitis subgroup, a subsequent randomized controlled trial was conducted and confirmed that high-volume, high-pressure devices can improve patients' nasal symptom scores significantly greater than the control group of allergic rhinitis patients.[12]

We also found a trend toward significance favoring high-volume, high-pressure devices for rhinosinusitis from the subgroup analysis.[11] To confirm this trend, the current study expands upon our previous research by examining the comparative effectiveness of various nasal irrigation devices in rhinosinusitis based on patient experience.

2 | MATERIALS AND METHODS

2.1 | Study design and setting

We conducted this multicenter survey study between November 2017 and December 2019. The questionnaires were distributed at four university hospitals (Khon Kaen University, Chiang Mai University, Mahidol University, and Prince of Songkhla University) and two tertiary hospitals (Udonthani Cancer Hospital and Nakhonphanom Hospital) in different regions of Thailand.

2.2 | Questionnaire

The patient questionnaire was developed based on the available literature[13-17] and expert opinion and consisted of questions regarding general personal information, devices used, saline solution concentration, and effectiveness scores ranging from 0 to 10 (0 = strongly disagree, 10 = strongly agree) that covered disease severity, convenience of use, learning curve, and device satisfaction. For patients who had used more than one device, their opinions regarding the device they most recently used were collected.

The content in the questionnaire was validated and approved by the governing board of the Thai Rhinologic Society (16 members) and three epidemiology experts of the Thailand Research Fund. The items in the questionnaire were derived from common symptoms of rhinosinusitis. The visual analog scale (VAS) score of 0 to 10 was based on the recommendation of The European Position Paper on Rhinosinusitis and Nasal Polyps (EP3OS) group, a task force was commissioned by the European Academy of Allergology and Clinical Immunology (EAACI).[10] Previous studies found that the VAS score was correlated with the Sino-nasal Outcome Test (SNOT-22).[18,19] The construct validity of this questionnaire was shown in our previous study.[11]

2.3 | Participants

The questionnaire was distributed to Otolaryngology residents and staff at each center as well as others within their networks. The physicians were asked to distribute the patient questionnaire to their rhinosinusitis patients who had experience using nasal irrigation devices. All participants were informed that filling in the questionnaire was considered consent to use the collected data for research. Participation was voluntary.

The diagnosis criteria for rhinosinusitis of the patients in this study were based on the clinical practice guideline of the American Academy of Otolaryngology-Head and Neck Surgery.[20]

Acute rhinosinusitis symptoms included purulent nasal drainage accompanied by nasal obstruction, facial pain-pressure-fullness, or both. Acute viral rhinosinusitis was defined when symptoms or signs of acute rhinosinusitis are present less than 10 days, and the symptoms are not worsening. Acute bacterial rhinosinusitis was defined when symptoms or signs of acute rhinosinusitis fail to improve within 10 days or more beyond the onset of upper respiratory symptoms, or symptoms or signs of acute rhinosinusitis worsen within 10 days after initial improvement (double worsening).

Chronic rhinosinusitis was defined as 12 weeks or longer of two or more of the following signs and symptoms: mucopurulent drainage, nasal obstruction, facial pain-pressure-fullness, or decreased sense of smell and inflammation is documented by one or more of the following findings: purulent mucus or edema in the middle meatus or anterior ethmoid region, polyps in the nasal cavity or the middle meatus, and/or radiographic imaging showing inflammation of the paranasal sinuses.

2.4 | Devices

Nasal irrigation devices were classified according to the volume of saline solution used, with high-volume devices using more than

TABLE 1 Nasal irrigation device experience in acute viral rhinosinusitis patients

Scale (0-10; higher is better)	High-volume, high-pressure (n = 24)	High-volume, low-pressure (n = 47)	Low-volume, high-pressure (n = 5)	*P*-value[a]
1. Improved overall symptoms	8.46 ± 1.44	7.85 ± 2.03	7.60 ± 1.52	.370
2. Improved nasal congestion	8.58 ± 1.25	7.47 ± 2.11	8.20 ± 0.45	.052
3. Reduced nasal discharge	8.26 ± 2.03	7.77 ± 2.03	8.00 ± 1.23	.636
4. Reduced the need for nose-blowing	8.82 ± 1.68	7.75 ± 2.15	8.00 ± 1.23	.122
5. Reduced viscosity	8.50 ± 2.38	7.86 ± 2.32	8.40 ± 0.55	.524
6. Improved sinus pain/headache	7.89 ± 2.63	6.73 ± 2.77	6.00 ± 1.41	.240
7. Reduced post-nasal drip	8.26 ± 1.91	7.16 ± 2.27	6.50 ± 1.92	.096
8. Improved taste and smell	8.06 ± 1.80	6.86 ± 2.93	6.67 ± 2.52	.273
9. Reduced sneezing	7.89 ± 2.19	7.24 ± 2.20	7.00 ± 2.65	.559
10. Reduced cough	7.31 ± 2.89	6.47 ± 2.78	8.00 ± 1.41	.513
11. Helping to clear secretion	8.54 ± 1.87	7.63 ± 2.01	4.50 ± 4.95	.017*
12. Improved sleep quality	8.68 ± 1.59	7.18 ± 2.72	7.25 ± 1.71	.060

[a]One-way ANOVA.
*$P < .05$.

TABLE 2 Nasal irrigation device experience in acute bacterial rhinosinusitis patients

Scale (0-10; higher is better)	High-volume, high-pressure (n = 13)	High-volume, low-pressure (n = 37)	Low-volume, high-pressure (n = 3)	*P*-value[a]
1. Improved overall symptoms	7.54 ± 2.26	8.03 ± 1.78	7.33 ± 1.92	.658
2. Improved nasal congestion	7.31 ± 2.66	7.56 ± 2.20	6.00 ± 4.36	.566
3. Reduced nasal discharge	6.92 ± 2.81	7.58 ± 1.92	5.67 ± 4.93	.345
4. Reduced the need for nose-blowing	7.42 ± 2.94	8.09 ± 1.87	5.67 ± 4.93	.217
5. Reduced viscosity	7.23 ± 2.59	8.33 ± 1.57	6.67 ± 3.22	.119
6. Improved sinus pain/headache	6.92 ± 2.25	7.67 ± 1.84	4.67 ± 4.51	.076
7. Reduced post-nasal drip	7.33 ± 2.46	7.80 ± 1.89	4.33 ± 4.51	.040*
8. Improved taste and smell	6.00 ± 3.02	7.70 ± 1.77	5.33 ± 3.22	.073
9. Reduced sneezing	6.90 ± 2.38	7.68 ± 1.95	4.33 ± 4.51	.063
10. Reduced cough	6.75 ± 2.05	7.45 ± 2.44	4.00 ± 5.66	.194
11. Helping to clear secretion	7.08 ± 2.66	8.06 ± 1.62	3.33 ± 4.93	.002*
12. Improved sleep quality	6.92 ± 1.98	7.96 ± 1.99	5.33 ± 4.51	.095

[a]One-way ANOVA.
*$P < .05$.

100 mL.[21] The devices were further divided according to the pressure of the solution when introduced into the nose. Low-pressure devices used gravitational pressure, or the solution will be expelled from the nose when the pressure is high.

The devices in this survey were divided into

- low-volume, high-pressure (eg, nasal spray)
- high-volume, low-pressure (using gravitational pressure or the saline will be expelled from the nose when the pressure is high, for example, neti pot, syringe, bulb)
- high-volume, high-pressure (eg, syringe with adapter, squeeze bottle).

Solutions used for irrigation can be classified as hypertonic, isotonic, or hypotonic, although there are limited data available as to their comparative effectiveness according to a recent systematic review.[22] Hypertonic and hypotonic saline may carry a greater risk of side effects such as nasal irritation and mucosal cell damage.[23,24]

2.5 | Ethical consideration

The research protocol was reviewed and approved by the Khon Kaen University Ethics Committee for Human Research (HE601419). Informed consent was waived due to the nature of this study.

TABLE 3 Nasal irrigation device experience in chronic rhinosinusitis without nasal polyps patients

Scale (0-10; higher is better)	High-volume, high-pressure (n = 49)	High-volume, low-pressure (n = 98)	Low-volume, high-pressure (n = 9)	*P*-value[a]
1. Improved overall symptoms	7.94 ± 1.95	7.66 ± 2.14	7.33 ± 1.66	.623
2. Improved nasal congestion	7.98 ± 1.93	7.59 ± 2.00	6.78 ± 2.44	.220
3. Reduced nasal discharge	7.57 ± 2.16	7.36 ± 2.09	6.56 ± 2.74	.436
4. Reduced the need for nose-blowing	7.26 ± 2.85	7.53 ± 2.11	6.56 ± 2.74	.469
5. Reduced viscosity	8.02 ± 2.04	7.98 ± 2.08	6.89 ± 1.90	.297
6. Improved sinus pain/headache	7.28 ± 2.65	7.12 ± 2.56	5.60 ± 3.36	.410
7. Reduced post-nasal drip	7.05 ± 2.59	7.47 ± 2.12	6.11 ± 2.85	.210
8. Improved taste and smell	6.46 ± 3.26	7.10 ± 2.80	6.25 ± 2.25	.465
9. Reduced sneezing	7.13 ± 2.68	7.63 ± 2.21	6.00 ± 3.32	.193
10. Reduced cough	6.88 ± 2.55	7.23 ± 2.46	5.25 ± 3.59	.287
11. Helping to clear secretion	8.07 ± 2.20	7.95 ± 2.04	5.67 ± 3.16	.009*
12. Improved sleep quality	7.73 ± 2.18	8.05 ± 2.14	6.00 ± 2.83	.082

[a]One-way ANOVA.
*$P < .05$.

TABLE 4 Nasal irrigation device experience in patients with chronic rhinosinusitis with nasal polyps

Scale (0-10; higher is better)	High-volume, high-pressure (n = 33)	High-volume, low-pressure (n = 89)	Low-volume, high-pressure (n = 11)	*P*-value[a]
1. Improved overall symptoms	8.24 ± 1.66	8.17 ± 1.89	8.00 ± 1.61	.929
2. Improved nasal congestion	8.19 ± 1.74	8.11 ± 1.66	8.09 ± 1.58	.971
3. Reduced nasal discharge	7.75 ± 2.17	7.49 ± 2.16	8.18 ± 0.87	.551
4. Reduced the need for nose-blowing	7.97 ± 1.85	7.73 ± 2.27	8.09 ± 1.14	.792
5. Reduced viscosity	8.41 ± 1.79	7.96 ± 1.88	8.18 ± 0.87	.498
6. Improved sinus pain/headache	7.50 ± 2.59	6.63 ± 3.07	7.71 ± 1.60	.368
7. Reduced post-nasal drip	7.54 ± 2.61	7.13 ± 2.62	5.88 ± 2.90	.301
8. Improved taste and smell	7.62 ± 2.64	7.22 ± 2.70	7.00 ± 1.41	.770
9. Reduced sneezing	8.18 ± 1.62	7.65 ± 2.43	8.50 ± 1.05	.462
10. Reduced cough	7.39 ± 2.46	7.06 ± 2.50	7.83 ± 1.47	.703
11. Helping to clear secretion	8.45 ± 1.68	8.47 ± 1.52	7.00 ± 2.39	.055
12. Improved sleep quality	8.46 ± 1.87	8.46 ± 1.83	7.86 ± 2.41	.714

[a]One-way ANOVA.

2.6 | Statistical analysis

The sample size was calculated based on a pilot study on ten patients, in which the mean nasal symptom score was 6.88 ± 2.40 (from 0 to 10). We predicted a 5% variation in the mean score. To attain a significance level of 0.5 and a power of 90%, we determined that a total of 245 subjects would be required.

Statistical analyses were performed using the SPSS version 20 and Stata version 14. Data were described as either means (for the continuous variables) or frequencies and percentages (for the categorical variables). The normality of the data was evaluated using a quantile-quantile plot. Significant differences between groups were determined using the Student *t* test, Mann-Whitney *U* test, or one-way ANOVA and repeated measure ANOVA for continuous variables. The chi-square test or Fisher's exact test was used to determine whether there was a significant difference between expected and observed frequencies. For all tests, $P < .05$ was considered statistically significant.

3 | RESULTS

Four hundred eighteen patients were enrolled in this study, 189 male (45%) and 229 female (55%). Seventy-six patients had acute viral

TABLE 5 Adverse events

	High-volume, high-pressure (n = 119)	High-volume, low-pressure (n = 271)	Low-volume, high-pressure (n = 28)	Total (n = 418) (%)	*P*-value[a]
Retained fluid in sinuses	24	38	2	64 (15.3)	.103
Salty taste	16	43	1	60 (14.4)	.212
Ear pain/hearing loss	15	31	1	47 (11.2)	.373
Aspiration	5	20	0	25 (6.0)	.201
Pain/discomfort	3	17	1	20 (4.8)	.304
Epistaxis	2	4	0	6 (1.4)	.790
Headache	0	11	0	11 (2.6)	.051

[a]Chi-square test.

TABLE 6 Symptom scores for high-volume devices

Scale (0-10; higher is better)	High-volume, high-pressure (n = 119)	High-volume, low-pressure (n = 271)	Mean difference (95% CI)	*P*-value[a]
1. Improved overall symptoms	8.11 ± 1.86	7.88 ± 1.97	0.23 (−0.24 to 0.70)	.331
2. Improved nasal congestion	8.14 ± 1.87	7.71 ± 1.92	0.43 (−0.04 to 0.90)	.073
3. Reduced nasal discharge	7.77 ± 2.20	7.54 ± 2.02	0.23 (−0.29 to 0.75)	.382
4. Reduced the need for nose-blowing	7.79 ± 2.45	7.69 ± 2.17	0.10 (−0.47 to 0.66)	.732
5. Reduced viscosity	8.14 ± 2.09	7.95 ± 2.03	0.19 (−0.32 to 0.69)	.463
6. Improved sinus pain/headache	7.48 ± 2.48	6.84 ± 2.77	0.64 (−0.11 to 1.40)	.096
7. Reduced post-nasal drip	7.56 ± 2.36	7.32 ± 2.23	0.25 (−0.35 to 0.84)	.416
8. Improved taste and smell	7.24 ± 2.814	7.21 ± 2.58	0.03 (−0.70 to 0.76)	.940
9. Reduced sneezing	7.45 ± 2.45	7.43 ± 2.29	0.02 (−0.66 to 0.70)	.953
10. Reduced cough	7.22 ± 2.47	7.03 ± 2.55	0.18 (−0.55 to 0.92)	.626
11. Helping to clear secretion	8.32 ± 1.86	8.03 ± 1.86	0.30 (−0.17 to 0.77)	.214
12. Improved sleep quality	8.17 ± 1.99	7.93 ± 2.25	0.25 (−0.34 to 0.84)	.406

[a]Independent *t* test.

rhinosinusitis (18%), 53 had acute bacterial rhinosinusitis (13%), 156 had chronic rhinosinusitis without nasal polyps (37%), and 133 had chronic rhinosinusitis with nasal polyps (32%).

3.1 | Acute viral rhinosinusitis

There were 76 patients who had recently performed nasal irrigation for acute viral rhinosinusitis, 23 of whom were male (30%) and 53 female (70%). The mean age of the patients was 39.01 ± 14.89 years, ranging from 13 to 74 years. Most did not smoke (93.4%).

In terms of the devices used, 42 patients used syringes (55.3%), 14 used squeeze bottles (18.4%), 10 used syringes with nasal adapters (13.2%), 5 used sprays (6.6%), 3 used neti pots (3.9%) and 2 used bulbs (2.6%).

The mean duration of use was 15.69 ± 16.065 days. Half of the patients performed irrigation twice per day.

The high-volume, high-pressure devices received the highest scores in 11 of 12 symptom domains and were significantly more effective in clearing secretion than other types of devices ($P = .017$; Table 1).

3.2 | Acute bacterial rhinosinusitis

There were 53 patients who had recently performed nasal irrigation for acute bacterial rhinosinusitis, 27 of whom were male (50.9%) and 26 female (49.1%). The mean age was 37.31 ± 14.92 years, ranging from 12 to 78 years. The majority of patients did not smoke (96.2%).

Thirty-four patients used syringes (64.2%), 7 used squeeze bottles (13.2%), 6 used syringes with a nasal adapters (11.3%), 3 used sprays (5.7%), 2 used bulbs (3.8%), and 1 used a neti pot (1.9%).

The mean duration of use was 36.10 ± 37.61 days, with 37.7% performing irrigation twice per day, 35.8% doing so once per day, and the rest more than twice per day (26.5%).

The high-volume, low-pressure devices received higher scores in all 12 symptom domains and were most effective in reducing post-

nasal drip and clearing secretion (P = .040 and .002, respectively; Table 2).

3.3 | Chronic rhinosinusitis without nasal polyps

There were 156 patients who had recently performed nasal irrigation for chronic rhinosinusitis without nasal polyps, 77 of whom were male (49.4%) and 79 female (50.6%). The mean age was 44.67 ± 18.22 years, ranging from 10 to 81 years. The majority did not smoke (86.5%).

Eighty-five patients used syringes (54.5%), 34 used squeeze bottles (21.8%), 15 used syringes with a nasal adapters (9.6%), 9 used sprays (5.8%), 8 used bulbs (5.1%), and 5 used neti pots (3.2%).

The mean duration of use was 29.49 ± 34.87 months. More than half of the patients performed the irrigation twice a day (57.7%).

The high-volume, high-pressure devices received higher scores in 7 of the 12 symptom domains and were most effective in clearing secretion (P = .009; Table 3).

3.4 | Chronic rhinosinusitis with nasal polyps

There were 133 patients who had recently performed nasal irrigation for chronic rhinosinusitis with nasal polyps, 62 male (46.6%) and 71 female (53.4%). The mean age was 45.07 ± 16.12 years, ranging from 10 to 79 years. Most did not smoke (87.2%).

Eighty-four patients used syringes (63.2%), 18 used squeeze bottles (13.5%), 15 used syringes with a nasal adapters (11.3%), 11 used sprays (8.3%), 3 used neti pots (2.3%), and 2 used bulbs (1.5%).

The mean duration of use was 21.16 ± 25.58 months. Over half of the patients performed irrigation twice per day (51.9%).

The high-volume, high-pressure devices received higher scores in 7 of the 12 symptom domains. However, the differences were not statistically significant (Table 4).

3.5 | Adverse events

The most common adverse event was retained fluid in the sinuses (15.3%). Other complications included salty taste (14.4%) and ear pain/hearing loss (11.2%). There was no statistically significant difference in terms of adverse events among device types (Table 5).

3.6 | Sensitivity analysis

Based on the results above, the high-volume devices were more effective than low-volume devices. However, there were conflicting results as to the relative effectiveness of high-volume, high-pressure and high-volume, low-pressure devices.

Data from all types of rhinosinusitis were combined, and high-volume devices were compared. There were 119 patients who had recently used high-volume, high-pressure devices and 271 who had recently used high-volume, low-pressure devices. The high-volume, high-pressure devices received higher scores in all 12 symptom domains. However, the difference was not statistically significant (Table 6).

3.7 | Subgroup analysis

The subgroup analysis was conducted in the patients who previously had sinus surgery to evaluate whether the specific type of nasal irrigation device can help to improve the nasal symptoms in this group of patients. There were 34 chronic rhinosinusitis without nasal polyps patients who had sinus surgery before. We found a trend toward significance favoring high-volume devices (9 of 12 symptoms). However, there was no significant difference in the nasal symptoms scores between groups (P > .05).

3.8 | Ease of use, learning curve, and satisfaction

The convenience score (higher is better) for high-volume, high-pressure; high-volume, low-pressure and low-volume, high-pressure devices were 8.61, 8.47, and 9.15 points, respectively (P = .306). The learning curve score (higher is better) for high-volume, high-pressure; high-volume, low-pressure and low-volume, high-pressure devices were 8.85, 8.69, and 8.90 points, respectively (P = .765). The device satisfaction score for high-volume, high-pressure; high-volume, low-pressure and low-volume, high-pressure devices were 8.82, 8.62, and 8.10 points, respectively (P = .271). There was no statistically significant difference in convenience score, learning curve score, and satisfaction score between each device (P > .05).

4 | DISCUSSION

There are many types of nasal irrigation devices currently available on the market. Although nasal irrigation is recommended as an adjunctive treatment for rhinosinusitis, there is currently no recommendation with regard to the specific type of device to be used.

The randomized controlled trials that have been conducted have yielded limited data and mixed results with regard to the comparative efficacy of various devices. One small study (20 patients) in patients with acute viral rhinosinusitis found that high-volume nasal saline irrigation was able to reduce rhinorrhea and post-nasal drip (P < .05).[25] By contrast, another small study (76 patients) found that high-volume nasal saline irrigation had no effect.[26] Yet another conducted in 75 patients with acute bacterial rhinosinusitis found that nasal saline spray was no more effective than no treatment.[27] In addition, a recent Cochrane's systematic review found no benefit to using saline spray over intranasal steroids for the treatment of chronic rhinosinusitis. However, there was some benefit to daily, high-volume saline irrigation with a hypertonic solution when compared with placebo.[15]

There have been two randomized controlled studies comparing high- and low-volume devices in chronic rhinosinusitis patients who underwent functional endoscopic sinus surgery. One (31 patients) found a significant improvement in nasal finding scores at 2 and 4 weeks in the high-volume, low-pressure group. However, the effect had diminished at 12 weeks postoperatively.[28] The other (86 patients) found no significant difference between groups.[29]

Furthermore, one randomized control study compared corticosteroid nasal irrigation and intranasal corticosteroid spray in chronic rhinosinusitis patients after surgery. They found a greater improvement in nasal blockage and Lund-Mackay score in the corticosteroid nasal irrigation group ($P < .05$).[30]

In theory, high-volume, high-pressure devices should be more effective in clearing secretion from the nose. Campos et al. performed an in vitro comparison of the irrigation devices available on the market using a nasal cavity mode and found that the greater the volume and pressure, the higher the chance the saline would reach the entire nasal cavity.[31] Wormald et al. compared nasal spray, nebulization, and nasal douching in 21 subjects (nine patients with chronic sinusitis after functional endoscopic sinus surgery and three healthy controls) and found that douching was significantly more effective in penetrating the maxillary sinus ($P = .036$) and frontal recess ($P = .003$).[32]

We found that the high-volume devices were most effective in clearing secretion in patients with acute viral rhinosinusitis, chronic rhinosinusitis without nasal polyps, and acute bacterial rhinosinusitis ($P = .017$, .009, .002, respectively) and in reducing post-nasal drip in those with acute bacterial rhinosinusitis ($P = .040$). There were no statistically significant differences among devices in patients with chronic rhinosinusitis with nasal polyps.

High-volume, high-pressure nasal irrigation devices got a higher score in acute viral rhinosinusitis ($P < .05$) and chronic rhinosinusitis without nasal polyps ($P < .05$). However, the high-volume, low-pressure devices seem to be more effective in acute bacterial rhinosinusitis ($P < .05$). In our opinion, acute bacterial rhinosinusitis patients commonly have more severe symptoms than other types of rhinosinusitis. Using a high-pressure device pushing the saline into the nose in this type of patient may aggravate the nasal discomfort and pain. So, the high-volume, low-pressure device may be more suitable for this type of patient.

Although high-volume, high-pressure nasal irrigation devices got a higher score in chronic rhinosinusitis with nasal polyps patients, there was no significant difference between groups ($P > .05$). In our opinion, we recommended the patients to use the high-volume, high-pressure as the first choice of nasal irrigation device. Some patients may experience pain/discomfort from the high-pressure or high-volume device when the nasal polyps were severely obstructing the nasal cavities. In such a case, a discussion on an alternative nasal irrigation device should be raised.

The most common adverse event was retained fluid in the sinuses (15.3%). Other complications included salty taste (14.4%) and ear pain/hearing loss (11.2%).

Although randomized controlled trials have yielded conflicting results, we found that high-volume devices yielded higher symptom scores from patients with all types of rhinosinusitis and resulted in minimal side effects.

The method of irrigation device selection for each patient in this study resulted from the discussion of the risk/benefit of each irrigation device between physicians and patients, which is resembling what the physician was done in their routine practice. The pragmatic method in this study could reflect the effectiveness of each device in real life. However, if the question is the efficacy of each device in the control environment, the randomized control trial comparing nasal irrigation devices would give the best answer. Therefore, we reckon that both pragmatic and randomized control trials were important to give clinical information for the physicians and patients to decide what is most suitable in their setting.

The participants in this study were recruited from a university hospital, a tertiary hospital, and their peer otolaryngology specialists, in which patients tend to suffer from more complex/severe illnesses than in community hospitals or general practice clinics. A future multicenter trial that includes patients in a general practice setting should be conducted to address this problem. Most of the survey studies can be affected by recall bias as they are asking patients about the past. However, this study was conducted in an outpatient setting and asking for the most recent experience of the irrigation device, that is, the device that the patients were currently used. So, the recall bias should have little effect in this study.

5 | CONCLUSIONS

Nasal irrigation with high-volume devices was an effective treatment for rhinosinusitis and was more effective at clearing nasal secretion and reducing post-nasal drip than that with other types of devices.

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CONFLICT OF INTEREST

The authors declare there are no competing interests.

ORCID

Patorn Piromchai https://orcid.org/0000-0002-2195-4837
Virat Kirtsreesakul https://orcid.org/0000-0002-3338-8975

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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