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Coronavirus Pandemic

Nasal irrigation for the prevention and treatment of upper respiratory tract infection by SARS-CoV-2: a narrative review

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Abstract
Introduction: The World Health Organization declared an end to the global emergency status of COVID-19 in May of 2023. However, the impact of COVID-19 is far from over. Individuals who have recovered from COVID-19 continue to experience physiological, psychological, or cognitive symptoms, such as fatigue, shortness of breath, dizziness, and loss of smell or taste, known as long COVID. This review aims to describe the clinical characteristics of the upper respiratory tract infection (URTI) caused by SARS-CoV-2, and provide evidence for the prevention and treatment of SARS-CoV-2 infection by using nasal irrigation.
COVID-19 and nasal irrigation: Nasal irrigation presents a promising adjunct to standard COVID-19 prevention and treatment protocols. This practice is theorized to diminish viral presence in the upper respiratory tract, a region identified as a primary site for SARS-CoV-2 replication and shedding. By facilitating the removal of viral particles and enhancing mucociliary clearance, nasal irrigation could potentially lessen the severity of URTI symptoms and slow transmission rates. The review consolidates current evidence of the efficacy and safety of this approach across various populations, underscoring its practicality in both preventive and therapeutic contexts.
Conclusions: We recommend that saline nasal irrigation is an effective, safe and convenient strategy to prevent the transmission of SARS-CoV-2 and alleviate the symptoms of URTI across various age groups.

Key words: upper respiratory tract infection; SARS-CoV-2; COVID-19; nasal irrigation; saline solution.

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Introduction

Rapid transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in a global pandemic of coronavirus disease 2019 (COVID-19). COVID-19, with its specific infectious and immune characteristics, has shown capabilities to evade vaccine-induced immunity. In May 2023, the World Health Organization (WHO) declared an end to the global emergency status of COVID-19. However, the impact of COVID-19 is far from over. According to the Centers for Disease Control and Prevention (CDC), the test positivity for COVID-19 by geographic area remains at 8.1%, and there were nearly 19,000 new hospital admissions as of the week ending 23 February 2024 [1]. At the same time, individuals who have recovered from COVID-19 continue to experience physiological, psychological, or cognitive symptoms that are collectively known as long COVID, and include symptoms such as fatigue, shortness of breath, dizziness, and loss of smell or taste [2]. Currently, the SARS-CoV-2 variants Omicron EG.5 and the BA.2.86 have spread globally [3]. These two variants have demonstrated increased prevalence, growth advantages, and immune evasion properties, raising significant public health concerns. On August 9, 2023, WHO classified the new coronavirus variant EG.5 as a strain "requiring attention" and urged countries to maintain surveillance. Furthermore, on December 8, 2023, the U.S. CDC website included the variant JN.1 for the first time in its COVID Data Tracker. JN.1 is a variant branching from the Omicron variant BA.2.86 of the novel coronavirus, and the CDC highlighted JN.1 as the fastest-growing variant of the novel coronavirus in the United States.

This review aims to describe the clinical characteristics of the upper respiratory tract infection

(URTI) caused by SARS-CoV-2 and provide evidence for the prevention and treatment of SARS-CoV-2 infection by using nasal irrigation. Nasal irrigation is a common adjuvant treatment for nasal and sinus diseases. It is used to flush secretions, blood crusts, germs, virus, and allergens out of the nasal cavity in order to improve the ciliary function of nasal mucosa, reduce the release of inflammatory factors, and decrease edema of nasal mucosa [4]. Advantages of nasal irrigation include low side effects, low cost, easy operation, and high safety and practicality.

COVID-19 was initially thought to be a pathogen that specifically infects the lower respiratory tract. However, as increasingly common upper respiratory symptoms were reported, there was increasing concern about the symptoms of URTI caused by COVID-19. Similar to URTI caused by other viruses, early infection with SARS-CoV-2occurs mainly in the nasal mucosa and nasopharyngeal mucosa with high viral load and usually causes upper respiratory tract symptoms including cough, runny nose, and loss of smell [5]. Therefore, the upper respiratory tract, including the nasal cavity, becomes a priority site for prevention and control of viral infections at the current stage of the epidemic. In addition to standardized mask wearing and frequent hand washing, nasal irrigation, as a commonly used therapy, was reported to reduce viral infection and accelerate inflammation recovery with low cost and few side effects. Nasal irrigation has been shown to reduce the duration of viral shedding [6] as well as alleviate the symptoms of URTI caused by SARS-CoV-2 [7,8]. Therefore, this review was developed to address the role of nasal irrigation in the prevention and treatment of URTI caused by of SARS-CoV-2; based on the review of available medical evidence, combined with existing mechanistic studies and our own clinical experience.

SARS-CoV-2 microbial pathogenesis

SARS-CoV-2, a member of the subgenus Sarbecovirus (beta-CoV lineage B), is characterized by an envelope and a pleomorphic shape, typically round or oval, and with a diameter ranging from 60 to 140 nm. Genome sequencing analysis places SARS-CoV-2 within the Betacoronavirus genus, which also includes the bat SARS-like coronavirus, severe acute respiratory syndrome coronavirus (SARS-CoV); and Middle East respiratory syndrome coronavirus (MERS-CoV) [9]. Despite belonging to the same genus, the genetic makeup of SARS-CoV-2 differs significantly from that of SARS-CoV and MERS-CoV [10].

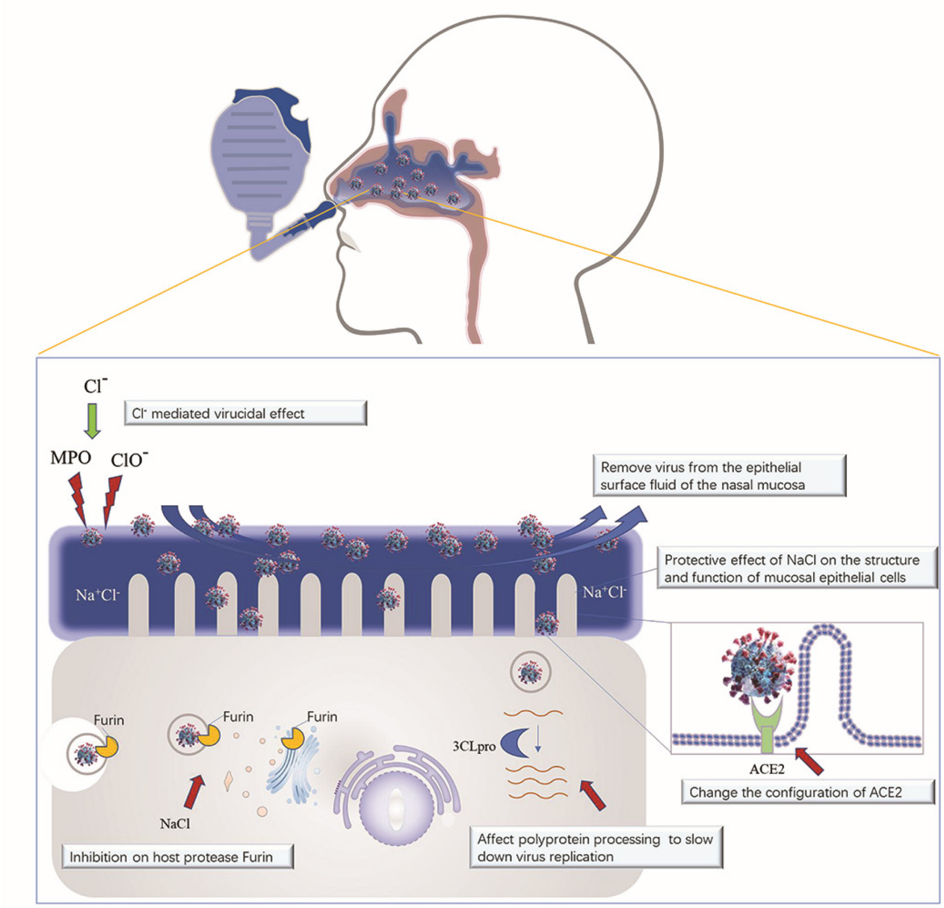
Both SARS-CoV-2 and SARS-CoV recognize the angiotensin-converting enzyme 2 (ACE2) receptor, which is abundant in nasal mucosal epithelial cells as well as cells of the lower respiratory tract, heart, kidney, and gastrointestinal tract [11]. SARS-CoV-2 exhibits a high affinity for host cell binding, primarily colonizing the nasopharynx and lungs [12,13]. The Omicron variant, in particular, demonstrates prominent colonization in the epithelium of the upper respiratory tract [14]. The nasal mucosa provides an optimal environment for viral replication and transmission [15]. In the early stages of COVID-19, SARS-CoV-2 primarily infects the upper respiratory tract; subsequently progressing to the lower respiratory tract and alveoli through swallowing and inhalation. Later, SARS-CoV-2 is rapidly replicated and shed in the nasopharynx, resulting in a much higher viral load detected in the nasopharynx than in the hypopharynx [16-18].

Given the rapid transmission of SARS-CoV-2, particularly with variants like Omicron, effective interventions remain limited. The virus is highly transmissible through respiratory droplets and close contact, with a strong potential for infection even in asymptomatic or mildly symptomatic individuals [19]. Symptoms of SARS-CoV-2 infection in the upper airway epithelium vary and may include hyposmia/anosmia, dysgeusia, nasal congestion, runny nose, URTI symptoms. Olfactory dysfunction has emerged as an early and sensitive indicator of COVID-19, with a prevalence exceeding 50% among patients [20,21]. Omicron infections often present as asymptomatic or with upper respiratory symptoms, deviating from classic pulmonary inflammation manifestations.

How do we prevent SARS-CoV-2 infection in populations at high risk and susceptibility?

SARS-CoV-2 infection should be actively prevented and controlled in highly susceptible populations who are at risk of infection, using measures like vaccination, oral administration of preventive antiviral drugs, and routine prevention of URTI (e.g., hand-mouth-eye cleaning and disinfection). Nasal irrigation with sodium chloride solution or povidone-iodine solution before and after exposure to SARS-CoV-2 is necessary to curb community transmission [3,22]. Since SARS-CoV-2 is mainly transmitted through contact with mucous membranes of the eyes, mouth, and nose, it is of high preventive value to maintain social distance, wear masks, wash hands and irrigate nasal passages [23,24]. Nasal irrigation

Figure 1. Mechanisms of antiviral activity of NaCl against SARS-CoV-2.



This figure illustrates the multifaceted antiviral effects of sodium chloride on the SARS-CoV-2 virus within the nasal mucosa. NaCl is depicted as having a dual role, both in directly eliminating viruses from the epithelial surface fluid and enhancing the defenses of mucosal epithelial cells. Key mechanisms include: 1) Physical removal: sodium chloride solution aids in the direct cleansing of viruses from the nasal epithelial lining fluid. 2) Protection of mucosa: it supports the structure and function of mucosal epithelial cells, thereby enhancing the mucociliary clearance system. 3) Chloride ion mediation: chloride ions mediate the inhibition of viral replication and enhance the antiviral effects of immune cells, such as through the activation of MPO to produce ClO-. 4) Structural change of ACE2: high concentrations of NaCl induce structural changes in the ACE2 receptor, potentially hindering viral entry into host cells. 5) Inhibition of viral protease 3CLpro: NaCl affects the dimerization and activity of the 3CLpro, a key enzyme in the SARS-CoV-2 replication process. 6) Inhibition of host protease furin: NaCl inhibits the activity of furin, a host protease involved in activating the SARS-CoV-2 spike protein, thereby slowing down virus replication. ACE2, angiotensin-converting enzyme 2 receptor; ClO-, hypochlorite ion; 3CLpro, 3-chymotrypsin-like protease; MPO, myeloperoxidase; NaCl, sodium chloride; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

effectively reduces viral transmission and relieves symptoms of acute respiratory viral infections. Previous studies have confirmed the preventive effect of nasal irrigation on viral colonization and replication in nasal and pharyngeal mucosa [7,24]. For example, nasal irrigation effectively reduces viral loads, prevents viral transmission, alleviates clinical symptoms, and decreases the demand for symptomatic medications in patients with a common cold. Cytological studies have shown that sodium chloride solution is capable of inhibiting the activities of DNA and RNA, in enveloped and non-enveloped viruses, including the herpes simplex virus, human coronavirus 229E (HCoV-229E), respiratory syncytial virus (RSV), influenza A virus, and coxsackievirus B3 (CVB3) [7,24,25]. Therefore, routine nasal saline irrigation could have a preventive effect.

How can nasal irrigation reduce the risk of SARS-CoV-2 infection?

Sodium chloride solution contributes to reducing the infectivity and pathogenicity of the virus through influencing viral colonization, infection, replication, and shedding via complex extracellular and intracellular mechanisms. It is generally believed that the protective mechanisms of sodium chloride solution against COVID-19 mainly involve non-specific antiviral effects, protection from the mucosal barrier and cilia, and specific antiviral effect against SARS-CoV-2 (Figure 1).

Non-specific antiviral effects

Physical cleansing

Nasal irrigation using sodium chloride solution wipes away viruses directly from the nasal epithelial lining fluid [26]. Physical cleaning by sodium chloride solution alleviates immune and inflammatory responses caused by SARS-CoV-2 infection through enhancing the viral shedding rate, reducing the concentration of viral particles, and the proportion of viruses invading the ciliated epithelial cells. Moreover, sodium chloride is ionized to reduce the conductance and viscosity of droplets formed by ciliated epithelial cells, thereby preventing the formation of bioaerosols and weakening the viral infectivity. Salinized droplets also reduce the discharge of toxic aerosols, which significantly decreases the risk of environmental transmission [27].

Chloride ion (Cl^-)-mediated inhibition of viral replication and enhancement on the antiviral effects of immune cells

Sodium chloride solution not only enhances the antiviral effect of hypochlorous acid (HClO) induced by Cl^- and myeloperoxidase (MPO), but also optimizes the concentration of Cl^- by enhancing Hecla in phagocytic cells to maintain the MPO activity in neutrophils [25,28,29]. Moreover, the continuous supply of Cl^- from NaCl maintains hypochlorite production in phagosomes [30], ensuring the continuation of phagocytosis. Sodium chloride solution also imparts antioxidant properties to thiocyanate (SCN^-), and Cl^- further promotes the production of the antiviral SCN^- [31]. Cl^- has been validated to be capable of clearing extracellular SARS-CoV-2 via reducing the production of reactive oxygen species (ROS) and neutrophil extracellular traps [32]. The antiviral effect of MPO mediated by non-myeloid epithelial cells can be activated by Cl^-, which depends on the synthesis of HClO from Cl^-.

Protective effect of sodium chloride solution on the structure and function of mucosal epithelial cells

Mucociliary clearance (MCC) is a mechanism that continuously removes dust, infectious agents, and other particles through ciliary movement [33-37]. Sodium chloride solution enhances the ability of rubbery mucus to trap pathogens [38–40], reduces adhesion of mucin to epithelium [41], and stimulates transport and clearance by cilia [42,43]. Under normal circumstances, the concentrations of Na^+ and Cl^- in the upper layer of the epithelial mucus are up to 0.58% or higher, when 0.29% NaCl exits in the periciliary layer. Such an ion concentration gradient ensures the effective and sustained transport of ions and water inside the epithelium, as well as the powerful swinging of cilia [44].

Specific antiviral effect against SARS-CoV-2

The antiviral effect of sodium chloride solution depends on the Na^+ concentration and the pH value. Interestingly, the coronaviruses MHV-2, MHV-N (mouse hepatitis viruses), and canine coronavirus (CCV) lose their infectivity after exposure to sodium chloride solution, thus leading to its listing as an antiviral agent [45]. Through interaction with the ions or charges of SARS-CoV-2, sodium chloride solution directly affects the infectivity of SARS-CoV-2. Machado *et al.* [27] have reported that the replication of SARS-CoV-2 in VeroCL-81 cells is dose-dependently inhibited by 0.8-1.7% NaCl. Therefore, we believe that sodium chloride saline exerts a specific antiviral effect against SARS-CoV-2.

Structural change of human ACE2 receptor

ACE2, as the receptor for SARS-CoV-2 entering the cell, is distributed in the nasal cavity, oropharynx, and lower respiratory tract, especially on ciliated cells in these areas. [13,46,47]. A high concentration of sodium chloride solution induces a dose-dependent structural change of ACE2 receptor. Experimental evidence has shown that NaCl is able to break the structure of ACE2 receptor at a concentration of 0.6%, which is close to the minimum effective inhibitory concentration of 0.8% NaCl against the replication of SARS-CoV-2 [45,48,49].

Inhibition on viral protease 3-chymotrypsin-like protease (3CLpro)

3CLpro is a cysteine protease that assists in the replication of SARS-CoV and SARS-CoV-2 in humans. Dimerization of 3CLpro can be significantly inhibited by the induction of NaCl at a minimal concentration of 0.6%, showing a complete 3CLpro blocking effect [50-56].

Inhibition on host protease furin

Furin is involved in the proteolytic activation of SARS-CoV-2 spike protein [57]. The hydrolysis activity of spike protein starts to be inhibited by 0.4% NaCl, with inhibition rates of 90% and 100% by 0.6% and 1.2% NaCl, respectively [27]. Anand *et al.* [58] have found that the furin insertion site is uniquely specific to SARS-CoV-2 [58].

Table 1. Clinical evidence for the prevention and treatment of SARS-CoV-2 caused URTI by nasal irrigation.

Author [Ref.]	Sample size	Irrigation solution	Additives	Study design	Main results
Ramalingam *et al*. [24]	66	Hypertonic saline	None	Post-hoc analysis	The duration of illness was lower by 1.9 days ($p = 0.01$), over-the-counter medications (OTCM) use by 36% ($p = 0.004$), transmission within household contacts by 35% ($p = 0.006$) and viral shedding by ≥ 0.5 log10/day ($p = 0.04$).
Kimura *et al*. [8]	45	Hypertonic saline	1% surfactant	Open-label randomized controlled trial	The global symptom scores continually declined during the study duration for all treatment groups, with a trend toward earlier time to symptom resolution in the intervention groups ($p = 0.16$). There was a significant difference in median days to symptom resolution for nasal congestion (NI 14 days; HTS 5 days; HTSS 7 days; $p = 0.04$) and headache (NI, 12 days; HTS, 3 days; HTSS, 5 days; $p = 0.02$).
Cegolon *et al*. [6]	108	Hypertonic saline	Seawater, xylitol, panthenol and lactic acid	Prospective open-label controlled trial	Nasal spray was effective against SARS-CoV-2, stopping viral shedding in the treatment arm two days before the control group. Patients in the experimental group also had more significant relief of dry cough than the control group.
Baxter *et al*. [61]	79	Isotonic saline	Povidone-iodine 10% or 2.5 mL sodium bicarbonate	Randomized controlled trial	SARS-CoV-2+ participants initiating nasal irrigation were over 8 times less likely to be hospitalized than the national rate.
Spinato *et al*. [62]	140	Isotonic saline	None	Case-control study	Symptoms of blocked nose and sneezing decreased by an average of 24.7% in the treatment group, while increased in the same period of time in the control group.
Liu *et al,* [63]	80	Hypertonic saline	None	Quasi-experimental study	The patients in the nasal irrigation group were more likely to get lower nucleic acid negative conversion time ($p < 0.001$) compared with the conventional group. The symptom disappearance time showed no significant improvement ($p > 0.05$).

HTS: hypertonic saline; HTSS: hypertonic saline with 1% surfactant; NI: non-intervention; OTCM: over-the-counter medications; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2; URTI: upper respiratory tract infection.

Evidence for the prevention and treatment of SARS-CoV-2 caused URTI by nasal irrigation

Saline nasal irrigation has been widely applied to the treatment of paranasal sinus diseases, common viral cold and flu. It can clear away rooted pathogens with recognized safety. Tano *et al.* [59] have suggested that daily isotonic saline nasal irrigation in healthy people can relieve the nasal symptoms of common cold, reduce nasal secretion and/or the days of nasal congestion, and the number of URTIs. Ao *et al.* [60] recruited influenza and non-influenza patients with URTI and randomly assigned them to the control group (daily conventional treatment) and nasal irrigation group (daily nasal irrigation). Their data revealed that the influenza antigen turned negative after three days of nasal irrigation. Besides, the concentration of soluble intercellular adhesion molecules in the nasal secretions of the nasal irrigation group was significantly lower than that in the control group on the fourth and eighth day. Sodium chloride solution dose-dependently inhibits the replication of DNA and RNA viruses, including HCoV-229E. Machado *et al*. [27] have shown that 1.5% NaCl can completely block SARS-CoV-2 replication, providing evidence for the use of hypertonic saline solution (> 0.9%).

Based on the support of fundamental research, there have been clinical trials demonstrating the effects of nasal irrigation in alleviating the symptoms of URTI caused by SARS-CoV-2 (Table 1). Ramalingam *et al.* [24] recently reported a study involving symptomatic patients within 48 h after URTI onset, who were randomly assigned into an experimental group and a control group. Patients in the experimental group were managed by nasal irrigation using hypertonic saline solution plus mouthwash (on-demand, no more than 12 times a day), and those in the latter were given conventional treatment. Compared with those in the control group, the duration of URTI, use of over-the-counter (OTC) drugs, and household contact transmissions in the experimental group were reduced by 1.9 days, 36%, and 35%, respectively. The rate of viral shedding in the experimental group was higher than 0.5 log_{10}/d. The interim results of Ramalingam *et* *al*. [23] also confirmed the direct effect of hypertonic saline on α and β coronaviruses, supporting the positive significance of nasal irrigation for SARS-CoV-2 infection, such as shortening the hospitalization for URTI.

Kimura *et al*. [8] conducted an open-label randomized controlled trial of patients who tested positive for SARS-CoV-2. The patients were randomized into non-intervention (NI), hypertonic saline (HTS), and hypertonic saline with 1% surfactant (HTSS) groups for nasal hypertonic saline irrigation. A modified version of the validated Wisconsin upper respiratory symptom-21 survey was used to evaluate patient symptoms. The results showed that patients in both the HTS and HTSS groups had significant alleviation of upper airway symptoms compared to the NI group. Another study has shown that the addition of additives to hypertonic saline shortens the time to viral shedding in patients affected by asymptomatic or mild COVID-19. In the study by Cegolon *et al.* [6] 108 patients with COVID-19 were divided into a test group (50 patients) and a control group (58 patients) and were treated with a nasal spray using a hypertonic saline solution with xylitol, panthenol and lactic acid (Tonimer Lab Panthexyl 800) as the primary intervention. The results showed that nasal spray with Tonimer Lab Panthexyl 800 was effective against SARS-CoV-2, stopping viral shedding in the treatment arm two days before the control group. Patients in the test group also had more significant relief of dry cough than the control group. Hence, nasal irrigation using hypertonic or isotonic saline, especially hypertonic saline, can effectively clean the nasal cavity to relieve upper respiratory symptoms.

The study by Baxter *et al*. [61] explored whether initiating saline nasal irrigation after COVID-19 diagnosis reduces hospitalization and death in high-risk outpatients compared with observational controls. They found that SARS-CoV-2+ participants initiating nasal irrigation were over 8 times less likely to be hospitalized than the national rate. In a study by Spinato *et al*., [62] a total of 140 subjects (including 68 participants in the treatment group and 72 in the control group) were enrolled to explore the effect of isotonic saline nasal irrigation in improving symptoms of COVID-19. They found that symptoms of blocked nose and sneezing decreased by an average of 24.7% in the treatment group while increasing in the same period of time in the control group. Liu *et al.* [63] investigated the effect of hypertonic saline nasal irrigation on the duration of symptoms and nucleic acid conversion of adults infected with the Omicron variant of COVID-19. They concluded that early nasal lavage shortened the time of nucleic acid-negative conversion in adults infected with the Omicron variant, but the time of symptom disappearance did not improve.

Clinical recommendations for nasal irrigation during the COVID-19 pandemic

Methods of nasal irrigation

Nasal irrigation can be performed through two methods, nasal rinsing and spraying. Quantitative or non-quantitative nasal spraying can be performed according to the type of disease and the comfort of patients. The irrigation solution is atomized into small droplets through an atomizing nasal irrigator and pulsed to diffuse into the deep nasal cavity and fissures. Due to its gentle irrigation and good compliance, children and infants can tolerate the atomizing nasal irrigation [64,65]. Macdonald *et al.* [66] have compared the efficacy of saline nasal irrigation using a nasal wash squeeze bottle and a nasal spray in patients with chronic rhinosinusitis after endoscopic sinus surgery. They found that both methods could alleviate postoperative symptoms and increase the quality of life. However, the former method may induce choking and ear pain due to a large amount of irrigating solution, and may cause surface contamination of the device during self-preparing of the solution. Atomizing nasal irrigators are sterilized and can effectively prevent cross-infection.

The recommended method of nasal irrigation is as follows: position the head so that one side with the head in a low position, irrigate the nasal cavity on the opposite side, and then alternate positions to complete the nasal irrigation on the other side. Breathe slowly with the mouth open during the operation, while avoiding talking and inhalation through the nose to avoid accidental aspiration, choking, or middle ear infection. During the operation, it is necessary to pay attention to the properties of the fluid flowing from the contralateral nostril, such as whether there is blood, scabs and purulent secretions in the flowing fluid. If coughing, vomiting, sneezing or other discomfort occurs during the flushing process, stop immediately and wait for a few moments before irrigating again. Keep the head tilted forward after nasal irrigation to allow the residual fluid in the nasal cavity to drain. Then blow the nose gently on each side to help clean the fluid. Surrounding surfaces (e.g., sinks, counters) and plastic bottles should also be decontaminated after irrigation to prevent subsequent infection. The specific time and frequency of nasal irrigation depends on the patient's condition, purpose of the irrigation, patient's cooperation. Routine nasal irrigation is usually performed twice a day, and the duration depends on the specific conditions mentioned above. It is recommended that nasal irrigation be performed daily in the morning and before going to bed, similar to the best time to clean teeth.

Osmotic pressure and additives

Hypertonic and isotonic saline is usually used as nasal irrigating solution. The randomized controlled clinical trials by Ramalingam *et al*. [24] and Kimura *et al.* [8] that investigated nasal irrigation in SARS-CoV-2 caused URTI were both conducted using hypertonic saline. Both studies concluded that hypertonic saline nasal irrigation could significantly benefit these patients. There is a lack of high-quality studies on isotonic saline in this area. Previous studies [66-68] have found that hypertonic saline improved the symptoms of inflammatory sinus disease more significantly compared to isotonic saline. Therefore, based on the available high-quality evidence of hypertonic saline for URTI caused by SARS-CoV-2 and comparative studies in related fields, the use of hypertonic saline for nasal irrigation for SARS-CoV-2 URTI is preferentially recommended. Since excessively hypertonic saline could lead to irreversible ciliary arrest, it is recommended that the concentration should not exceed 3% [69]. The study by Cegolon *et al.* [6] investigated the role of additives (xylitol, panthenol and lactic acid) in nasal irrigation for the treatment of SARS-CoV-2 caused URTI and obtained positive results. Some studies have also explored the addition of glucocorticoids to the nasal irrigation solution for the treatment of olfactory impairment due to COVID-19 [70], which was generally found to be beneficial for the recovery of olfaction. Overall, however, there is a lack of sufficient research on whether additives are beneficial for URTI caused by SARS-CoV-2, and more high-quality studies are needed.

Indications and contraindications for nasal irrigation

Nasal irrigation has a wide range of applicability due to its convenience, safety, and tolerability. It is recommended to be used with caution for infants and children who cannot cooperate, patients with diagnosed nasal tumors (risk of tumor metastasis), patients with severe URTI and acute middle ear infections (possible spread of infection), patients with hemiplegia (possible choking and coughing), and people who cannot take care of themselves. Due to the safety of saline, there are no absolute contraindications for nasal irrigation.

Adverse effects of nasal irrigation

Nasal irrigation is generally a relatively safe physical therapy and does not usually cause significant adverse effects when performed according to standard practice. However, some people may suffer from adverse reactions due to differences in nasal structure and sensitivity or improper operation, such as nasal burning, discomfort and ear swelling or pain etc. [26]. Nasal burning or discomfort may be caused by excessive irrigation pressure and requires self-adjustment of the pressure. Some patients may have sensitive nasal mucosa and need to adapt slowly. These adverse reactions generally have no significant effect on the patient. Swelling and pain in the ear is usually caused by the incorrect position causing the fluid to enter the eustachian tube, which can be improved by changing the position during irrigation.

Recommendations for nasal irrigation

<u>Pre-exposure prevention for high-risk medical workers</u>

Nasal irrigation using 2% or 0.9% sodium chloride solution can be performed prior to aerosol-generating procedures, such as dental procedures, medical procedures in otolaryngology, tracheal intubation and non-invasive ventilation. It should be given immediately after the procedure is completed and protective equipment is taken off.

<u>Pre-exposure prevention for the general population and healthcare workers</u>

Nasal irrigation can be performed before and after gatherings (e.g., community gatherings in elderly care institutions or rehabilitation facilities, family gatherings, and meetings) and outdoor activities. Children and caregivers in schools and kindergartens are recommended to receive nasal irrigation. In the case of healthcare workers, nasal irrigation at home and hospital is necessary to clean out viruses that may adhere to the nasal cavity. Nasal irrigation should be guided by experts to ensure that the irrigating solution will not contaminate the environment.

<u>Post-exposure prevention for the general population and healthcare workers</u>

Nasal irrigation using 2% hypertonic saline solution should be performed for 7-14 days after a close contact with individuals infected with SARS-CoV-2. 0.9% sodium chloride solution can be continuously irrigated for those who have no conditions to prepare or who are intolerant to hypertonic saline. Previous studies have demonstrated the antiviral effect of sodium chloride solution, as well as its effect in physically cleaning the oral and nasal passages. The infection of SARS-CoV or MERS-CoV usually induces the lower respiratory tract, leading to severe complications like pneumonia or even death. As a result, nasal irrigation is not suitable for the prevention of a severe infectious disease. The Omicron variant infection is characterized by low severity, mild symptoms in 90-95% of cases, and topical infection in the respiratory epithelium. We considered that a rational use of nasal irrigation by hypertonic or isotonic saline could reduce the viral load of SARS-CoV-2, thus preventing the transmission and alleviating the clinical symptoms of URTI.

Conclusions

The COVID-19 pandemic poses a significant health burden worldwide, and there is a lack of effective therapeutic agents for the disease. Proper nasal irrigation can reduce the viral load in the nasal mucosa and help shorten the viral shedding period, helping to slow the spread of SARS-CoV-2 virus in the community. In addition, SARS-CoV-2 caused URTI symptoms could be alleviated by nasal irrigation. Therefore, nasal irrigation is suitable for large-scale use under current epidemic conditions as an effective physical therapy with convenience, high safety, low adverse effects, and wide age coverage.

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Authors' contributions

Conceptualization, SL and XCS; data curation, ZFW, LH, and JJW; methodology, SL and XCS; resources, MY, LC, and DHW; funding acquisition: LC; writing—original draft, SL, XCS, and ZFW; writing—review and editing, LC and DHW. All authors have read and agreed to the published version of the manuscript.

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